

Sweden's Tenth National Report under the Convention on Nuclear Safety

Sweden's implementation of the obligations of the Convention



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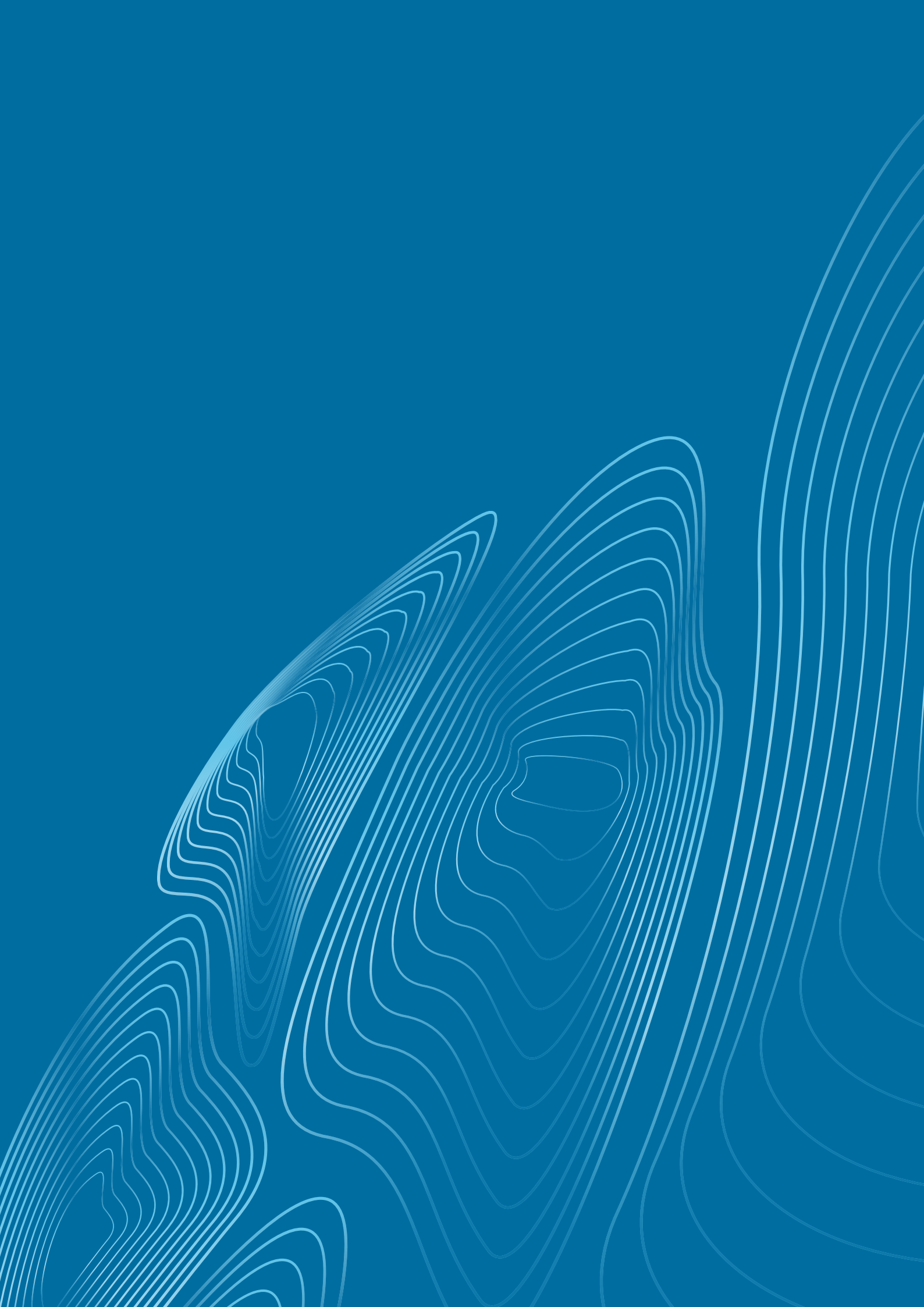
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Ds 2025:22

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Foreword

The Swedish nuclear programme is in a phase of change. A massive expansion of the nuclear power production is anticipated to provide clean energy needed to meet the climate objective of net-zero emissions by 2045. At the same time, full-scale dismantling and disassembly of several reactors is underway. The Swedish Government is currently taking a full range of measures to facilitate the construction and commissioning of new reactors while ensuring the high level of safety, security, and safeguards.

The national reports for the review meetings are developed in response to Article 5 of the Convention on Nuclear Safety, which calls for a self-assessment by each Contracting Party with regard to compliance with the obligations of the Convention. On the part of Sweden, this self-assessment has demonstrated compliance with all the obligations of the Convention, as shown in Chapter 3 of this national report.

The Swedish reactors have been operating safely. There has not been any events occurring that would indicate a serious degradation of safety or radiation protection over the reporting period.

As mentioned in the previous national report, the Swedish nuclear power plants have completed all major measures identified by the EU stress test National Action Plan in accordance with the original given time schedule, meaning that the identified primary measures were all implemented by the end of 2020. The Independent Core Cooling System installations marked the completion of the action plan. During the current reporting period only less significant changes and developments have taken place.

Sweden continues to fulfil the requirements on nuclear safety, radiation protection and safe waste management. A second full scope IAEA IRRS mission to Sweden was performed in November 2022, followed by a back-to-back ARTEMIS mission in April 2023. Both missions provided valuable feedback that enables further development and improvement of nuclear safety, radiation protection and safe waste management.

A major revision of the Swedish Radiation Safety Authority's Code of Statutes is being undertaken. On 1 March 2022, the second part, with key regulations applying to design, assessment and operation of nuclear power plants, together with radioactive waste management, entered into force. The remaining parts of the new Code of Statutes are expected to be completed and enter into force in 2026. During 2025, minor updates will be made to the present regulations with regard to some new reactor technologies that can be expected in applications for new build.

Russia's full scale invasion of Ukraine has prompted the Swedish Radiation Safety Authority to review and strengthen its own and, by extension, Sweden's ability to deal with nuclear or radiological emergencies. The outcomes of the Authority's activities are valid both for peacetime emergency preparedness and for heightened alert situations.

At the previous combined 8th and 9th review meeting, two challenges were identified for Sweden; one concerning the scaling up of national competencies in anticipation of new nuclear power, and another concerning adaptation of the regulatory framework and further development of the authorisation process for new nuclear applications. Both challenges have been addressed through strategic initiatives, work concerning review and updates of the regulatory framework as well as strengthened national coordination.

The present national report covers the period March 2022–February 2025.

Stockholm, 19 August 2025



Romina Pourmokhtari
Minister for Climate and the Environment

1. Introduction



1.1. About this report

This national report fulfils Sweden's obligations under Article 5 of the Convention on Nuclear Safety (CNS). It has been prepared by a working group comprising representatives from the Swedish Government Offices, the Swedish Radiation Safety Authority (SSM), and the licensed operators of nuclear power plants (NPPs) in Sweden. SSM has been assigned to coordinate the preparation of the national report. The licensees have been represented by the following organisations:

- Vattenfall AB (Ringhals NPP and Forsmark NPP).
- Uniper SE (Oskarshamn NPP).

Sweden is a Category 1 Contracting Party to the CNS. As such, it has reported under the Articles 6 to 19.

1.2. National policy towards nuclear activities

1.2.1. Political developments

After the 2022 elections, the newly appointed Swedish Government initiated a major political shift towards nuclear power. In 2023, the Swedish Parliament decided to change the energy policy target for the composition of electricity production from 100 % renewable electricity to 100 % fossil free electricity by 2040. To meet the rapidly increasing demand for fossil free electricity at competitive prices, the Government believes that new NPPs will be needed. They also believe that NPPs are needed to meet future electricity demands and to increase supply security in the electricity system.

Since then, the Government has taken several steps to improve conditions for investments in new NPPs. To enable an increased number of reactors on both existing and new sites, the Swedish Parliament decided in 2023, through legislative amendments, to remove the restriction of only having ten reactors in Sweden. The parliament also decided to remove the legal restriction preventing the build of new reactors at sites other than the three existing ones. These amendments came into force on 1 January 2024.

In 2024, Sweden appointed a national nuclear new-build coordinator. This is a new role within the Government administration that serves to facilitate the expansion of nuclear power in Sweden through coordinating relevant stakeholders and advising the Government on suitable measures to enable new NPPs. The coordinator operates as a standalone committee.

In November 2023, the Government established an inquiry to review the licensing process for new reactors. The purpose of the inquiry is to facilitate an efficient new build process by presenting laws making the licensing procedure of nuclear activities more effective, as well as proposing appropriate fees for the licensing of new reactors. This first part of the inquiry was handed over to the Government in January 2025 and is now being reviewed as a matter of priority by the Government. The next steps for the Committee of Inquiry are to assess the national system for nuclear waste management including disposal by autumn 2025, and to assess the need for a graded approach for some emergency preparedness and response measures by February 2026.

The Government has also allocated additional funding to support the strengthening of resources at the national nuclear regulator, SSM, and has set up another inquiry into whether Sweden should establish an independent Technical and Scientific Support Organisation (TSO). This inquiry handed over its results to the Government in January 2025, with the proposal that a TSO should be established within SSM to facilitate the national consolidation of knowledge on nuclear safety and radiation protection. The Government is now assessing these proposals.

Furthermore, in May 2025 the Government passed a bill to improve financial conditions for nuclear investments, including introducing a financing and risk-sharing model.

The Government's objective is to have new NPPs with installed capacity equivalent to at least two large-scale reactors in place by 2035 at the latest, and that by 2045 a powerful expansion is needed that could, for example, correspond to ten new large-scale reactors (LSR). The exact amount of NPPs (i.e. the number of large-scale and small modular reactors (SMR)) that will be required is determined by several parameters. These parameters include for example the expansion rate of the electricity system, the location of new consumption and production, technological developments in NPP design, as well as the possibility of extending the operating time of existing nuclear power reactors.

1.2.2. Regulatory preparations with respect to new nuclear power

Since 2022, there has been significant interest in new nuclear power in Sweden from both the Government and the industry, see also section 1.2.1. SSM has received additional funding from the Government for resource and competence building with respect to new nuclear power. In addition, extra funds have been allocated for research funding. In 2024, special recruitment efforts by SSM resulted in substantial new recruitment.

SSM is conducting extensive work to be well prepared when a licence application is submitted. Over 50 years have passed since the first Swedish NPPs were commissioned, and now various new nuclear initiatives are beginning to emerge. Although it is still uncertain which initiatives and which reactor technologies will be realised in actual licence applications, it is essential for SSM to be well prepared. In order to meet these challenges as effectively as possible, several prerequisites have been important for SSM to establish. SSM has established collaborations with other regulatory authorities internationally, that are in similar stages of preparations. Furthermore, SSM is working, both nationally and internationally, to gain knowledge and expertise about new reactor technologies and to identify and investigate new safety issues. In addition, SSM is updating and adapting its regulatory requirements with respect to new nuclear technologies, as well as reviewing the processes and routines that ensure that safety issues are handled robustly during licensing (see sections 7.2.2 and 2.1 (Challenge 2)).

1.2.3. National competence

National competence building is essential for the future of nuclear power in Sweden. The Government provides basic conditions for building and maintaining national competence relevant to all parties that have responsibilities in relation to the safety of facilities and activities. The Government has done so in part by providing basic funding for universities, higher education and research institutions. It has also appointed SSM as the responsible authority for building and maintaining the competence that is needed for nuclear and radiation safety. The Government has established legal obligations relating to competence for safety, which are imposed on persons carrying out activities with ionising radiation and upon licence holders for nuclear activities. These parties are also responsible for ensuring that adequate financial, administrative and human resources are available to fulfil legal obligations or those arising from regulations or decisions issued under the legislation.

The Government has taken several actions in line with a proposal from SSM for a national strategic focus on competence in the area of nuclear and radiation safety, which was submitted to the Government in March 2022.

SSM has received increased funding to be used to build competence within nuclear and radiation safety, both nationally and within its own organisation. Increased research funding has also been directed from the Swedish Energy Agency to the area of nuclear safety related to new nuclear. See also reporting under Article 8 (section 8.10) for SSM's activities with respect to maintaining and developing national competence.

In January 2025, the Swedish Agency for Public Management delivered the results of a government assignment to investigate and propose a structure for an effective and efficient organisation of the technical support within nuclear safety and radiation protection (see also section 1.2.1). The Agency has proposed the establishment of a TSO-function as an organisational unit within SSM that is directly subordinate to the Government. The proposal has undergone a comprehensive consultation and is now being further assessed by the Government.

In February 2025, the Government presented a new education and research strategy to meet future competence needs in the areas of science, technology, engineering and mathematics. The strategy is targeting several areas that need to be strengthened in order to meet societal challenges. One of them is an increased need for plannable, fossil free electricity production, e.g. nuclear power. The strategy is focussing on all levels of education and is accompanied by investments in basic and applied research. The Swedish Research Council manages increased funding for basic nuclear power research in consultation with SSM and the Swedish Energy Agency. The Government also allocates increased funding to the Swedish Energy Agency for special investments in research and innovation within nuclear, e.g. pilot- and demonstration projects and research infrastructure.

1.3. National nuclear power programme

1.3.1. Development of the nuclear power programme in Sweden

In Sweden, the first steps towards a national nuclear programme were taken in 1947, when AB Atomenergi was established to realise a development programme decided by the Parliament. As a result, the first research reactor, located at the Royal Institute of Technology (KTH) in Stockholm, went critical in 1954. This was followed by the first prototype, a pressurised heavy water reactor (PHWR), Ågesta NPP, located in a rock cavern near a suburb of Stockholm, and research reactors built at the Studsvik research centre. The Ågesta NPP was in operation between 1964 and 1974, and was mainly used for district heating. The first commercial NPP, Oskarshamn 1, was commissioned in 1972. Between 1974 and 1985 another eleven reactors were taken into operation at the sites in Barsebäck, Oskarshamn, Ringhals and Forsmark. The twelve commercial reactors built in Sweden comprise nine boiling water reactors (BWR) and three pressurised water reactors (PWR).

As a result of political decisions, the BWR units Barsebäck 1 and 2 were shut down permanently in 1999 and 2005. In 2004, Studsvik Nuclear AB decided to shut down the two research reactors R2-0 and R2 at the Studsvik site. R2-0 was a research reactor of pool type with a thermal power of 1 MW. R2 was a research and materials testing reactor with a thermal power of 50 MW. The final dismantling of the research reactors, which began in 2015, has been completed. Applications for clearance of the remaining buildings and sub-surface structures were approved by SSM in 2023.

In 2015, decisions were taken by the owners of the nuclear power plants at Ringhals and Oskarshamn to phase out the reactor units Ringhals 1 and 2 and Oskarshamn 1 and 2. The decisions were taken based on the overall business and energy market situation, prevailing taxation rules, and SSM's requirements for investment in safety measures to enable continued operation beyond 2020. Ringhals 1 and 2 were shut down permanently in 2020 and 2019, and Oskarshamn 1 and 2 in 2017 and 2015. Subsequently, a new and important mission for the utility companies responsible for the power plants, has been to ensure safe and effective decommissioning of the permanently shut down units while continuing the safe routine operation of the remaining reactors.

The nuclear safety strategy for existing NPPs in Sweden is to apply continuous improvements based on regular and systematic reassessments, aiming at ensuring compliance with modern requirements and current design basis. This strategy is in line with article 8a of Council Directive 2014/87/Euratom for nuclear installations. The strategy also includes identification of further safety improvements by taking into account ageing issues, operational experience, most recent research and development, and developments in international standards.

Examples of implemented safety measures through relevant modifications and, in some cases, by means of comprehensive modernisation projects include those taken following the accident at Three Mile Island in 1979, when severe accident management systems (including Filtered Containment Venting System, FCVS) were introduced at the Swedish NPPs. Extensive modernisation programmes were also introduced in 2005 and completed in 2015 for all Swedish NPPs in order to meet new requirements issued by the regulator in 2004. These included improvements in separation and diversification, as well as enhancing the capability to control conditions that might arise during design basis accidents. Actions have also been taken to considerably strengthen the capabilities to operate the plants and monitor the status of the barriers by introducing new or upgraded instrumentation and control equipment.

Furthermore, safety improvements have also been identified through international reviews, such as the now completed EU stress test and its associated National Action Plan (NAcP), where all identified measures have been fully implemented.

Through a decision by SSM in 2014, the licensees were required to implement an independent core cooling system (ICCS) at reactors intended to be operated beyond 2020. The principal design solutions for the ICCS functions are presented in section 18.2.1.6 and the new systems were taken into operation during 2020.

Basic information about the design of the reactors and about modernisation and key safety upgrades that have been implemented is provided in section 18.2 and Appendix 1. Further details on implemented safety measures can be found in the previous national report to the CNS (Ds 2022:19), where Appendix 1 provides an overview of implemented safety upgrades and measures, and Appendix 2 summarises the NAcP.

1.3.2. Nuclear power installations in Sweden

An overview of the current situation and the main data for nuclear power installations in Sweden are shown in table 1. As of February 2025, Sweden has six nuclear power reactors with an operational licence. Seven nuclear power reactors have been permanently shut down.

Table 1. Main data for nuclear power installations in Sweden.

Power reactor	Licensed thermal power level (MW)	Electrical gross output (MW)	Type	Operator	Construction start	Commercial operation
Ågesta	105	12	PHWR	AB Atomenergi Vattenfall	1957	1964–1974 ¹
Barsebäck 1	1,800	615	BWR	Barsebäck Kraft AB	1970	1975–1999
Barsebäck 2	1,800	615	BWR	Barsebäck Kraft AB	1972	1977–2005
Forsmark 1	3,253	1,120	BWR	Forsmarks Kraftgrupp AB	1971	1980
Forsmark 2	3,253	1,120	BWR	Forsmarks Kraftgrupp AB	1975	1981
Forsmark 3	3,300	1,167	BWR	Forsmarks Kraftgrupp AB	1978	1985
Oskarshamn 1	1,375	492	BWR	OKG Aktiebolag	1966	1972–2017
Oskarshamn 2	1,800	661	BWR	OKG Aktiebolag	1969	1975–2015
Oskarshamn 3	3,900	1,450	BWR	OKG Aktiebolag	1980	1985
Ringhals 1	2,540	910	BWR	Ringhals AB	1968	1976–2020
Ringhals 2	2,660	966	PWR	Ringhals AB	1969	1975–2020
Ringhals 3	3,144	1,117	PWR	Ringhals AB	1972	1981
Ringhals 4	3,300	1,171	PWR	Ringhals AB	1973	1983

All Swedish BWRs, and Ågesta PHWR, were designed by a domestic vendor ASEA-Atom (later merged into ABB Atom, subsequently Westinghouse Electric Sweden AB), and all Swedish PWRs were designed by Westinghouse Electric Company (USA). The maximum power level of the reactors currently in operation has been uprated between 6 % and 38 % from the original licensed power levels (see section 6.3). Figure 1 shows the geographical locations of Swedish nuclear facilities, all of which are situated in the southern parts of Sweden.

¹ Maintained by Vattenfall AB and AB SVAFO. All fuel and heavy water as well as parts of the primary system (some of the steam generators) have been removed from the installation.

Nuclear Facilities in Sweden

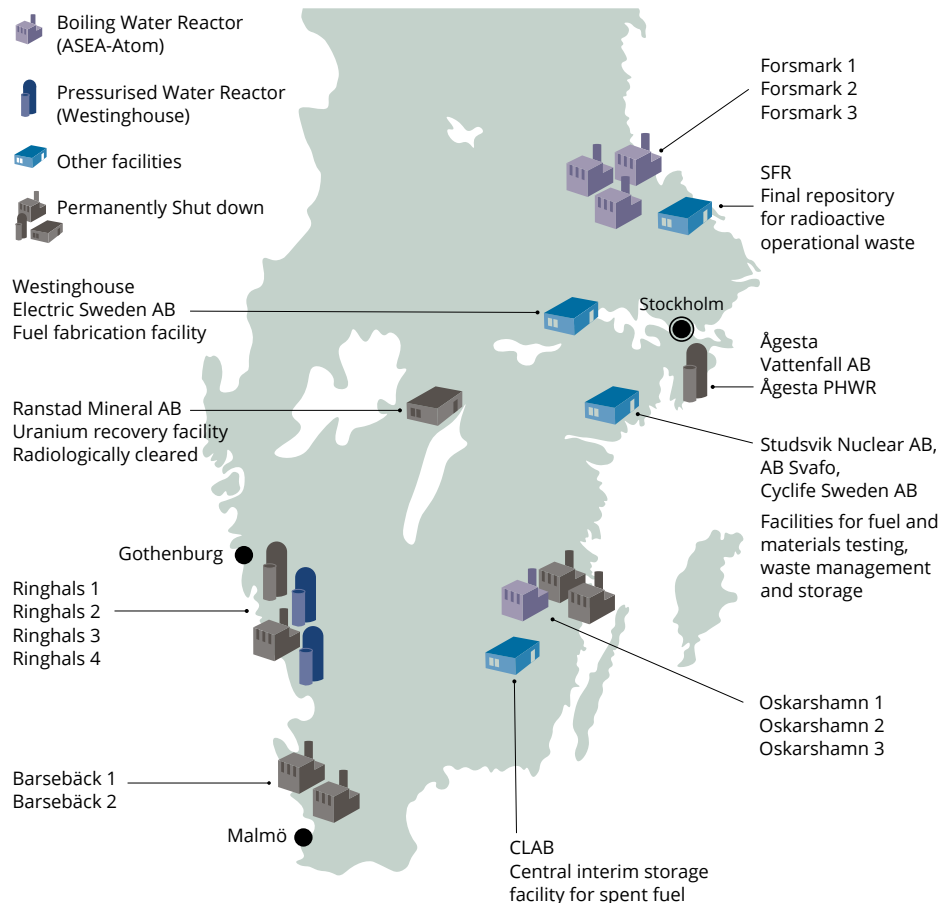


Figure 1. Locations of nuclear facilities in Sweden.

A schematic overview of the ownership of Swedish NPPs is shown in figure 2. Vattenfall AB is the majority owner of Ringhals AB (Ringhals NPP) and Forsmarks Kraftgrupp AB (Forsmark NPP). Uniper SE is the majority owner of OKG Aktiebolag (Oskarshamn NPP). Sydkraft Nuclear Power AB (owned by Uniper SE) owns Barsebäck NPP and has shares in Forsmarks Kraftgrupp AB, Ringhals AB and OKG Aktiebolag. Fortum Generation AB owns shares in OKG Aktiebolag and Forsmarks Kraftgrupp AB.

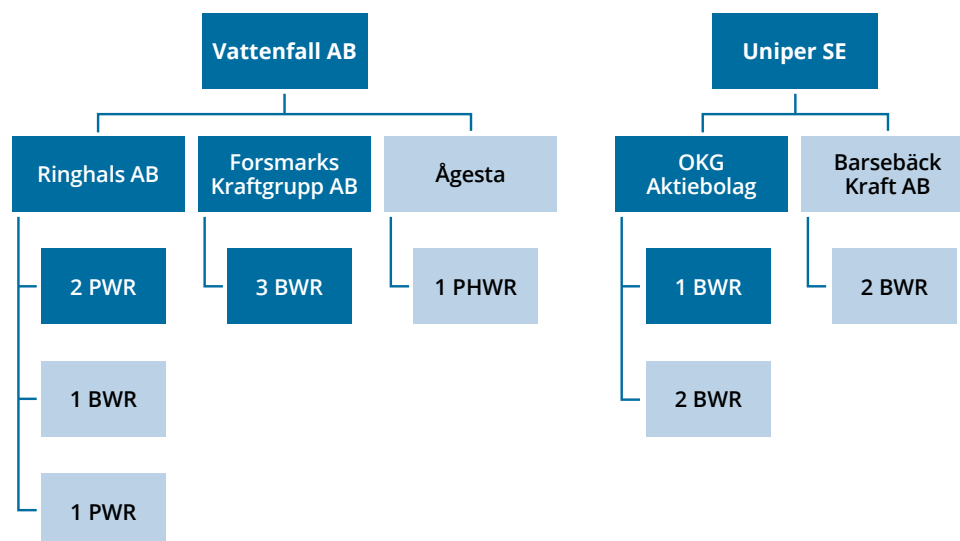


Figure 2. Schematic overview of ownership structure. Light blue indicates shut down NPPs.

1.3.3. Support organisations of owner and licensees

Swedish NPP operators jointly own the following support organisations:

- KSU AB (Nuclear Training and Safety Centre): Provides operational training, including simulator training, on a contractual basis to all Swedish NPPs. KSU also analyses international operational experience and provides the results to the Swedish operators.
- SQC (Swedish Qualification Centre): A company for independent qualification of NDT systems (Non-Destructive Testing) to be used by NDT companies at Swedish NPPs.
- Norderf (formerly ERFATOM): Formed by Swedish and Finnish NPP operators, KSU and SKB. The aim is to proactively monitor trends and deviating results, and to carry out experience feedback analysis of both events in Swedish and Finnish NPPs, as well as of international operational experience.
- SKB (Swedish Nuclear Fuel and Waste Management Company): A company that deals with the long-term management of Swedish spent nuclear fuel and radioactive waste. SKB owns and operates the central interim storage facility for spent nuclear fuel (Clab) at Oskarshamn and the final repository for short-lived radioactive waste (SFR) at Forsmark. SKB is also responsible for the implementation of, and supporting research and development program for, the planned final repository for spent nuclear fuel.
 - » In 2021, the Government issued a new licence under the Nuclear Activities Act to allow for extension of the capacity of SFR from 63,000 m³ to 180,000 m³. SSM decided in November 2024 to approve start of construction works, which are currently ongoing.
 - » In 2022, the Government formally approved SKB's licence applications under the Nuclear Activities Act for establishing a geological disposal facility for spent nuclear fuel at Forsmark and a plant for encapsulation of spent nuclear fuel in Oskarshamn. In January 2025, SKB submitted a Preliminary Safety Analysis Report (PSAR) for the geological disposal facility, approval of which is a precondition for the start of construction works. The PSAR is currently under review by SSM.
- AB Svafo is a non-profit company located at Studsvik Tech Park, established to be responsible for coordinating and managing legacy waste – primarily from historical government research activities. Among its responsibilities, AB Svafo undertakes decommissioning of nuclear facilities from previous research and development activities at the Studsvik Tech Park, as well as temporary storage of decommissioning waste (including the Ågesta reactor) and legacy wastes until final disposal can be carried out.

1.3.4. Other commercial services in the nuclear industry

The supply of services in the nuclear field has become concentrated to a few companies. The main Swedish vendor, previously ASEA-Atom/ABB Atom, is now part of Westinghouse Corporation, which is owned by Brookfield Business Partners L.P. under the name Westinghouse Electric Sweden AB. Other active vendors on the Swedish market are Framatome, Westinghouse, GE Hitachi Nuclear Energy, GE, Siemens, and Alstom.

Studsvik Nuclear AB is a contractor for material testing and nuclear fuel investigations. Studsvik Nuclear AB operates a hot-cell laboratory for fuel investigations. The company also provides decommissioning and waste treatment services. Cyclife Sweden AB (Cyclife) operates on the Studsvik Tech Park outside Nyköping. The company provides waste treatment services for NPPs and other industries that use radiation. Cyclife operations were previously part of Studsvik Nuclear AB but were sold in 2016 to a subsidiary of the French company Electricité de France (EDF).

According to the amended EU Nuclear Safety Directive and Swedish law, a licence holder is required to make the necessary checks regarding the quality and competence of a contractor and to take full responsibility for the work performed by such contractors.

1.3.5. Nuclear waste

Operational radioactive waste is generated by nuclear reactors and fuel cycle facilities, such as facilities at Studsvik Tech Park and Westinghouse Electric Sweden AB's fuel fabrication plant, located in Vasterås. Radioactive waste also originates from medical and research institutions, industry and consumer products.

In total, the Swedish nuclear power programme is expected to generate approximately 20,000 m³ (12,000 tonnes) of spent fuel, 180,000 m³ of short-lived low and intermediate level waste (LILW) from operations and decommissioning, and 16,000 m³ of long-lived LILW. The estimated quantities are based on assuming 60 years of operation of existing reactors, and the actual periods of operation for the permanently shut down reactors.

The current national waste management programme includes the waste treatment facilities at Studsvik Tech Park, the final repository for short-lived radioactive waste (SFR), shallow land burials of very low level waste, the central interim storage facility for spent nuclear fuel (Clab), the transportation system, and the use of clearance. Material may be cleared for unrestricted use, for example recycling, or for treatment as conventional non-radioactive waste. SKB has started the construction of an extension of the SFR facility to accommodate short-lived wastes arising from nuclear facility decommissioning. Three additional major waste management facilities are foreseen to be designed, sited, constructed and licensed in the future: a plant for encapsulation of spent nuclear fuel, a disposal facility for spent fuel and a disposal facility for long-lived low and intermediate level waste. Additional land burials for very low level waste may also be constructed.

Transport of spent nuclear fuel and nuclear waste is done largely by sea, from the NPPs to Clab and SFR. The transport system consists of a custom build transport ship, transport casks and containers, and terminal vehicles for loading and unloading.

1.3.6. Nuclear education, research and development

In Sweden, higher education in nuclear technology is mainly concentrated at the Royal Institute of Technology in Stockholm (KTH), Chalmers University of Technology in Gothenburg (Chalmers), and Uppsala University (UU).

The three Swedish NPP licensees, SSM and Westinghouse Electric Sweden AB jointly support these three universities through the Swedish Centre of Nuclear Technology (SKC), an organisation for sponsoring and coordination that has been in existence since 1992. SKC supports undergraduate education, graduate schools as well as research. The present SKC contract period is from 2024 to 2027.

When SKC was set up in 1992, a political decision on closure of NPPs was under consideration, and student enrolment in nuclear studies was very low. The industry and the regulatory authority faced similar challenges in competence development in general and staff renewal in particular. Thirty years later, similar challenges face Sweden in terms of maintaining sufficient competence for the safe operation of the six remaining reactors. Unlike 1992, however, enrolment in nuclear studies is currently relatively high.

To ensure the availability of qualified staff and necessary competences in the future, all actors in the nuclear industry in Sweden are working systematically with competence management and competence retention. In cooperation with the industry, SSM has developed a ten year plan for competence retention, focusing on five strategic areas; national coordination, international research collaboration, research policy for viable research environments, education for the competence needs of society, and the attractiveness of the nuclear and radiation safety sector (see also 8.10.2).

There is currently only one master programme on Nuclear Engineering in Sweden and this is the TNEEM programme that was established in 2007 at KTH Royal Institute of Technology. It is at the same time both a regular masters programme and an international educational collaboration. Students enrolled in courses given in the programme can be either enrolled in the TNEEM programme, join the programme through the European Master In Nuclear Engineering (EMINE), or through several double degree bilateral agreements. From all these enrollement paths, the programme currently graduates around 50 students per year.

The industry and university partners have also formed a centre of excellence, called ANItA, for research on SMR technologies, with a focus on light water SMR technology. The participants are Vattenfall, Fortum, Uniper, and the nuclear technology companies Westinghouse and Studsvik Nuclear, together with Uppsala University, Chalmers and the KTH Royal Institute of Technology. The centre was proposed in response to the call from the Swedish Energy Agency for centres of excellence for a sustainable energy system. The centre's research is focused on how SMRs can support transitioning the Swedish energy system into a sustainable system and to resolve technical and regulatory matters in order to realise SMRs in the most effective way. The centre started in January 2022 and has received a SEK 25 million research grant from the Swedish Energy Agency, representing about one third of the total funding for the centre.

1.3.7. National industry cooperation

A joint industry initiative was taken in 2013 by forming a coordination group, KSKG (Kärnkrafts-säkerhetskoordineringsgrupp), to coordinate critical nuclear safety and security issues (primarily following the Fukushima Daiichi accident), EU stress tests on nuclear safety, EU Topical Peer Reviews (TPR) and work on other upcoming regulatory requirements. The goal of this liaison group is to develop and strengthen safety and security in an effective way. KSKG delivers position papers on high priority and strategic issues. The members of KSKG are the licence holders: Forsmarks Kraftgrupp AB, Ringhals AB, OKG Aktiebolag, SKB and the owners of the nuclear facilities, i.e. Vattenfall AB, Sydkraft Nuclear Power AB, Uniper SE and Fortum Generation AB.

1.4. Swedish participation in international activities to enhance nuclear safety and radiation protection

1.4.1. The regulatory body (SSM)

Through SSM, Sweden is involved in about 175 international working groups. The majority of these groups deals with nuclear safety and radiation protection issues. In recent years, a number of working groups concerning new nuclear power have been formed. The cooperation mainly takes place within the frameworks of the IAEA, OECD/NEA, UNSCEAR and EU, and also in connection with the international conventions ratified by Sweden as well as in organisations such as the Western European Nuclear Regulators Association (WENRA), Heads of European Radiation Control Authorities (HERCA), International Nuclear Regulators Association (INRA) and the International Commission on Radiological Protection (ICRP).

In addition to multilateral collaboration, SSM currently has bilateral agreements with several countries. These agreements concern the exchange of information and cooperation within agreed areas, e.g. nuclear safety, emergency preparedness, occupational exposure, environmental radiological protection, and radioactive waste management. These countries are Australia, Belarus, Canada, France, Finland, Georgia, Germany, Japan, Moldova, South Korea, Lithuania, Poland, Russian Federation, Ukraine, the United Kingdom and the United States. There is, however, currently no active cooperation with Belarus, Georgia or the Russian Federation. In addition, SSM has a long history of cooperation with other Nordic countries (Denmark, Finland, Iceland and Norway) and has special agreements with them regarding emergency preparedness and information exchange.

SSM participates in ENSREG (European Nuclear Safety Regulators Group), an expert advisory group to the European Commission. ENSREG is composed of senior officials from national nuclear safety, radioactive waste safety and radiation protection regulatory authorities and senior civil servants with competence in these fields from all 27 Member States of the European Union together with representatives of the European Commission.

During 2022–2023, the second EU TPR under the amended Council Directive 2014/87/Euratom, took place. 'Fire-protection at nuclear installations' was the topic for this second peer review process. On behalf of the Swedish government and with input from the Swedish licensees, SSM developed and published a national assessment report and participated actively in the peer review process. Reports of the TPR activities are published on the ENSREG website.

SSM participates actively in the work performed within international conventions in the areas of nuclear safety and radiation protection, such as the Convention on Nuclear Safety, the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, the Convention on Early Notification of a Nuclear Accident, the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, the Espoo Convention on Environmental Impact Assessment in a Transboundary Context, 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.

SSM participates actively in the development of the IAEA safety standards, through membership of the Commission on Safety Standards (CSS) as well as membership of the Safety Standards Committees.

In addition to regulatory matters, SSM is engaged in a number of international research projects, mostly within the framework of cooperation projects carried out by the Nordic countries, the EU research programme, OECD/NEA, and the IAEA. Sweden is also active in networks for promoting research and cooperation in radiobiology, radioecology and biological dosimetry. Furthermore, SSM staff have been involved in many international expert missions, for example as experts in the IAEA peer review service teams of the IRRS, ARTEMIS, OSART and SALTO.

SSM is active within the framework of OECD/NEA through participation in committees and working groups as well as in several Joint Research Projects.

SSM plays an active role in WENRA and its working groups. SSM has contributed to the review and development of the updated WENRA Safety Reference Levels for Existing Reactors, and participated in WENRA's ongoing benchmarking projects, which involve a systematic comparison of national reactor safety requirements and their implementation against jointly agreed reference levels.

1.4.2. International development and cooperation programmes

Through SSM, Sweden is involved in a number of development and cooperation programmes with countries in Central and Eastern Europe. The cooperation programmes primarily aim to ensure improvements in nuclear safety, radiation protection, non-proliferation, environmental monitoring and the management of radioactive waste.

Since Russia's invasion of Ukraine in 2022, the focus of the Authority's development cooperation in Eastern Europe has shifted. Cooperation with Russia and Belarus was stopped, and the main focus shifted to cooperation with Ukraine. Certain projects are also undertaken with Moldova and Armenia. SSM closely follows developments and evaluates the security situation continuously in the partner countries.

The programmes are based on Government decisions, with financing provided by the Swedish Government, the Swedish Environmental Protection Agency and Sweden's International Development Cooperation Agency (Sida).

1.4.3. Utilities

Utilities in Sweden are active in international cooperation for the purpose of enhancing nuclear safety by sharing experience, contributing to work on international regulation and guidelines, and by participating in safety assessments and peer reviews. At the present time, this is primarily accomplished through memberships in World Association of Nuclear Operators (WANO), in owners group associations of major European and US vendors, through Electric Power Research Institute (EPRI) and by participation in the nucleareurope initiative European Nuclear Installations Safety Standards (ENISS), the European Utilities Requirements project as well as through cooperation with IAEA and OECD/NEA, and participation in IAEA activities.

Swedish utilities are also engaged in international projects and research organisations. Examples are the Nordic Nuclear Safety Research (NKS), ongoing since 1977, and programmes and projects within the framework of EU and OECD/NEA.

2. Summary



This national report, which is the 10th for Sweden, has been issued in compliance with the provisions of Article 5 of the CNS.

On the part of Sweden, this self-assessment has demonstrated compliance with the obligations of the Convention, as shown in Chapter 3 of this report.

Sweden has six NPPs in operation (4 BWRs and 2 PWRs) and all have entered long-term operation. The licensees of these reactors currently plan for 60 years of operation. At present, there is no official end date for nuclear energy in Sweden.

2.1. Summary of response to applicable challenges and suggestions

Sweden has addressed the challenges and suggestions that remain open from the previous review meeting as follows:

Challenges

Challenge 1 from Joint 8th and 9th review meeting: Scale up national competencies for both the regulator and the licensees in anticipation of new build and to address the findings of the IRRS mission.

In 2022, SSM provided the Government with a proposal for a national strategy regarding the Swedish knowledge management in the area of nuclear and radiation safety. The proposal was based on conclusions from SSM's previous government assignments relating to national competence and it was also prompted by recommendations in the area of "Competence for Safety" that emerged from the IRRS missions in 2012 and 2022 (see section 8.10.2).

The Government has taken several actions in line with the proposal for a national strategic focus that was submitted by SSM. SSM has received increased funding to be used to build competence in the area of nuclear and radiation safety, both nationally and within its own organisation. Increased research funding has also been directed from the Swedish Energy Agency to the area of nuclear safety related to new nuclear (see section 1.2.3).

Furthermore, in January 2025, the Swedish Agency for Public Management delivered a proposal for the establishment of a TSO-function as an internal organisational unit that is directly subordinate to the Government. The proposal has undergone a comprehensive consultation and is now being further assessed by the Government (see section 1.2.3).

Additionally, in February 2025, the Government presented a new education and research strategy to meet future competence needs in the areas of science, technology, engineering and mathematics (STEM). The strategy is accompanied by investments in basic and applied research (see section 1.2.3).

Regarding the Authority, SSM has experienced significant growth in recent years. By the end of 2024, the Authority had 342 employees, an increase from 297 employees at the end of 2021. Additionally, in recent years, staff turnover has decreased and stabilised around 12 % (see section 8.5.1).

To further strengthen the Authority's skills development, long-term competence supply and attractiveness as an employer, SSM has decided to develop a coherent and systematic approach to education and learning. An analysis and needs inventory has been conducted, forming the basis for continued development (see section 8.5). As part of this effort, an education strategist has been appointed, and work is underway to systematically identify training needs and gather existing educations in a training portal to improve visibility, facilitate learning follow-up and support gap analysis.

Also, a strategic initiative from SSM has been implemented to expand operations in Gothenburg and thereby to broaden the recruitment base, particularly in specialist nuclear technology expertise. This has proven successful, as positions previously difficult to fill have, to some extent, been successfully staffed with Gothenburg as the designated location (see section 8.5).

Regarding licensees, it is not expected that existing licence holders will apply for new nuclear. Should such applications be submitted, they are expected to come from a newly established company, rather than from existing licence holders.

Challenge 2 from Joint 8th and 9th review meeting: Adapt the regulatory framework and further develop the authorisation process to accommodate new nuclear applications.

Sweden is currently assessing potential amendments to, or updates of, the Act on Nuclear Activities and the system of licensing according to the proposals in the inquiry reports mentioned in section 7.1.2. In addition, a recent review of SSM's Code of Statutes (SSMFS) shows that they to a large extent can be applied to new reactor technologies and SMR. During 2025, minor updates will be made to the present regulations (level 2 regulations) with regard to some new reactor technologies that can be expected in applications for new build (see section 7.2.2).

SSM has issued a guide to the licensing of nuclear facilities addressed to future applicants, and is in dialog with companies that have shown interest in applying for a licence. In parallel, SSM is developing and reviewing its methods of working relating to the authorisation process by updating internal guidance on licensing review, ensuring compliance with IAEA SSG-12 (Licensing Process for Nuclear Installations), and producing internal guidelines and instructions for the review of an application. Experiences from authorisation reviews undertaken by SSM for other types of facilities are taken into account. SSM is also establishing exchange with other Swedish authorities that will be involved in the review of a licence application as well as with authorities in other countries that have more recent experience in such reviews.

Suggestions

No suggestions were made for Sweden at the previous review meeting.

2.2. Summary of other significant changes and developments since the previous report

In addition to the work summarised above to address the challenges that remain open from the previous review meeting, a number of other changes and developments have taken place. The most relevant are:

Article 6 and 19

- Forsmark 1 obtained permission for trial operation at a higher reactor power with a maximum thermal output of 3,253 MW, which corresponds to 120 % of the original output (see sections 6.3 and 19.1.3).

Article 7

- On 1 March 2022, the second part of SSM's new Code of Statutes, SSMFS – covering design, assessment and operation of NPPs, as well as radioactive waste management – entered into force (see section 7.2.2).

Article 8

- SSM has made adjustments to its organisation, aimed at ensuring that the Authority effectively can receive and process a new licence application for an NPP (see section 8.1.1).

Article 14

- Sweden has maintained a strong focus on ageing issues and long term operation, as well as regulatory supervision in this area (see section 14.3.2–14.3.4).

Article 16

- Following the extension of the emergency planning distance (EPD) around Swedish NPPs from 50 km to 100 km in July 2022, radiation monitoring capabilities within the County Administrative Boards in the affected counties have been substantially enhanced through the implementation of mobile dose rate systems with real-time data integration into RadGIS (see section 16.2.2 and 16.2.3).
- A development project (ETAPP), regarding electronic transmission of NPP parameters, has been completed by SSM and Swedish NPPs. ETAPP is fully running and implemented regarding education, training and exercises (see section 16.2.2 and 16.3.1).
- Russia's full scale invasion of Ukraine has prompted SSM to review and strengthen its own and, by extension, Sweden's ability to deal with nuclear or radiological emergencies. The outcomes of the Authority's activities are valid both for peacetime emergency preparedness and for heightened alert situations (see section 16.6.3).

Article 17

- Potential impact of climate change has been addressed and evaluated. Since all Swedish NPPs are located on the coast, sea-level rise has specifically been considered. In general, the NPPs are found to be well prepared against impacts of climate change, at least under what reasonably may be regarded as a very long but nevertheless foreseeable time to come (see section 17.2.1.10).

Article 19

- During the period since the previous report, SSM has reviewed the work of the operators of Forsmark and Oskarshamn on developing and implementing new Severe Accident Management Guidelines and has found that this has been completed satisfactorily and achieved a good quality (see section 19.3.3).

A more comprehensive description of changes and developments since the previous report is provided in Chapter 3 under each Article.

2.3. IAEA IRRS mission and other IAEA peer-reviews

The second full-scope IAEA IRRS mission to Sweden was conducted in November 2022, along with a back-to-back ARTEMIS mission during April 2023. The IRRS mission identified one good practice and several areas of good performance. However, challenges remain, particularly in terms of staffing shortages for key regulatory functions. The IRRS team provided recommendations for both the Government and SSM, emphasising the need for a national competence strategy, enhanced coordination among authorities, regulatory process improvements, and strengthened supervision measures. Sweden is now carrying out the work necessary to address the recommendations and suggestions of the IRRS 2022, and has requested coordinated IRRS and ARTEMIS follow-up missions to be conducted in the spring of 2027 (see section 8.12).

Furthermore, several IAEA SALTO review missions were conducted in Sweden during the current reporting period. In October 2024, IAEA conducted a SALTO peer review for Oskarshamn 3. At Forsmark NPP, a full SALTO peer review was conducted in 2023 for Forsmark 1 and 2 and a SALTO expert mission for Forsmark 3 was undertaken in March 2025 (see section 9.2.3.2).

2.4. Vienna Declaration on Nuclear Safety (VDNS)

The VDNS was adopted by the Contracting Parties in 2015. In the VDNS, the Contracting Parties to the CNS have established principles to guide them, as appropriate, in the implementation of the CNS objective – to prevent accidents with radiological consequences and mitigate such consequences should they occur.

The nuclear safety strategy in Sweden is to apply continuous improvements based on regular and systematic re-assessments, aiming at ensuring compliance with modern requirements and current design basis. The strategy also includes identification of further safety improvements by taking into account ageing issues, operational experience, most recent research and development and developments in international standards, including the principles defined in the VDNS.

Articles 6, 7, 14, 18 and 19 contain specific paragraphs regarding implementation of the VDNS principles, where more comprehensive descriptions are provided.

2.5. Notable achievement

Sweden has identified the following notable achievements during the review period:

- The implemented co-regulation of radiation protection and nuclear safety and security in Sweden (see section 7.2.2) has enhanced consistency and transparency of regulatory requirements, and contributes to a more holistic regulatory supervision of NPPs.
- Sweden (SSM) has procured a new system for mobile dose rate measurements intended for mapping, from vehicles, of fallout after an NPP accident. This significantly raises the effectiveness of fallout mapping in the three Swedish NPP-counties (see section 16.2.2 and 16.2.3). The implementation represents a notable achievement in strengthening national emergency preparedness and response capabilities.

2.6. Future focus

Sweden has identified the following issues as areas that demand future effort to resolve:

- Despite extensive and ongoing national efforts to secure and develop competence across the nuclear sector – including education, research, organisational development, and strategic planning – Sweden identifies the long-term supply of skilled personnel as a continued consideration. This concerns both the regulatory body and the licensees and is particularly relevant in light of parallel needs related to operation, decommissioning, and plans for new nuclear power.
- Managing an authorisation process for new nuclear power plants, in parallel with the supervision of ageing issues and long-term operation of the reactors currently in operation, will place considerable demands on the regulatory body. Such dual responsibility will require careful balancing of resources and expertise to ensure both a safe expansion of nuclear power and the sustained maintenance of a high level of nuclear safety across the sector.

2.7. Planned activities and improvements

In the upcoming period until preparation of the next national report, there are a number of activities already ongoing and planned that will be of importance for further work to ensure that nuclear and radiation safety are properly maintained. The most relevant activities are as follows:

- Continuation of ongoing work on preparations to review an application for new nuclear power facilities (see section 2.1, Challenge 2).
- Work connected to the proposed amendments to, or updates of, the Act on Nuclear Activities (see section 7.1.2).
- Continuation of work related to the major overhaul of SSM's Code of Statutes, SSMFS, where the remaining parts (level 3 regulations for all nuclear facilities and level 2 regulations for nuclear facilities other than nuclear power plant) are expected to be completed and enter into force in 2026. During 2025, minor updates will be made to the present regulations (level 2 regulations) with regard to some new reactor technologies that can be expected in applications for new builds (see section 7.2.2).
- Preparations for the IRRS follow-up mission, scheduled for 2027 (see section 8.6 and 8.12).
- Based on current work with quantifying the sector's need for competence and education, and in collaboration with stakeholders, to propose any necessary further measures to strengthen the overall competence supply system in the country (see section 8.10.2).
- For Oskarshamn 3, a follow-up SALTO is tentatively planned for 2026, while for Forsmark NPP the issues raised from the SALTO reviews will be followed up by IAEA in 2027 (see section 9.2.3.2).
- Continuation of ongoing work on radiological acceptance criteria regarding exposure of the public to ionising radiation from new nuclear power reactors (see section 16.2.2).
- Continuation of ongoing work regarding building up civil defence capabilities in view of security-related developments around Sweden. This includes 10 emergency service sectors, covering over 60 authorities, i.e. authorities with special significance for public emergency preparedness and total defence (see section 16.2).

- During 2025 and 2026, the gamma monitoring network will be upgraded with new spectroscopic stations (see section 16.2.3).
- SSM aims to improve the understanding and knowledge of issues that need to be resolved to ensure safe LTO of NPPs beyond 60 years of operation.

2.8. Major common issues

At the previous review meeting, several major common issues were identified. Table 2 indicates where they are addressed in this report.

Table 2. Reporting on Major Common Issues.

Major common issue	Section
Contracting Parties are encouraged to develop and maintain strategies, approaches and contingency plans in managing extraordinary circumstances, such as Covid-19 pandemic, extreme natural disasters, armed conflicts, etc.	16.1.2 16.2 16.6.3
Contracting Parties should establish durable capacity building programmes to align regulatory capabilities with future needs.	8.5 8.10.2
Contracting Parties are encouraged to foster international collaboration and, as appropriate, to participate in different types of collaborative schemes for the review of SMR designs.	1.2.2
Contracting Parties are encouraged to invite on regular basis IAEA peer review missions, including follow-up missions to confirm the status and timely implementation of peer review findings.	8.12 14.2.6
Contracting Parties are encouraged to address possible impact of climate change on nuclear installations, in particular those related to the increased frequency and intensity of extreme weather conditions.	17.2.1.4 17.2.1.5 17.2.1.6 17.2.1.10 18.2.1.2 18.2.1.3
Contracting Parties are encouraged to share experience in securing supply chains and exchange information on practices in addressing NCFSI.	13.1.1.2 13.2.3
Contracting Parties are encouraged to exchange experiences on the implementation of their aging management strategies and effectiveness of ageing management practices from design to decommissioning, with a special focus on newly identified ageing processes on specific SSCs, when applicable.	14.2.6
Contracting Parties are encouraged to strengthen diligent cross border cooperation, including participation in joint emergency exercises, and to foster cooperation between experts in nuclear and radiation safety in relation to emergency response.	16.6

3. Compliance with Articles 4–19 of the Convention



Part I

General Provisions

Article 4. Implementing measures

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

The legislative, regulatory and other measures to fulfil the obligations of the Convention in Sweden are accounted for in this report.

Article 5. Reporting

Each Contracting Party shall submit for review, prior to each meeting referred to in Article 20, a report on the measures it has taken to implement each of the obligations of this Convention.

The present report constitutes Sweden's tenth report issued in compliance with Article 5 of the Convention.

In the reporting for Articles 6–19, the present report describes and accounts for Sweden's compliance with the obligations of the Convention's Articles. Articles 6–8 are structured to enable reporting in a clear and reviewable manner. Articles 9–19 have a similar basic structure, where information is provided about the regulatory requirements relating to the corresponding Article and measures taken by the licence holders to comply with the regulatory requirements. These accounts also include information about the licensees' own safety initiatives as well as about regulatory control.

Article 6. Existing nuclear installations

Each Contracting Party shall take the appropriate steps to ensure that the safety of nuclear installations existing at the time the Convention enters into force for that Contracting Party is reviewed as soon as possible. When necessary in the context of this Convention, the Contracting Party shall ensure that all reasonable practicable improvements are made as a matter of urgency to upgrade the safety of the nuclear installation. If such upgrading cannot be achieved, plans should be implemented to shut down the nuclear installation as soon as practically possible. The timing of the shut-down may take into account the whole energy context and possible alternatives as well as the social, environmental and economic impact.

Under this article, Sweden provides information about significant events that have occurred at the NPPs during the reporting period, as well as conclusions drawn from these events. Furthermore, information is provided about performed and planned measures for safety upgrades and power uprates of the reactors. Basic information about the design of the reactors and about modernisation and key safety upgrades that have been implemented is provided in section 18.2 and Appendix 1. Further details on specific measures may be found in the previous national report to the CNS.

Summary statement for the article

Sweden complies with the obligations of Article 6.

Summary of significant changes and developments since the previous report

Forsmark 1 obtained permission for trial operation at a new increased power level in 2023 (see section 6.3).

6.1. Significant events since the previous national report

During the current reporting period, no events occurred indicating a serious degradation of safety and radiation protection at Swedish NPPs. An overview of the most relevant events during the period is provided below.

Pressuriser heaters energised during outage at Ringhals 4

On 29 August 2022, during a logical test of signals for safety injection, two banks of backup heaters in the pressuriser were energised in dry state resulting in severe damage to the heater elements. The reactor was in outage with no operability requirements on the pressuriser. The event caused an extended outage to a total of 215 days. The water inventory was low in the primary system and consequently the pressuriser had no water inventory. The unintentional activation of the heaters was caused by faulty configuration in the power supply system during preparation for a logic test in the pressuriser. The event caused major damages to the heaters, and also minor damage to the inner surface of the pressuriser. Contributing factors were found to be unclear working procedures and communication, as well as lack of questioning attitude.

The event was rated as INES-1.

Two scrams at Forsmark 1 and 2 after faulty coupling in switchgear in the national grid

On 26 April 2023, a short-circuit occurred in a switchyard more than 100 km from Forsmark NPP. The short-circuit resulted in a voltage drop in the 400 kV power line for approx. 7 sec. The power failure had a major impact on the infrastructure in the Stockholm area; metro, traffic signals, TV, radio etc. were affected. The 400 kV unit breakers tripped on Forsmark 1 and 2 after approx. 1 sec. and the reactors entered house load mode which failed after a few seconds. Both reactors scrammed. The Nordic electricity distribution system is designed to withstand an instant power loss of 1,400 MW (power from the largest NPP, Oskarshamn 3). On this occasion, the instant power loss was 2,150 MW. A fortunate set of circumstances ensured that the event did not cause a major blackout, as the inertia (stored rotational energy) in the power distribution system was high and the transmission lines had significant free capacity.

At Forsmark 1 and 2, the voltage regulators acted to compensate during the prolonged voltage drop. When the unit breaker opened, it overcompensated the voltage and an overvoltage situation occurred in the internal bus bars. The voltage surge caused an overcurrent that tripped the inverters for the energy storage system that shall make sure the circulation pumps roll out with delay in order to protect the fuel from a transient. Consequently, the pumps stopped immediately but follow-up analyses showed that limits for fuel integrity had not been exceeded. In 2024, Forsmark 1 and 2 modified the electrical protection system in order to keep the plant in house load mode following similar events.

Open passenger lock at Ringhals 3

On 25 June 2022, during startup after outage, while Ringhals 3 was in operating mode 4, open doors to the containment were found. The open passenger lock was discovered approx. two hours after entering operating mode 4. Personnel were sent to close and lock the doors when the situation was discovered. The event led to the consequence that a barrier in the facility's defence in depth had been open during an operating mode where it is not permitted.

The event was rated as INES-1.

Use of incorrect fuses for cooling fans for emergency diesel generators (EDG) at Ringhals 3 and 4

During EDG tests at Ringhals 4 on 3 September 2024, all EDGs started as expected and revved up to idle operation. Operators observed that it was hot in one of the EDG rooms, 40°C and rising, and that none of the room cooler fans were operating. The EDG was declared not operational as the room cooling support function was not working.

Fuses for room coolers connected to all EDGs at Ringhals 3 and 4 were found to be undersized, based on the starting currents that can occur in case of high temperatures requiring simultaneous starting of both fan packages of the room coolers. The incorrect fuses were installed in a plant modification 2017. All affected fuses have subsequently been replaced. The risk of Common Cause Failure (CCF) on all EDGs was present.

The event was rated as INES-1.

Emergency diesel generators (EDG) do not fulfil requirements regarding extreme weather conditions at Forsmark 1 and 2

On 28 November 2023, the weather conditions were harsh with heavy snowfall and strong winds, including gusts of wind of around 30 m/s (extreme winds in the Safety Analysis Report (SAR) are defined as being 80 m/s) and a temperature around -1°C. During the annual long term test of an EDG at Forsmark 1, a ground fault without safety impact occurred. Snow and water was found on the EDGs and other equipment in the diesel building. A decision was made to interrupt the long term test due to the conditions inside the building.

The snow inside the building was identified as coming through an open ventilation damper that did not close properly. This led to strong wind entering the EDG room and also a lower temperature, making it possible for the snow to be transported all the way to the EDG. The investigation revealed more weaknesses in the ventilation dampers, but not of the same nature and therefore not regarded as a CCF. Weakness were found in all the EDG rooms at Forsmark 1, and in one EDG room at Forsmark 2.

Examination of enclosures revealed that all speed controllers were equipped with connectors of the wrong enclosure class. This meant that water could ingress to the specific electrical equipment of the EDG. The same equipment is installed at Forsmark 2. Consequently, all connectors to speed controllers at Forsmark 1 and 2 did not fulfil requirements regarding enclosure class. All 8 EDGs were affected.

The weaknesses in measures to keep the EDG room free from snow and the fact that all connectors to the speed controllers were equipped with the wrong ingress protection rating makes it a two barriers failure and a weak design to withstand extreme snowfall and strong winds. Assuming extreme weather, the risk of CCF on EDG was present. However, since two diesels are located on one side, and two on the other side of the reactor building, it was not likely that more than two would be affected at the same time. Actions were implemented immediately to mitigate the risk of CCF.

Design conditions not met for extreme weather conditions at Ringhals 3 and 4

On 5 February 2024, all mesh grilles at the air intakes for all EDGs at Ringhals 3 and 4 were checked after analysis findings raising question marks regarding the capacity to withstand extreme weather conditions including ice storm or extreme hoar frost.

The air intakes of the diesel generators at Ringhals 3 and 4 are fitted with mesh grilles that are intended to prevent larger extraneous materials from entering the air intakes and air filters of the diesel generators.

During ice storms there is a risk of ice building up on the mesh grille which can lead to blockage of the air intake. The grilles are therefore designed to open at high differential pressure. For two out of four EDGs at Ringhals 3 and at four out of four EDGs at Ringhals 4, the lower hinge was found to be rusted, requiring a greater force to open the grilles than that described in the design assumptions. This could have led to the air intakes being blocked. All grilles have been lubricated and verified ready for operation.

The risk of CCF on the EDGs was present if an extreme weather condition should occur and the incident reveals a deficiency of a common cause nature.

6.2. Safety improvements of nuclear power reactors

A basic overview of plant modifications performed in the past is presented in Appendix 1. Further details on specific measures may be found in the previous national report to the CNS (Ds 2022:19).

The nuclear safety strategy in Sweden is to apply continuous improvements based on regular and systematic re-assessments, aiming at ensuring compliance with modern requirements and current design basis. The strategy also includes identification of further safety improvements by taking into account ageing issues, operational experience, most recent research and development and developments in international standards.

During the year 2018, SSM sent a regulatory injunction to the licensees of all Swedish BWRs regarding verification of the capacity to withstand loads from steam explosions inside the containment during a severe accident. The licensees sent a response that was reviewed by SSM. The review showed that it was not verified that containment air locks for personnel entrance and equipment transport locks had the required capacity. As a consequence, SSM demanded in 2022 that the licensees should develop an action plan to ensure that those air locks would fulfil the requirements. New analyses showed that the personal air locks could be verified to fulfil the requirements, but that the transport air locks needed to be strengthened. The licensees implemented the needed corrective actions in 2024 and 2025.

6.3. Status of the nuclear power reactors

Operating licences, which are issued by the Government, stipulate the highest allowed thermal power level. To further increase the power level, the licensee must apply to the Government for a new licence in accordance with the Act on Nuclear Activities (1984:3).

The power uprate programmes in Sweden have included major power uprates of seven reactors, and a minor power uprate of one reactor. Several Swedish reactors were uprated in the 1980s, with additional power uprates having been implemented over the past twelve years. The levels of these power uprates for those reactors currently in operation are illustrated in figure 3 below.

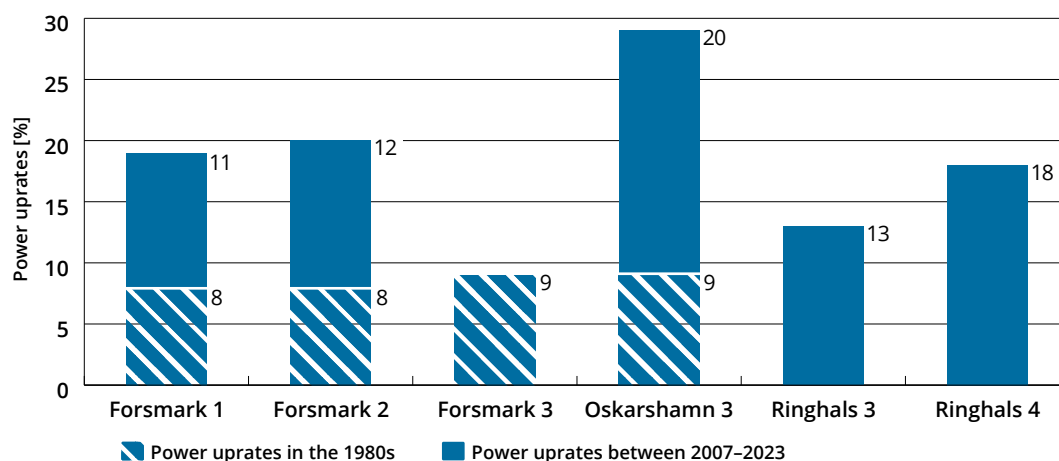


Figure 3. Power uprate levels of Swedish reactors in operation.

Depending on the magnitude of the power uprate, a power increase can affect the facility in a number of different ways and to varying degrees. Conditions and parameters that might affect safety must therefore be identified and analysed in order to show that the safety requirements are met. A number of components and systems in the NPP must be verified as having a capacity corresponding to the higher power level. Consequently, planning as well as reviewing a power uprate are key aspects requiring special attention for the purpose of ensuring that there is no impact on plant safety.

In its regulatory review of a power uprate application, SSM checks that the licensee is in compliance with all applicable safety requirements. In this sense, an application for a power uprate comprises an opportunity to revise and verify the entire safety case. The licensing process in Sweden is described in section 7.3.

Since the previous report, Forsmark 1 obtained permission for trial operation at a new increased power level in 2023.

6.4. Vienna Declaration on Nuclear Safety (VDNS)

The nuclear safety strategy in Sweden is to apply continuous improvements based on regular and systematic re-assessments, aiming at ensuring compliance with modern requirements and current design basis. The strategy also includes identification of further safety improvements by taking into account ageing issues, operational experience, most recent research and development and developments in international standards, incl. the principles defined in the VDNS.

Since the introduction of nuclear power in Sweden, extensive safety modifications and modernisation programs have been introduced at all NPPs in operation. Measures to improve safety include, among other things, the introduction of severe accident management systems (including Filtered Containment Venting System, FCVS) in response to the accident in Three Mile Island in 1979, as well as the most recent completion of the ICCS (see Appendix 1).

Part II

Legislation and regulation



Article 7. Legislative and regulatory framework

1. Each Contracting Party shall establish and maintain legislative and regulatory framework to govern the safety of nuclear installations.
2. The legislative and regulatory framework shall provide for:
 - (i) the establishment of applicable national safety requirements and regulations;
 - (ii) a system of licensing with regard to nuclear installations and the prohibition of the operation of a nuclear installation without a licence;
 - (iii) a system of regulatory inspection and assessment of nuclear installations to ascertain compliance with applicable regulations and the terms of licences;
 - (iv) the enforcement of applicable regulations and the terms of licences, including suspension, modification or revocation.

Summary statement for the article

Sweden complies with the obligations of Article 7.

Summary of significant changes and developments since the previous report

- On 1 March 2022, the second part of SSM's new Code of Statutes, SSMFS – covering design (SSMFS 2021:4), assessment (SSMFS 2021:5) and operation (SSMFS 2021:6) of NPPs, as well as radioactive waste management (SSMFS 2021:7) – entered into force (see section 7.2.2).
- On 15 January 2025, an inquiry chair appointed by the Government to assess licensing procedures for new nuclear facilities presented proposals regarding changes in the Act on Nuclear Activities and the Environmental Code, as well as a new Law on Decision in Principle. This proposal has been submitted for a consultation procedure involving authorities, municipalities, licensees and other stakeholders (see section 7.1.2 and 7.3.2).

7.1. Swedish legislative framework

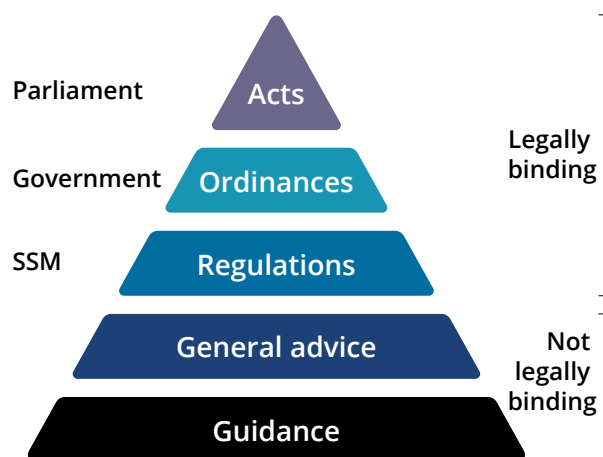


Figure 4. Hierarchy of Swedish legislation and the regulatory framework.

In the Swedish system the Parliament decides on acts, the Government on ordinances and SSM on more detailed regulations and guides, see figure 4. Acts, ordinances and SSM's regulations are legally binding. General advice is not legally binding per se, but cannot be ignored by the licensee without risking actions being taken by the regulatory body. The general advice belonging to a regulation can be seen as a strong recommendation. Measures should be taken according to the general advice or, alternatively, methods that are deemed as justified, and equivalent from a safety point of view, should be implemented. Guidance is provided to support understanding of the implications of the regulations, with descriptions of the background, explanations and examples of application. Guidance is not binding.

7.1.1. Basic nuclear safety and radiation protection legislation

The following five enactments constitute the primary nuclear safety and radiation protection legislation in Sweden:

- The Act on Nuclear Activities (1984:3),
- The Radiation Protection Act (2018:396),
- The Environmental Code,
- The Act on the Financing of Residual Products from Nuclear Activities (2006:647), and
- The Act on Liability and Compensation for Radiological Accidents (2010:950).

All acts and the Environmental Code are supplemented by a number of ordinances and other secondary legislation that contain more detailed provisions for particular aspects of the primary legal requirements.

Operation of a nuclear facility may only be conducted in accordance with a licence issued under the Act on Nuclear Activities, as well as with a licence issued under the Environmental Code. The Act on Nuclear Activities mainly concerns issues of nuclear safety and security, while the Environmental Code regulates general aspects related to the possible impacts of all “environmentally hazardous activities”, including nuclear activities.

The objective of the Radiation Protection Act is to protect people and the environment (including flora and fauna) from harmful effects of radiation. The Act applies to radiation protection in general and, in this context, includes provisions relating to the protection of workers, radioactive waste management, and the protection of the general public and the environment.

The Act on the Financing of Residual Products from Nuclear Activities contains provisions concerning the future costs of spent fuel disposal, decommissioning of nuclear facilities, and research and development in the field of nuclear waste management. Financial means for these purposes are secured by fees paid by licensees into the national Nuclear Waste Fund.

The Act on Liability and Compensation for Radiological Accidents implements Sweden's obligations as a party to the 1960 Paris Convention on Third Party Liability in the Field of Nuclear Energy, and the 1963 Brussels Convention Supplementary to the Paris Convention.

Other relevant items of primary legislation are the Act on Control of Export of Dual-Use Products and Technical Assistance (2000:1064) and the Act on Inspections According to International Agreements on Non-proliferation of Nuclear Weapons (2000:140). Emergency preparedness matters are regulated by the Civil Protection Act (2003:778) and related Ordinance (2003:789).

7.1.2. The Act and Ordinance on Nuclear Activities

The Act on Nuclear Activities is the primary law regulating nuclear safety in Sweden. It contains basic provisions concerning safety in connection with nuclear activities, and applies to the operation of NPPs and other nuclear facilities, as well as to the handling of nuclear material and nuclear waste.

The Act does not contain provisions concerning radiation protection or general provisions on environmental protection. These areas are regulated by the Radiation Protection Act (see section 7.1.3) and the Environmental Code (see section 7.1.4). As far as nuclear activities are concerned, the Radiation Protection Act, the Environmental Code and the Act on Nuclear Activities are applied in parallel and in close association with each other.

In the Act on Nuclear Activities, nuclear activities are defined as:

- The construction, possession and operation of a nuclear installation,
- Acquisition, possession, transfer, handling, processing, transport or other dealings with nuclear substances and nuclear waste,
- Import of nuclear substances and nuclear waste,
- Export of nuclear waste.

The Act on Nuclear Activities contains:

- Basic requirements for nuclear safety, including nuclear security and measures to be taken to prevent unlawful dealings with nuclear material or nuclear waste.
- Licensing obligation, licensing requirements, mandate to decide on licence conditions and conditions for revocation of licences.
- Provisions on subsidiary responsibility of the state for nuclear activities and ultimate responsibility of the state for nuclear waste.
- General obligations of the licensees, including requirements for measures to maintain and improve safety, to perform periodic safety reviews (PSR), to decommission and dismantle facilities, and to safely handle and dispose of nuclear waste.
- Provisions on supervision and mandates of the regulatory authority.
- Provisions on public transparency.
- Provisions on responsibilities and sanctions.

The Ordinance on Nuclear Activities (1984:14) contains more detailed provisions on matters including definitions, applications for licences, reviews, evaluations and inspections. The Ordinance also specifies that the regulatory authority is authorised to impose licence conditions and to issue general regulations concerning measures to maintain the safety of nuclear activities.

On 1 April 2019, an inquiry chair delivered a report (SOU 2019:16) to the Swedish Government. In this report, it is proposed that the present Act on Nuclear Activities should be repealed and replaced by a new act having a new structure. Most of the substance of the present provisions is transferred to the proposed new act, albeit occasionally using revised wording. Some of the provisions are suggested to be modified and others removed. A small number of entirely new provisions are also added to the proposed legislation. The report was the subject of broad consultation with government agencies, municipal authorities, licensees and other stakeholders. Certain proposals in the report regarding subsidiary responsibility and ultimate responsibility of the state were implemented through amendments to the current act in 2020. The remainder of the proposals are still being handled within the Government Offices.

On 15 January 2025, another inquiry chair delivered a further report (SOU 2025:7) to the Swedish Government. In this report, changes to the Act on Nuclear Activities are proposed, with the objective of making the licensing process more efficient and effective. A summary of these proposals is presented below:

Voluntary steps to facilitate a complete application are introduced

The inquiry proposes that the Act on Nuclear Activities is being supplemented by the introduction of two voluntary elements preceding the application for a licence to construct a new nuclear facility. The first element concerns a clarified and formalised opportunity for early engagement between the party intending to apply for a licence for a nuclear facility and SSM. The second element concerns the possibility for a potential applicant or supplier or other manufacturer to request an advance ruling from SSM before submitting an application for a licence for a new nuclear facility, in order to obtain an assessment of whether the conditions exist to meet the requirements on nuclear safety and security, radiation protection and safeguards.

SSM becomes the decision-making body for licences

The inquiry proposes that the instance hierarchy under the Act on Nuclear Activities will be changed so that SSM is mandated to authorise licences for nuclear activities. The Authority will be given the opportunity to raise issues of principle or of particular importance to the Government for consideration. Both licence and supervisory decisions issued by SSM under the Act on Nuclear Activities shall be appealed to the Administrative Court instead of to the Government.

A formal stepwise licensing process is introduced

The inquiry proposes that a stepwise process for the licensing of nuclear operations or facilities are to be introduced in the Act on Nuclear Activities. Up until now, the stepwise licensing process has had its legal basis in conditions stipulated by the Government in the licence decision. It is also proposed that the special approval required for the applicant to start construction of a nuclear facility is removed, which means that construction may start as soon as all necessary licences are in place.

Other adjustments in order to make the licensing more efficient and clear

The inquiry proposes that the licensing process under the Act on Nuclear Activities no longer needs to be coordinated with the licensing process under the Environmental Code. By removing references in the same Act to the Environmental Code being applied in licensing matters, the licensing assessment under the Act on Nuclear Activities is clarified to relate only to issues of nuclear safety and security, radiation protection and safeguards.

A single licence for the construction, possession and operation of a nuclear facility is advocated. This enables adaptation to future ownership and operation models where the applicant's ability and conditions for assuming the statutory responsibility for nuclear safety and security, radiation protection and safeguards do not need to be assessed in their entirety and simultaneously at an initial stage of the licensing process. Provisions on the transfer of licences are introduced by an explicit provision in the Act on Nuclear Activities. Transfer can take place after a customary assessment of whether the party to whom the licence is to be transferred is deemed to have the prerequisites to conduct the activity in accordance with the applicable regulations.

The Act on Nuclear Activities is clarified to make it clear that in order to fulfil statutory obligations, the licensee does not have to be able to fulfil all requirements within its own organisation. The clarification reflects a practice that has developed, and which means that a licensee may, to a certain extent, use temporary staff.

The inquiry proposes that a facility that has been released in accordance with the requirements of the Radiation Protection Act ceases to be classified as nuclear facility.

7.1.3. The Radiation Protection Act and Ordinance

Legal requirements relating to radiation protection are set out in the Radiation Protection Act and Radiation Protection Ordinance. The purpose of the legislation is to protect people and the environment against harmful effects of radiation.

The Act applies to all activities involving radiation. These are defined as including all activities involving radioactive substances or 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 product and NORM). As far as nuclear installations are concerned, this Act and the Act on Nuclear Activities are applied in parallel.

The Radiation Protection Act contains:

- Basic provisions on protection against ionising radiation, including issues of justification, optimisation, dose limits, waste, releases and environmental protection.
- Obligations for licensees, regulating areas such as precautionary measures, knowledge management, and financial, administrative and human resources.
- Prohibition on employing anyone below 18 years of age.
- Provisions on medical examinations, notification of pregnancy and breastfeeding.
- Provisions on providing information concerning tasks in radiological emergency situations and voluntary work for their implementation, in addition to surveillance and protective devices.
- Provisions relating to radioactive waste management, and measures for clearance of building structures and areas.
- Licensing obligation, licensing requirements, mandate to decide on licence conditions and conditions for revocation of licenses.
- Provisions on supervision and mandates of the regulatory authority.
- Provisions on responsibilities and sanctions.

The Radiation Protection Ordinance (2018:506) contains detailed information on dose limits for ionising radiation activities. The Ordinance also contains detailed provisions pursuant to authorisation under the Radiation Protection Act. It 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 regulatory authority may also issue regulations stipulating that certain provisions in the Act do not apply to very low-level radioactive materials and technical equipment emitting only low-level radiation (exemption).

7.1.4. The Environmental Code

The objective of the 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 scope of the Code includes nuclear activities and activities involving radiation and must be applied in parallel with the Act on Nuclear Activities and the Radiation Protection Act.

In the inquiry report of January 2025 (SOU 2025:7), mentioned in section 7.1.2, it is proposed that the Environmental Code should only address issues that are not covered by the licensing process under the Act on Nuclear Activities, thus eliminating the need for a mandatory parallel licensing process.

The Code is supplemented by a number of ordinances. These are laid down by the Swedish Government.

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 water areas 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, water areas 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.

The Environmental Code contains general rules of consideration. These relate to several important principles that must be complied with by a licensee, e.g:

- The knowledge principle means that the implementer must possess the knowledge regarding the nature and scope of the activity that is necessary to protect human health and the environment against damage or detriment.
- The precautionary and BAT (Best Available Technique) 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. To the same end, the best possible technology shall be used to protect against damage or detriment in connection with the activities.
- The most suitable site principle means that the chosen site for an activity involving the use of land or water shall be selected so as to make it possible to achieve the objective of the activity with a minimum of damage or detriment to human health and the environment.
- The remediation liability principle means that an actor that has pursued an activity that causes damage or is detrimental to the environment shall be responsible, to the extent it can be considered reasonable, for necessary remedial actions or for providing appropriate compensation.

The general rules of consideration function as a preventive tool and follow the principle that the economic risks of environmental impact should be borne by the polluter and not by the environment.

According to the Environmental Code, a permit is required for environmentally hazardous activities. The Government has in the Environmental Assessment Ordinance (2013:251) stipulated that facilities for the treatment, storage or disposal of spent fuel, nuclear waste or radioactive waste are among those that need a permit. A permit is also needed for the decommissioning of nuclear reactors. The Land and Environment Court is the court of first instance for the hearing of cases concerning such activities. However, a prerequisite for environmental permitting in relation to certain activities, including facilities that are subject to government licensing under the Act on Nuclear Activities, is that the Government must first determine the permissibility of the activity. The system for licensing is further described in section 7.3.

7.1.5. The principle of Public access (Open government)

To guarantee transparency, the principles of public access to official documents are enshrined in one of the fundamental laws, Chapters 2 and 3 of the Freedom of the Press Act.

“To encourage the free exchange of opinion and availability of comprehensive information, every Swedish citizen shall be entitled to have free access to official documents.”
(Chapter 2, Article 1, Freedom of the Press Act)

The principle of public access entitles the general public to access official documents submitted to or drawn up by the authorities. Anyone may avail himself/herself of this possibility whenever they wish. Documents that are received or sent out by the Government Offices and other government agencies, e.g. letters, decisions and inquiries, usually constitute official documents. As a general rule, all incoming documents should be registered by the receiving authority. Notes and draft decisions are not normally classified as official documents.

If a member of the public wants to know what documents are held by a government agency or wants to get hold of them, this person should contact the agency in question.

The principle of public access also means that officials and others working for central government, municipalities and county councils have freedom of communication. This means that, with some exceptions, they have the right to tell the media about matters that would otherwise be secret without punishment and without the employer discovering who provided the information.

7.2. Swedish nuclear safety and radiation protection regulations

7.2.1. SSM's nuclear safety and radiation protection regulations

In keeping with its legal mandate, SSM issues legally binding safety and radiation protection regulations for nuclear facilities in its Code of Statutes, SSMFS. General advice provides recommendations relating to the implementation of the regulations, while guidance is intended to support understanding regarding the meaning and purpose of the regulations, including explanations and examples of application. See also figure 4 in the introduction to section 7.1.

SSM's regulations also implement binding EU legislation and international obligations. In preparing SSM's regulations, consideration is given to IAEA safety standards, WENRA Safety Reference Levels (SRL) and other WENRA reports as well as other relevant international recommendations. SSM's regulations are issued in accordance with an established management procedure, which stipulates technical and legal reviews of draft versions. In accordance with governmental rules, consultation with government authorities, licensees and various other interested parties is required before new regulations are issued.

SSM's Code of Statutes (SSMFS) currently (February 2025) contains 19 parts regarding nuclear safety, nuclear security and radiation protection.

7.2.2. Major revision of the Code of Statutes, SSMFS

SSM is currently revising its Code of Statutes relating to nuclear activities and radiation protection. Revision is being carried out because experience has demonstrated a need to clarify and broaden the regulations in order to create more predictability for licensees and to improve the regulatory support. Another reason for this revision is the IRRS mission report to Sweden in spring 2012, which concluded that Swedish regulations for nuclear facilities had, historically, emerged as the identified need for regulation arose. This meant that, while IAEA's safety standards were being used as a basis for the Swedish nuclear safety rules, or were referenced therein, this was not done in a systematic way. The IRRS mission report therefore recommended that SSM review and revise its regulatory framework to make it clearer, more consistent and comprehensive. Moreover, the Swedish Government has, through appropriation directions, ordered SSM in 2012 and 2013 to review its regulations concerning nuclear power reactors, to ensure that appropriate requirements were in place for potential new NPPs, taking into account the experiences of events and accidents that have occurred as well as new international safety standards.

Against this background, a major and thorough review of the Code of Statutes, SSMFS, began in late 2013. In the early stage of the work, a decision in principle was taken stating that the aspects of radiation protection and nuclear safety and security, to a greater extent than previously, should be regulated in an integrated manner according to the contexts in which these aspects are relevant, and not in separate regulations. See also figure 5. The objectives of the revision are to establish an improved and more transparent and consistent set of requirements, give a more logical structure, and to improve the preconditions for more integrated regulatory supervision.

Traditional way of regulating in Sweden				
	Nuclear safety	Radiation protection	Nuclear security	Non-proliferation control
New integrated regulation	X	X	X	X
Design and construction	X	X	X	X
Analysis and assessment	X	X	X	X
Operation	X	X	X	X
Decommissioning	X	X	X	X

Figure 5. Different approaches to regulation of various aspects.

The new structure that was decided provides for regulation of nuclear safety and radiation protection at nuclear facilities for different phases of a facility's lifetime and for different main types of substantive issues. Moreover, the overall organisation of the regulation is formulated according to three levels, namely:

1. The first level represents requirements that are applicable to all licensed activities involving ionising radiation;
2. The second level addresses facility/activity-specific requirements; and
3. The third level consists of more detailed requirements applying to specific topics within nuclear safety and radiation protection.

This structure is also illustrated schematically in figure 6 below.

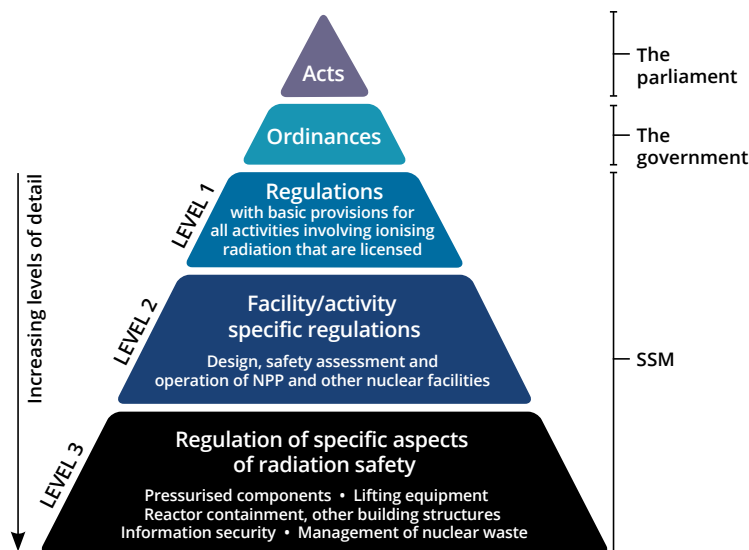


Figure 6. Schematic illustration of the structure of Swedish regulations.

Considering the relatively large change to the structure and content as well as to the regulatory approach that these new regulations were expected to introduce in relation to the existing situation, it was obvious that extensive interaction with concerned parties would be needed before new regulations could be issued. SSM therefore decided to apply a multi-step process during the development process. Hence, all the proposed regulations and associated general advice produced as part of this project are subject to several steps of review and consultation:

1. An initial internal consultation procedure within SSM;
2. A preliminary consultation procedure with relevant licensees;
3. A second internal consultation procedure within SSM in parallel with a second preliminary consultation procedure with relevant licensees. At this stage SSM also requests input to the associated regulatory impact assessments, from concerned licensees; and
4. A formal external consultation procedure with relevant licensees, in addition to a number of Swedish public authorities and other organisations, including Non-Governmental Organisations (NGOs). In addition, the proposals are published as draft documents on SSM's website to enable interested parties in the public to submit their comments. This final step in the consultation procedure includes a report on the impact of the new regulations on the facilities and activities in question.

The first parts of the new Code of Statutes, establishing basic requirements for all licensed activities with ionising radiation (SSMFS 2018:1) (level 1 regulations), entered into force in June 2018. Key regulations applying to design (SSMFS 2021:4), assessment (SSMFS 2021:5) and operation (SSMFS 2021:6) of NPPs (level 2 regulations), together with radioactive waste management (SSMFS 2021:7) (level 3 regulations), entered into force on 1 March 2022. Remaining parts of the new Code of Statutes (level 3 regulations applicable to all nuclear facilities and level 2 regulations for nuclear facilities other than NPPs) are expected to be completed and enter into force in 2026. As part of this process, still valid older regulations with detailed regulations on some mechanical equipment (SSMFS 2018:13) (level 3 regulations) will be replaced. During 2025, minor updates will be made to the present regulations (level 2 regulations) for NPPs, in order to accommodate certain new reactor technologies that can be expected in applications for new builds.

7.3. System of licensing

Licensing of nuclear activities is governed by several acts having different purposes. This also involves a number of different authorities. A general permissibility consideration has to be made as to whether or not to grant permission for an activity. Furthermore, a nuclear activity must be approved in accordance with aspects of nuclear safety and radiation protection to ensure the protection of human health and the environment. Lastly, licensing conditions are issued under the various acts by the responsible licensing authorities.

New nuclear facilities and major modifications of existing facilities that are subject to authorisation must be considered under both the Act on Nuclear Activities and the Environmental Code. As stipulated by the procedure for applications, a licence application must be submitted to SSM, which processes the matter under the Act on Nuclear Activities, and to the Land and the Environment Court, which processes the case under the Environmental Code. Applications are to be accompanied by an Environmental Impact Assessment (EIA), developed in accordance with the provisions of Chapter 6 of the Environmental Code. Figure 7 below is a schematic illustration of the current licensing process for construction of a new nuclear facility. The figure shows how parallel review and licensing tasks are assigned.

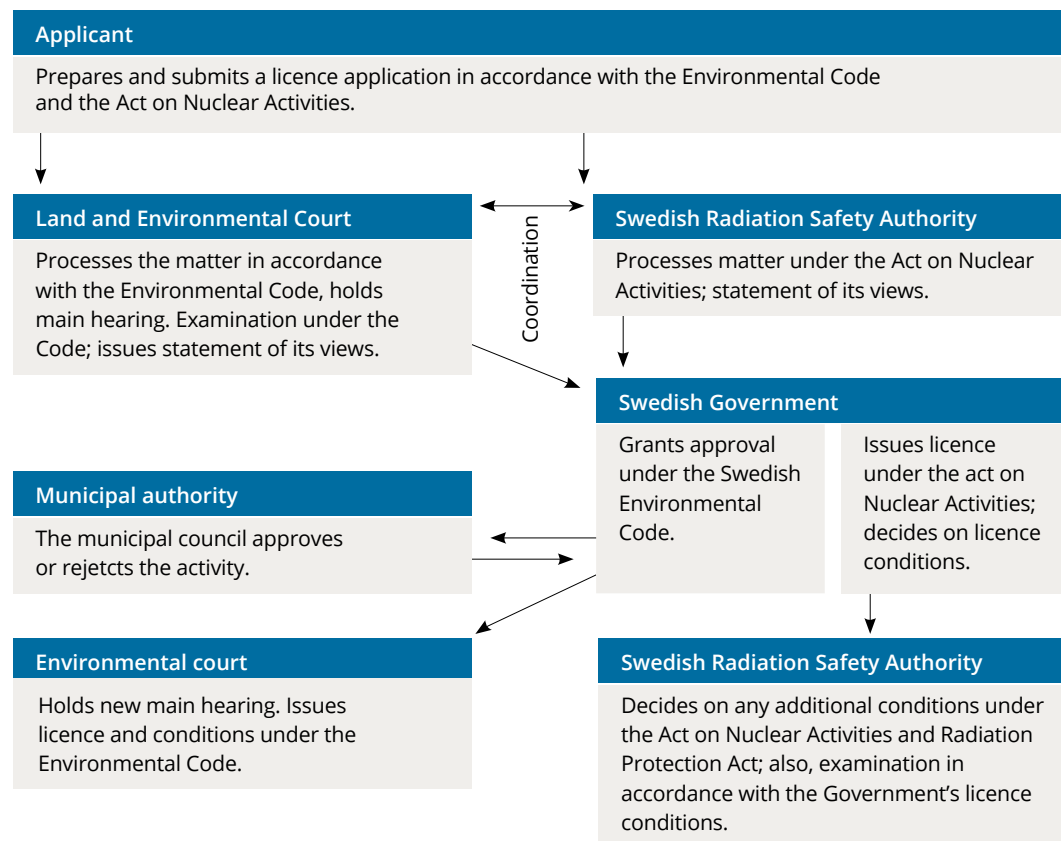


Figure 7. Schematic illustration of the licensing process for a new nuclear facility.

7.3.1. Environmental Impact Assessment (EIA) and consultation with other countries

During the licensing process, an important instrument is the EIA. Swedish EIA legislation is in accordance with Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011, amended by Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014, 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 permission to conduct environmentally hazardous activities. An EIA must also be submitted in support of a licence application for the decommissioning of nuclear facilities.

If an activity is likely to have a significant environmental impact in another country, the authority responsible, as designated by the Government, must inform the authority responsible in the possibly affected country about the planned activity. This requirement is intended to give the country concerned and the citizens who are affected the opportunity to take part in a consultation procedure concerning the application and the environmental impact assessment. Another requirement is providing this kind of information when so requested by another country that is likely to be exposed to a significant environmental impact.

7.3.2. Permissibility, licensing approval and step-wise review process

According to the Environmental Code, as a step of the licensing process, the Government is to consider the permissibility of certain activities, such as represented by facilities for nuclear activities under the Act on Nuclear Activities. An environmental impact statement must be submitted for the permissibility assessment. The Land and Environment Court reviews an application for permissibility, which is thereafter forwarded to the Government for final consideration. The Government may decide on the permissibility only if the municipal council concerned agrees that the planned activities may be sited in the municipality (municipal veto).

In the inquiry report from January 2025 (SOU 2025:7), mentioned in section 7.1.2, a new law on Decision in Principle is proposed, with the aim that the Government takes a position at an early stage on whether it is compatible with the overall interests of society to construct and operate a nuclear facility at a specific site. The municipal council in the municipality where the activity is to be located must approve the application in order for the Government to approve a decision in principle.

If the Government assesses an activity to be permissible according to the provisions of 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.

A licence application according to the Act on Nuclear Activities is reviewed by the regulatory authority assigned by the Government (i.e. SSM) and subsequently forwarded, together with SSM's opinion, for a Government decision. A separate licence under the Radiation Protection Act is not required for activities encompassed by the Act on Nuclear Activities. Following a government permissibility decision, the Land and Environment Court grants a possible licence and issues conditions imposed on environmentally hazardous activities under the Environmental Code. The Land and Environment 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.

The preparation and review of an application under the Environmental Code, as well as the issuing of a licence and related conditions, take place in open court hearings at the Land and Environment Court. At these hearings, all interested parties may attend and comment, including the relevant authorities. The applicant must verbally describe all relevant aspects of its case. Questions may be submitted during the proceedings.

In a case where SSM approves the application and proposes that the Government grant a licence under the Act on Nuclear Activities, SSM also proposes that the Government take a decision on licence conditions that involve a continued step-wise review process until the planned facility is taken into routine operation.

Typically, one or more of the following licence conditions will be proposed:

- The facility may not commence construction prior to approval by SSM.
- The facility may not commence trial operation (commissioning) prior to approval by SSM.
- The facility may not commence regular operation prior to approval by SSM.

Based on these licence conditions, a step-wise review process then follows, where SSM decides at each stage if the licensee is allowed to proceed to the next step. In the inquiry reports into potential legislative changes mentioned in section 7.1.2, this process involving step-wise reviews is proposed to be regulated by the Act on Nuclear Activities.

It should be noted that for all nuclear power reactors in operation in Sweden, the operating licences have been granted with an indefinite term. This means that the operation of a nuclear power reactor is allowed as long as the licensee continues to meet the requirements set by the applicable laws, government ordinances, regulation of the nuclear regulatory authority, and conditions imposed to the licence.

7.3.3. Legal provisions to prevent the operation of a nuclear installation without a valid licence

All activities involving nuclear installations require a licence. As mentioned in the introduction to section 7.3, licensing of nuclear activities is governed by several acts having different purposes, and involves a number of government authorities.

A licence to conduct nuclear activities may be revoked by the authority issuing the permit in cases where

- conditions or regulations 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 viewpoint of safety to revoke the licence; or
- there are any other very specific reasons for revocation, from the viewpoint 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 NPP is revoked, the licence holder remains responsible for waste management and decommissioning.

According to Section 18 of the Act on Nuclear Activities, the regulatory authority (SSM) may decide on the measures that are needed, including prohibitions in individual cases, to ensure compliance with the Act, or with regulations issued or conditions established under the Act.

Furthermore, according to Section 25 of the Act on Nuclear Activities, anyone without permission who intentionally or negligently is engaged in nuclear activities shall receive a fine or imprisonment not exceeding two years.

7.4. EU legislation

7.4.1. The European Nuclear Safety Directive

On 25 June 2009, Council Directive 2009/71/Euratom was adopted establishing a Community framework for the nuclear safety of nuclear installations in the Member States. On 8 July 2014, an amended Nuclear Safety Directive was adopted by the Council, the Council Directive 2014/87/Euratom of 8 July 2014.

The amended directive introduces nuclear safety objectives comparable to the nuclear safety objectives included in the Vienna Declaration on Nuclear Safety, which aims to limit the consequences of a potential nuclear accident while also addressing the safety of the entire lifecycle of nuclear installations (siting, design, construction, commissioning, operation and decommissioning of NPPs), including on-site emergency preparedness and response.

The amended directive further strengthens the role and the independence in regulatory decision-making of national regulatory authorities, and enhances transparency in nuclear safety matters. Also, the provisions on the information to be provided to the general public are now more specific. As the consequences of a nuclear accident may cross national borders, close cooperation, coordination and information exchange between regulatory authorities of member states in the vicinity of a nuclear installation are encouraged by the amended directive. The amended directive also introduced a new concept for exchange of experiences through its provisions on topical peer reviews. Starting in 2017, these are to be performed on the nuclear installations at least every sixth year.

7.4.1.1. Implementation of the amended nuclear safety directive in the national regulatory framework

On 15 June 2017, the Swedish Parliament decided on amendments to the Act on Nuclear Activities to transpose several important provisions of the Council Directive (2014/87/Euratom) amending Directive 2009/71/Euratom establishing a Community framework for the nuclear safety of nuclear installations. The amendments to the Act on Nuclear Activities entered into force on 1 August 2017. This included Article 8a, paragraphs (a) and (b) of the directive, which correspond to safety objectives as per the Vienna Declaration on Nuclear Safety. These provisions in the Act on Nuclear Activities apply both to existing Swedish nuclear power reactors and to any new reactors that might be built.

The amendments to the Act on Nuclear Activities also clarified licensee responsibility as well as the requirements for continuous analysis and assessment of safety at facilities.

Changes to SSM regulations were also made in order to transpose those safety provisions of the Directive 2014/87/Euratom that are not regulated by the amended Act on Nuclear Activities or which, through previous readings, were not considered to be sufficient encompassed by the regulations.

7.4.2. European basic safety standards (EU BSS) for protection against the dangers arising from exposure to ionising radiation

On 5 December 2013, Council Directive 2013/59/Euratom was adopted, establishing a set of basic safety standards to protect workers, members of the public and patients against the dangers arising from ionising radiation (EU BSS). The directive also strengthens requirements for emergency preparedness and response.

The aim of the EU BSS basic safety standards is to ensure:

- Protection of workers exposed to ionising radiation, such as workers in the nuclear industry and other industrial applications, medical staff, and those working in places with indoor radon or in activities involving naturally occurring radioactive material (NORM).
- Protection of members of the public, for example from radon in buildings.
- Protection of medical patients, for example by avoiding accidents in radio-diagnosis and radiotherapy.
- More stringent regulation of emergency preparedness and response, incorporating lessons learnt from the Fukushima accident.

The directive incorporates the recommendations of the International Commission on Radiological Protection (ICRP) published in 2007, and harmonises the EU regime with the requirements of the Basic Safety Standards of the IAEA.

7.4.2.1. Implementation of basic safety standards for protection against the dangers arising from exposure to ionising radiation

The main transposition into Swedish legislation of Directive 2013/59/Euratom has been in the form of additions to the amended Radiation Protection Act (2018:396) and its appurtenant ordinance (2018:506), together with SSM's regulations (SSMFS 2018:1) on basic rules for all licensed activities involving ionising radiation, which all entered into force on 1 June 2018. In addition, five other acts as well as several ordinances and authority regulations were amended to fully transpose provisions of the Directive 2013/59/Euratom in Sweden. These amendments also entered into force on 1 June 2018.

7.5. Enforcement of applicable regulations and terms of licences

7.5.1. Powers for legal actions and enforcement measures available to the regulatory body

SSM has a strong mandate as a regulatory body. According to the Act on Nuclear Activities, SSM may, during the term of validity of a licence, decide that it is necessary to stipulate certain conditions to ensure safety. SSM may also decide that additional measures are necessary, and issue orders or prohibitions to the licensee to ensure that the Act, or regulations or conditions issued under the Act, are observed.

A licence may be revoked for activities that do not fulfil the obligations set out in legislation. If there is an ongoing licensed activity that does not comply with regulations or the terms of the licence, the supervisory authority may issue any injunctions and prohibitions required in the specific case to ensure compliance.

Injunctions or prohibitions issued under the acts may carry contingent fines. If a person fails to carry out a measure incumbent upon him or her under the acts, ordinances, or regulations, or conditions issued pursuant to the acts, or under SSM's injunction, SSM may arrange for the measure to be implemented at this person's own expense.

The Act on Nuclear Activities also contains provisions regulating areas such as safeguards and sanctions. Anyone who is proved to have conducted nuclear activities without possessing a licence, or disregards conditions or regulations, shall be sentenced to pay a fine, or to imprisonment for a maximum of two years. Such cases are submitted to a prosecutor and it is not SSM who decides on a sanction or penalty. If the offence is intentional and aggravated, the individual shall be sentenced to imprisonment for a minimum of six months or 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.

SSM has a similar mandate under the Radiation Protection Act to decide whether additional measures are necessary, and to issue orders and prohibitions to the licensee to ensure compliance with the Act, or with regulations or conditions issued under the Act.

According to the provisions of both the Act on Nuclear Activities and the Radiation Protection Act, the police authority shall, if necessary, provide the assistance needed for SSM's supervision.

SSM has access to a variety of measures that can be used to remedy a non-compliance situation, see further description in section 8.9.

7.6. Regulatory supervision

SSM's regulatory activities relating to inspection and assessment are reported under Article 8.

An overview of SSM's supervision with regard to the safety of nuclear installations and supervisory programme is contained in section 8.8.

7.7. Openness and transparency

In line with the Aarhus Convention, Sweden's legal framework contains provisions regulating access to information, public participation in decision making, and access to justice.

The Swedish Constitution also contains provisions regulating public access to official records as described in section 7.1.5.

Under EIA provisions, the public is also guaranteed opportunities to gain access to information and to submit their opinions on planned activities and facilities for which permission is sought. These provisions require consultation (in addition to that conducted between municipalities and authorities) with the public concerned and with environmental organisations.

In various cases, decisions issued by the Land and Environment Court or by government authorities may be appealed not only by the party concerned, but also by environmental organisations and non-governmental organisations.

A decision by the Government on permissibility under the Environmental Code (see section 7.1.4) and a licence granted under the Act on Nuclear Activities (see section 7.1.2) cannot be directly appealed. Under certain conditions, the Supreme Administrative Court might examine whether the process followed by the Government in making such a decision is in contravention of any rule of law. This does not imply an examination of the case in substance, but rather to ascertain whether the decision was taken according to the correct procedures.

To ensure that necessary information in relation to the safety of nuclear installations and its regulation is made available to the employees of licensees and to the general public, all reports issued by SSM are made publicly available and the SSM website is used to provide information on current events and Authority decisions in accordance with the SSM communication policy. In addition, the licensees provides information to their employees through working meetings, intranets and internal information meetings, and to the public through their websites and public media. In specific cases, licensees may also host public information meetings.

Furthermore, according to the Act on Nuclear Activities, NPP licensees are liable to provide Local Safety Boards, as appointed by the Government, with insight into the safety and radiation protection work at the facility. The insight shall enable the board to obtain information about the safety and radiation protection work that has been conducted or is being planned at the facility and to compile material in order to inform the general public about this work.

7.8. The WENRA Reactor Harmonisation Project

As a member of WENRA, SSM participates in the development of the WENRA SRLs for existing nuclear power reactors. The SRL reports were issued in 2006 and updated in January 2008, September 2014 and March 2020 (issued February 2021). The 2020 SRLs include issues such as internal hazards and external hazards. WENRA reports are available on the WENRA website (www.wenra.eu).

The 2020 SRLs are based on latest available knowledge and experience and take into account the lessons learned from the accident at the Fukushima Daiichi NPP, including the insight from the EU stress tests, the reviews of IAEA safety requirements as well as the conclusions from the 2nd Extraordinary Meeting of the Contracting Parties to the Convention on Nuclear Safety. Prior to finalisation of updated versions, WENRA made the reference levels available for stakeholder consultation.

WENRA has during the last three-year period produced technical specifications for the ENSREG Topical Peer Review regarding Fire Safety, as well as the 2024 SRLs revision programme. Furthermore, WENRA has published a number of reports, guidances, position papers and recommendations. These include a guidance document relating to SRLs for external hazards and a report on the applicability of the Safety Objectives to SMRs. WENRA has also published a report on Practical Elimination Applied to New NPP Designs, which provides a common understanding of the approach to demonstrate the avoidance of early releases and large releases by using the notion of practical elimination.

WENRA members are currently working with the self-assessment and peer reviews of the 2020 SRLs.

In preparing SSM's new Code of Statutes, the WENRA SRLs as well as other WENRA reports have been taken into account.

7.9. Vienna Declaration on Nuclear Safety (VDNS)

Article 8a, paragraphs (a) and (b) of Directive 2009/71/Euratom, correspond to the first and second principles under the VDNS. These provisions of the Directive have been transposed into the Swedish Act on Nuclear Activities, which means that the first and second principles established in the VDNS are implemented in Swedish legislation. The provisions in the Act on Nuclear Activities concern both existing nuclear power reactors and new nuclear power reactors.

Section 7.2.2 describes how Sweden implements the third principle of the VDNS in the form of SSM's ongoing comprehensive review of its Code of Statutes, which aims to ensure that IAEA Safety Standards are systematically referenced and used as a basis for the regulations governing safety, security and radiation protection at nuclear facilities.

Article 8. 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 7, and provided with adequate authority, competence and financial and human resources to fulfil its assigned responsibilities.
2. Each Contracting Party shall take the appropriate steps to ensure an effective separation between the functions of the regulatory body and those of any other body or organisation concerned with the promotion or utilization of nuclear energy.

Summary statement for the article

Sweden complies with the obligations of Article 8.

Summary of significant changes and developments since the previous report

- SSM has made adjustments to its organisation, aimed at ensuring that the Authority effectively can receive and process a new licence application for an NPP (see section 8.1.1).
- The Authority's headquarter has been relocated to Solna and SSM has established an office in Gothenburg (see section 8.1.1).
- SSM has restarted its work on development of its internal safety culture (see section 8.4).
- SSM has undergone significant employee growth in recent years (see section 8.5.1).
- The Authority has reviewed structures, responsibilities and roles for maintaining and developing the management system (see section 8.6).
- SSM is working to quantify the sector's need for competence and education, to enhance the attractiveness of careers in the radiological and nuclear sector, to strengthen the education capacity, and to develop collaboration between stakeholders (see section 8.10.2).
- An IRRS mission to Sweden was conducted in November 2022 along with a back-to-back ARTEMIS mission during April 2023 (see section 8.12).

8.1. The regulatory body and its mandate

8.1.1. General information about the Swedish Radiation Safety Authority (SSM)

SSM is a central administrative authority, independent in its decision-making (see section 8.2), that reports to the Ministry of Climate and Enterprise. SSM works to promote protection of people and the environment from harmful effects of radiation, now and in the future. The mission and tasks of SSM are defined in an ordinance with instructions for the Authority and in the annual government appropriation directions, which contain detailed objectives and reporting obligations. Other authorities that have a supervisory mandate relating to NPPs are the Swedish Civil Contingencies Agency, the Swedish Work Environment Authority, the Nuclear Waste Fund, and the National Electrical Safety Board.

As an emergency authority, SSM coordinates the national system for emergency preparedness and radiation protection. SSM maintains 24-hour emergency preparedness for the purpose of rapid response to the consequences of accidents and events involving radiation in Sweden or abroad. SSM also has functions in place for IAEA inspections, press contacts and IT support outside office hours.

The director general of SSM is appointed by the Government, normally for a term of six years. The director general has the sole responsibility and reports directly to the Government. However, the Authority also has a statutory advisory council whose members are appointed by the Government. The council members are usually members of parliament, agency officials or independent experts. The functions of the council are to advise the director general and to ensure public transparency (insight) regarding the Authority's activities, but it has no decision-making powers.

SSM, as a Swedish public agency, is subject to wide-range obligations regarding openness and providing information upon request from the general public or other government bodies. Swedish official documents are public unless the information contained in them is subject to secrecy under the Public Access to Information and Secrecy Act (2009:400). Secrecy may be warranted in the interests of national security, international relations, commercial relations, or individuals' right to privacy. No one needs to explain why they wish to review a public document, or to reveal her/his identity in order to gain access to a document.

As is the case with all other Swedish public authorities, SSM issues an annual report and financial statement, which are submitted to the Government. It summarises major results, effects, revenues and costs. The Government carries out follow-up work and evaluates an authority's operations based on the annual report.

SSM publishes reports to inform interested parties and stakeholders. The SSM website is used to provide information on current events and Authority 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; most of them are available for downloading from the SSM website.

In June 2021, SSM launched a new organisational structure derived from SSM's roles and responsibilities, i.e. policies, regulation and harmonisation, licensing, inspection and enforcement, emergency preparedness and knowledge management. The organisational structure effectively separates the authority's regulatory decision-making with respect to policies and regulations, inspection and enforcement and its licensing and authorisation function in three separate departments.

During 2023 and 2024, SSM has made relatively minor adjustments to the organisation on a number of occasions. These adjustments have been done primarily with the aim of ensuring that the Authority effectively can receive and process a new licence application for an NPP. For example, the former Unit for Licensing of Nuclear Facilities has been divided into two new sections – the Unit for Licensing of Nuclear Reactors and the Unit for Licensing of Nuclear Facilities. In addition, a new Unit for technical review and analysis relating to Radioactive waste has been established.

The government decided on 22 June 2023 (KN2023/02719) to give the Authority an assignment to relocate the authority's seat and management function from Katrineholm to Stockholm County, where the authority currently operates in Solna. As of 1 October 2023, the Authority's seat and management is located in Solna.

In order to handle staffing expansion, due to the Government plans for new nuclear power, SSM has established an office in Gothenburg. The office is close to Chalmers University of Technology, Gothenburg University and also Ringhals NPP. Having offices in Solna, Katrineholm and Gothenburg, facilitates long term competency supply for the Authority while at the same time enables SSM the possibility to offer flexible solutions for new and existing employees.

SSM's expansion in staff numbers is also a result of the Government's decision to build up resources relating to Sweden's civil defence.

8.2. Independence of the regulatory body

The de jure and de facto independence of the regulatory body from political pressure and promotional interests is well provided for in Sweden.

According to the Swedish constitution, administrative authorities are independent in their regulatory decision-making within the legislation and statutes laid down by the Government. An individual minister is not allowed to interfere in a specific case handled by an administrative authority. The Government as a whole is responsible for all governmental decisions. In practice, a large number of routine matters are decided upon by individual ministers, and only formally confirmed by the Government. However, the principle of collective responsibility is reflected in all forms of governmental work.

SSM is tasked with applying legal frameworks that are exclusively concerned with nuclear safety and security, nuclear non-proliferation and radiation protection. SSM has no role in promoting or utilising nuclear energy. SSM reports to the Ministry of Climate and Enterprise where the responsible unit/department to which SSM reports similarly has no such role.

8.3. Missions, tasks and fundamental values

SSM's missions and tasks are defined in the Ordinance (2008:452) with instructions to the Authority and in annual appropriation directions. In the latter, the Government issues directives for national authorities, which include the use of budget appropriations.

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 on nuclear and radiation safety, including nuclear security 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 and radiation safety in society and, through its activities, take actions to:

1. Prevent radiological accidents and ensure safe operations and safe waste management at the 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 linked to exposure to naturally occurring radiation; and
5. contribute to an enhanced level of nuclear and radiation safety internationally.

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

SSM shall furthermore:

1. Take measures to fulfil Swedish obligations according to conventions, EU ordinances/directives, and other binding agreements;
2. exercise supervision to confirm that nuclear material and equipment are used as declared and in manner that agrees with the international commitments;
3. carry out international cooperation with national and multinational organisations;
4. monitor and contribute to the progress of international standards and recommendations;
5. coordinate activities needed to prevent, identify and detect nuclear or radiological emergencies, as well as organise and lead the national organisation for expert advice to authorities involved in, or leading, emergency response operations;
6. contribute to national competence development within the Authority's field of activities;
7. provide data for radiation protection assessments and maintain the competence to predict and manage evolving issues; and
8. ensure public insight into all the Authority's activities.

The annual appropriation directions supplement the general instructions by focusing more on short-term priorities and funding of the Authority's activities.

SSM's work include supervision of activities relating to non-ionising and ionising radiation. As far as ionising radiation is concerned, the main regulatory areas are: use of nuclear technology and power production, the medical sector with therapy and diagnostics, the use of radiation sources and x-ray equipment in industry, public use of sources and devices in commodities, use of detectors and scanning equipment for security reasons, and exposure to ionising radiation from naturally occurring radioactive material (NORM).

SSM is also responsible for the National Metrology Laboratory for ionising radiation and maintains the national secondary standards for the dosimetric quantities of kerma, absorbed dose and dose equivalent. Furthermore, SSM operates a national dose register and issues national individual dose passports.

SSM has no resident inspectors for supervision of nuclear facilities. However, there is an appointed inspector responsible for the coordination between the licensee and regulator, who monitors the licensee's overall activities and the Authority's activities towards the licensee. The task rotates between the inspectors in relation to the respective plant, at an interval of about four years. Inspections are carried out by teams where the inspection team is composed of different competencies relevant to the area of inspection. In general, the inspector in charge of coordination between the licensee and SSM participates in the inspections.

When IAEA carries out inspections in Sweden, inspectors from SSM always participate in order to ensure that the inspections are carried out in accordance with the Authority's regulations. At the same time, the Authority then conducts its own inspection in parallel.

SSM has, in terms of the safety of nuclear facilities, permanent advisory committees on reactor safety, radioactive waste and spent nuclear fuel, and research and development. SSM also has advisory committees in other fields such as UV, and electromagnetic fields.

8.3.1. Fundamental values

SSM embraces the fundamental values held by Swedish public administration based on the platform of democracy and human rights, while continually striving to follow the rule of law, maintain efficiency and effectiveness, and have a citizen's perspective. The fundamental values of the Authority comprise its vision, mission statement and key values. These fundamental values also shape the Authority's safety culture.

SSM's vision

A society safe from harmful effects of radiation.

Mission statement of SSM

SSM works proactively and preventively to protect people and the environment from harmful effects of radiation, now and in the future. The Authority has a systematic and structured approach to continual improvements in its processes in order to develop its operations, render them more efficient and achieve its objectives.

Key values

Credibility, Integrity and Openness.

Credibility means pursuing work on the basis of facts. Credibility is achieved when employees are competent, objective and impartial. "Competence" means employees having the requisite professional skills, education, training and experience.

Integrity means maintaining the Authority's independence and not allowing it to be unduly influenced when it comes to its own decisions, standpoints, advice and recommendations. Integrity involves taking charge, both while exercising authority and on an employee level.

Openness means that the work of the Authority is transparent to the outside world and that SSM clearly and proactively provide information about its work, standpoints, advice, recommendations and decisions. Openness also involves its willingness to be attentive to and consider external views.

The key values are an active component of all the Authority's activities. They are for instance used to underpin the decision making of the Authority.

8.4. Safety Culture

One important aspect of the development of the regulatory body is to scrutinise its own safety culture and its wider role in the national safety infrastructure. To be trustworthy in giving public safety as the primary focus, it is essential for the regulatory body itself to have a strong safety culture. Under the reporting period, SSM has restarted its work on its internal safety culture. After having performed a follow-up survey on the internal safety culture in the winter of 2023/2024, work has begun throughout the organisation in re-establishing a strong safety culture that is fit for purpose.

In the area of safety culture, SSM has also been active internationally, participating e.g. in the OECD/NEA senior task group, which developed the booklet ‘The Safety Culture of an Effective Nuclear Regulatory Body’ (NEA No. 7247, OECD 2016). As a direct result of this work, SSM has incorporated the five principles from these efforts into its management system. These five principles are:

- Safety and security aspects are clear elements of the Authority’s leadership.
- All SSM employees have a personal responsibility for patterns of behaviour that influence safety and security.
- A culture that promotes safety and security facilitates cooperation and open dialogue.
- The Authority has a holistic approach to aspects of safety and security.
- Continual improvements, learning and self-assessments on all levels of the organisation.

SSM is continuously working to support and promote the safety culture within the regulatory body. The director general has recently decided on a direction for the internal safety culture work. An implementation plan has been drawn up and a dialogue on what safety culture means to the authority has been carried out, involving all employees.

8.5. Human and financial resources

8.5.1. Staff and Staff Turnover

SSM has undergone significant growth in recent years. At the end of 2024, the Authority had 342 employees, an increase from 297 employees at the end of 2021. 82 new employees were recruited in 2024, corresponding to approximately one-quarter of the total workforce.

The ambition for the Authority was to have 370 employees by the end of 2024, but several factors affected the ability to achieve this goal. Competition for expertise from industry, lead times for security vetting, and a lack of qualified applicants resulted in some recruitments being discontinued. Recruitment also demands significant time from recruiting managers, leading to a high workload for managers overseeing sections undergoing substantial growth. This has impacted the growth rate. Overall, the Authority recognises that the recruitment target for 2024 was ambitious and that the growth achieved in 2024 represents a significant expansion of the workforce.

As a result of the organisational changes in 2021 and new working methods, staff turnover increased from 12 % in 2021 to 17 % in 2022. In 2024, staff turnover stabilised and decreased to 12 %. 35 employees left the Authority in 2024, a reduction compared to 2023, when 39 employees left.

Gender equality remains an important aspect, and the gender balance has been maintained despite the expansion. At the turn of 2024, the workforce comprised 172 men and 170 women.

8.5.2. Attract and Recruit

To support workforce growth, SSM has established a more systematic strategic approach to skills supply, based on three perspectives: operations, finances, and competence. This approach aims to support sustainable growth with the right expertise by ensuring a holistic perspective and strengthening governance and follow-up. As a basis for the operational perspective, the Authority conducted extensive skills analyses in 2022, 2023, and 2024. These analyses have been central in identifying required critical competencies and recruitment needs for the Authority to fulfil its mission in the short and long term.

The Authority has invested in increased support for recruiting managers and enhanced the recruitment process through digitalisation, systematic selection procedures, and improved advertising strategies. A strategic initiative has been made to expand operations in Gothenburg to broaden the recruitment base, particularly in specialist nuclear technology expertise. This has proven successful, as positions previously difficult to fill have, to some extent, been successfully staffed with Gothenburg as the designated location.

SSM has also actively worked on skills supply by making greater use of its managerial prerogative. To facilitate this, a process has been developed for internal expressions of interest, clarifying the conditions under which this procedure can be applied. This process will enable the Authority to utilise internal competence more effectively over time, enhance internal development opportunities, and create a more dynamic skills supply.

8.5.3. Develop and Retain

To strengthen the Authority's attractiveness, skills development, and long-term competence supply, SSM has decided to develop a coherent and systematic approach to education and learning (i.e. knowledge management). A current state analysis and needs inventory have been conducted, forming the basis for continued work.

Many new employees have joined SSM, prompting a continued revision of the introduction programme. The introduction also includes a security training module, as all employees at SSM are subject to security clearance. The process is designed to introduce a larger number of employees annually, to be fit for purpose, and to include pre-boarding.

A well-functioning work environment is essential for employee satisfaction and retention. Therefore, SSM has prioritised establishing a solid foundation for a more active and proactive approach to supporting this. Work environment, collaboration, and leadership conditions have been central development areas.

In 2023, a joint decision was made to strengthen work environment efforts through structured dialogue within the Authority. These discussions revealed a recurring theme: the need for clearer collaboration structures across departmental boundaries, a better understanding of the Authority's mission, and increased confidence in assigning the right priorities. These insights formed the basis for the 2024 operational planning under the objective of "Effective work and collaboration structures, as well as efficient competence supply", which all departments planned their work around.

The joint efforts to strengthen the work environment continue, and an overarching work environment strategy has been developed for 2025–2027. This strategy, based on a joint analysis between the employer and the health and safety organisation, clarifies the desired progress in two areas: workload and systematic risk assessment.

Managers' conditions were examined from a work environment perspective in 2024 through a survey answered by all managers in the organisation. The results indicate that managers at SSM experience a high workload and request greater clarity regarding common objectives. The survey findings have been addressed and form the basis for collective development work within the management teams and among managers as a group regarding the identified areas for improvement.

The Authority has continued to improve leadership skills by providing fundamental training for new managers in developmental leadership. Additionally, all departmental management teams have undergone group development initiatives. The objective was to strengthen cohesion, leadership, and develop the teams' shared missions and goals.

8.5.4. Financial Resources

The regulatory activities of SSM are financed by the State budget. These costs are largely recovered from licensees in the form of fees that cover the cost of regulatory activities and related research. The amounts of the fees are proposed annually by SSM, but decided by the Government. The budgets for 2022, 2023 and 2024, including the funding of the separately financed international cooperation and development work, are shown in table 3. Additional resources in the form of fees for processing of special applications and licensing work, are directly payable to the Authority.

Table 3. Budget of SSM in million SEK.

Budget item	2022	2023	2024	Source of funding
Nuclear safety, radiation protection, emergency preparedness, supervision, crisis management, nuclear non-proliferation (including administration)	423	459	518	Mix of fees and tax funded
<i>Supervision of nuclear facilities (proportion of above)</i>	<i>154</i>	<i>146</i>	<i>149</i>	<i>Fees</i>
<i>Nuclear crisis management (proportion of above)</i>	<i>33</i>	<i>33</i>	<i>33</i>	<i>Fees</i>
<i>Nuclear non-proliferation (proportion of above)</i>	<i>13</i>	<i>13</i>	<i>12</i>	<i>Fees</i>
<i>Nuclear safety research (proportion of above)</i>	<i>66</i>	<i>66</i>	<i>86</i>	<i>Mainly fees</i>
Final disposal of radioactive waste	60	70	70	Fees
Licensing fees	9	19	23	Fees
Notification obligation fees	19	9	8	Fees
Historical wastes etc.	3	3	3	Tax funded
International co-operation and development	28	33	38	Tax funded
Total (million SEK)	542	593	659	

8.6. Management system

SSM has a process-based management system that describes how activities are controlled, implemented, followed up and improved. The management system has been designed to ensure that requirements on nuclear and radiation safety are fulfilled in coordination with other operational requirements. It has also been designed to support and promote a culture whereby issues with an impact on nuclear and radiation safety are given the attention and priority that their importance requires (see section 8.4). The management system has also been developed taking into account external requirements for management systems.

The various processes of the management system form the basis for how the authority's activities are to be conducted in order to fulfil its objectives. The management process is based on the authority's overall remit to be proactive in ensuring good levels of nuclear and radiation safety. An internal management and control system is integrated with the authority's financial planning and the management of objectives and results within the scope of the management process.

Every year, a management review is carried out with a focus on the functioning of the management system. The review aims to provide a basis for assessing whether the processes and working methods in the management system provide deliverables of the right quality and desired results. It also seeks to determine how well the work on continuous improvements of the management system is progressing and identify opportunities for its further improvement.

Figure 8 illustrates SSM's present overarching process map.

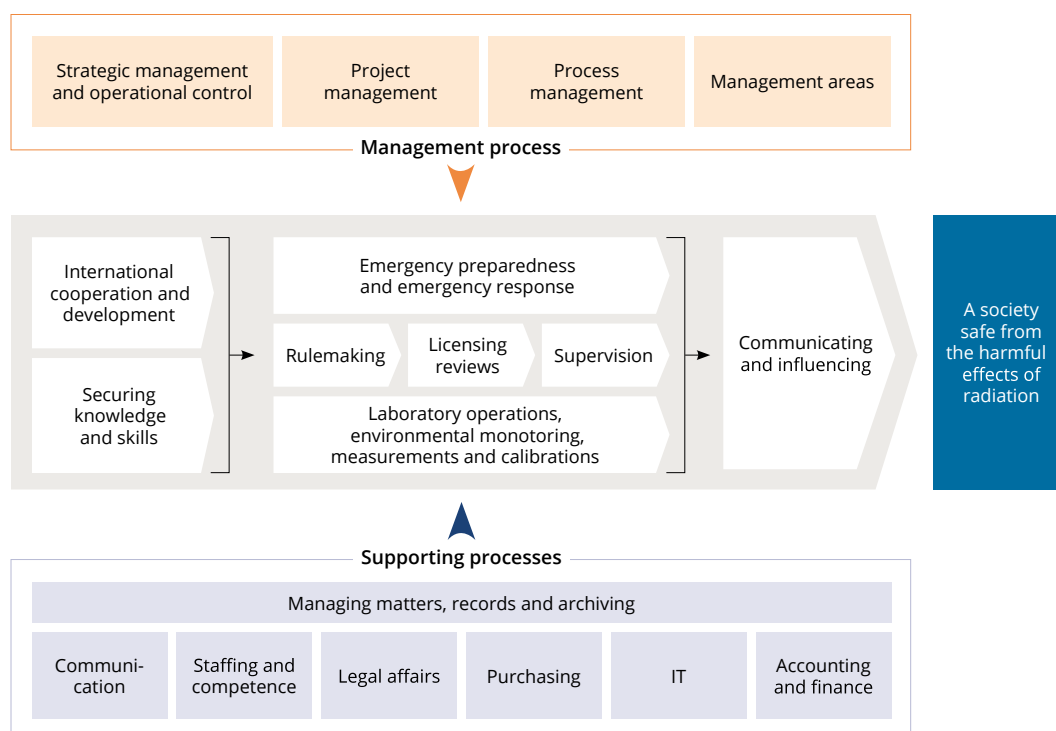


Figure 8. SSM's overarching process map.

During 2023–2024, the Authority reviewed structures, responsibilities and roles for maintaining and developing the management system. The changes aim to facilitate and increase continuous improvements, thus work is needed in order to fully implement and make the management system even more efficient.

In the report from the IRRS mission conducted in 2022, some of the identified recommendations concern the Authority's management system. The recommendations are currently being addressed by SSM. In the annual appropriation directions for 2025, the Government has given SSM a specific assignment to report on its ongoing work on the implementation of the IRRS recommendations related to the management system.

8.7. Internal and external audits

The management system accounts for both internal and external requirements; the latter including statutes and legal provisions. The purpose of internal audits is to assess how well the management system is functioning, and to identify areas for improvement and deviations. The basis for internal audits are external requirements, requirements in IAEA GSR Part 2 Leadership and Management for Safety, and internal requirements that follow from established governing documents and processes.

The review of structures, responsibilities and roles for maintaining and developing the management system conducted in 2023–2024 (as mentioned above in section 8.6), included internal audits. As a consequence of the revised organisational structure introduced in 2021 and the review in 2023–2024, internal audits have only been conducted within the area of environment in order to meet the requirements in Ordinance (2009:907) on environmental management in government agencies.

External audits of SSM's annual report, finances and effectiveness are conducted every year by the Swedish National Audit Office. The metrological activities of SSM's National Metrology Laboratory are supervised regularly by SWEDAC, the Swedish Board for Accreditation and Conformity Assessment, in accordance with the standard SS-ISO 17025.

8.8. Regulatory supervision

Regulatory inspections and safety assessments are carried out by SSM as authorised by the Ordinance on Nuclear Activities and the Radiation Protection Ordinance, and according to the Government's general instruction to the Authority.

8.8.1. SSM's supervisory practices

SSM has since 2023 continued to develop its supervisory processes and methods. The supervisory process is currently divided into the following sub-processes:

- Compliance inspections
- Surveillance inspections
- Reviews
- Managing events
- Managing reports
- Integrated safety assessments

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

8.8.2. Supervisory programme for NPPs

The programme is designed to provide an overview and clear risk-based analysis as a basis for planning, implementation, and follow-up of supervision. The supervisory programme is structured into two main parts, baseline supervision and demand-based supervision.

8.8.2.1. Baseline supervision

The requirements that underline the baseline supervision plan are divided into six fundamental aspects (see figure 9):

- Management and control
- Safety analysis
- Design
- Plant status
- Operation
- Environmental impact

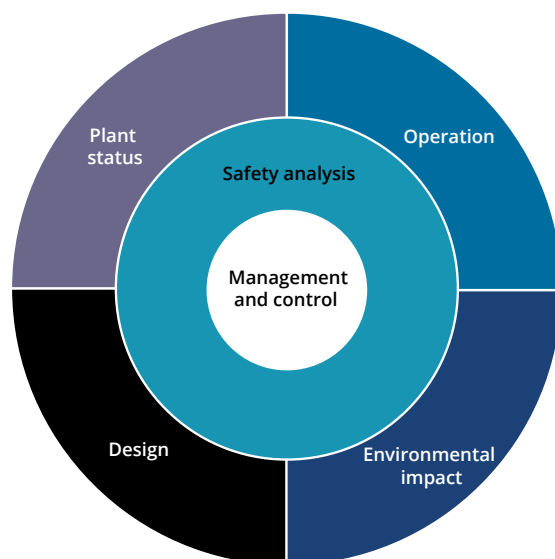


Figure 9. Functional supervisory aspects.

The baseline supervision plan covers a period of 10 years and describes the supervision groups that are carried out each year for NPPs in operation. Over the 10-year period, the baseline supervision programme is intended to cover every requirement in the regulations at least once.

The supervision groups are carried out every three, five or seven years, based on the risk importance of the group. There are a total of 36 supervision groups.

8.8.2.2. Identification of supervision needs

As an important complement to the baseline supervision, the demand-based supervision is defined yearly. It can therefore differ from year to year, depending on:

- Results from integrated safety assessments.
- Results from inspections carried out or events that have occurred.
- Identified areas where supervision is deemed necessary according to, e.g., events or concerns.
- Major ongoing changes, technical or organisational.
- Other identified needs.

8.8.3. Nuclear safety and radiation protection inspections

The compliance inspections are carried out by teams consisting of inspectors with expertise in relevant areas. An exit meeting is held where preliminary results are communicated to the licensee. The inspection report documents the purpose and objectives of the inspection, observations, compliance and deviations from requirements, as well as an assessment of the significance of any deviations. The report is accompanied by a decision on further regulatory actions or termination of the supervision.

In addition to compliance inspections, SSM carries out surveillance inspections to gather information on safety problems and overall activities at the plants. Normally these surveillance inspections include three or four annual meetings with each reactor operations management, annual meetings with the safety department, and yearly meetings to review safety and internal audit programmes. Some surveillance inspections are made in connection with events, to follow up organisational change, or in relation to other ongoing issues, such as findings from earlier inspections. In many cases, these inspections focus on non-technical issues, such as safety management and safety culture.

Preparation and documentation of surveillance inspections are simplified in comparison with compliance inspections, but the results are systematically documented. Each surveillance inspection typically takes 1–2 days on site for 1–2 inspectors with expertise in relevant areas. Table 4 below provides an overview of the performed activities at Swedish NPPs.

Table 4. Number of supervision activities at NPPs 2022–2024.

Year	Regulatory Activity	Forsmark	Oskarshamn	Ringhals	Total
2024	Compliance inspections	8	5	8	21
	Surveillance inspections	18	7	11	36
	Reviews	9	8	8	25
2023	Compliance inspections	12	7	10	29
	Surveillance inspections	13	11	14	38
	Reviews	6	8	10	24
2022	Compliance inspections	9	4	4	17
	Surveillance inspections	23	13	18	54
	Reviews	22	11	20	53

Under SSM regulations, inspection of the licensees' programmes, activities and results of surveillance, and in-service inspection of mechanical components, are performed by an accredited control body ("third-party control"). If the requirements are fulfilled, a compliance certificate is issued by the control organisation (see section 14.3.3.1).

8.8.4. Periodic Safety Reviews (PSR)

PSRs have previously been part of the supervision process but are now formally included under the licensing and authorisation process (see section 7.3). However, the description of PSR fits better in this chapter.

PSRs were introduced in Sweden in the early 1980s, following the nuclear accident at Three Mile Island. The requirements regarding the reviews have developed over the years and are now quite similar to those recommended in the IAEA Safety Standards.

The licensees perform a PSR in a systematic way, with an interval not exceeding ten years. The purpose of the PSR is for the licence holder to re-assess, verify and continuously improve the safety of its nuclear installations. In addition, the PSR should address any issues that might limit the planned operating period of the facility, and shows how they will be managed. All reasonably practicable improvements shall be taken by the licensee.

SSM reviews the licensee's PSR regarding confidence in the level of nuclear safety and radiation protection at present, and the licence holder's ability to maintain and increase it in the future. Once the review is completed, SSM can initiate a new case within its supervisory framework if the review, for example, results in findings that could affect nuclear safety or radiation protection. SSM may then decide to prohibit certain activities or impose specific measures. Such decisions may be subject to legal challenge.

Recently performed PSRs are described in section 14.3.2.

8.8.5. SSM's integrated safety assessments

SSM's integrated safety assessments comprise nuclear safety and radiation protection assessments of each major facility under SSM's supervision. Until 2024, the integrated safety assessments were carried out annually. From 2025 they are being conducted every second year. Based on the outcomes of all compliance inspections, surveillance inspections and reviews, as well as authority decisions and other relevant information, a general appraisal is made of the nuclear safety, radiation protection and non-proliferation control status of the facility against relevant requirements. The basic material also covers earlier information and conclusions in order to identify trends that could otherwise be difficult to detect in a short-term perspective. The reports are approved by the head of SSM's supervision division and presented at top-level management meetings with the licensees.

An aspect of importance when drafting the integrated safety assessment report is the traceability from the basis of data, via the analysis, to the final conclusions and the assessment. It should be clearly described how SSM evaluated the relevant issues, and the report should be comprehensible to interested parties lacking expert knowledge in the assessed areas.

8.9. Enforcement measures

It is the task of the regulatory body to enforce the constitutional rules, judgments, conditions and other decisions governing the activities of a licensee. SSM has the task of providing advice and information to create the conditions for regulatory objectives to be met, and taking the necessary steps to remedy a situation if necessary. Under the Act on Nuclear Activities, the Radiation Protection Act, the Protective Security Act and the Environmental Code, the regulatory body has extensive legal powers to enforce the regulations and its decisions.

The regulatory body has access to a variety of measures that can be used to remedy a non-compliance situation. Whoever becomes the subject of a regulatory decision always has the option to appeal the decision.

Normally the regulatory body uses a scale of administrative sanctions in cases where the licensees deviate from the regulations. The different steps are:

- Issuing a remark on issues to be corrected by the licensee.
- Ordering an action plan to be developed and actions to be taken within a certain time period.
- Ordering specified actions to be taken within a certain time period and the results to be submitted for review and approval. Such an order can be combined with a conditional fine, which may be enforced by a court if the licensee fails to comply.
- Ordering suspension of operations until deficiencies are corrected and the measures taken are reviewed and approved by the Authority.
- Revoking a licence.

In combination with the above sanctions, the regulatory body can take the following actions:

- Impose additional licensing conditions.
- Temporary care pending compliance with a correction order (Radiation Protection Act).
- Sealing of premises to prevent unlawful use of installations (Radiation Protection Act).
- Correction at the licensee's expense.
- Refer suspected cases of criminal violations to a public prosecutor.

8.10. Regulatory research funding

According to legislative provisions concerning the conduct of research, as laid down in the Ordinance (2008:452) with instructions for SSM, the overall objective of the research funded by SSM is to:

- Maintain and develop national competence of importance for nuclear and radiation safety, and
- Ensure that SSM has the knowledge and tools needed to carry out effective regulatory and supervisory activities.

SSM's total annual research funding budget is about 140 million SEK. Of this amount, about 65 million SEK is devoted to nuclear safety research related to the current NPP fleet, whereas 40 million SEK (since 2025) is devoted to strengthening the national competence for new nuclear power.

8.10.1. National research

Research is a prerequisite for SSM to be able to conduct its regulatory activities and to support national competence in nuclear and radiation safety. SSM funds research mainly through open calls but in certain cases also through direct support to national and international research programmes. Typically, there are two basic objectives with the research funding: either to support the regulatory activities by providing increased knowledge on specific research topics, or to strengthen the national competence in general. In the latter case, the exact research topic is of less importance than the fact that there is active research within Sweden in a selected research area.

The research in nuclear safety funded by SSM typically covers areas such as safety assessment, safety analysis, reactor technology, material and fuel properties, severe accidents, non-proliferation, human factors, emergency preparedness and ageing of reactor components. In the area of radiation protection for nuclear activities, research on radioecology, radiation biology and radiation dosimetry is of importance, as well as research about source terms, and new detection and measurement methods.

SSM is engaged in a large number of different national research collaborations, involving e.g. universities, the industry and other authorities.

8.10.2. National competence

SSM has established from previous investigations into the maintenance of national competence that there is a need to strengthen the national framework for knowledge management in areas relating to nuclear and radiation safety, both for the purpose of meeting today's requirements, and for anticipating needs arising in the years to come. One of the root causes of this national vulnerability in the knowledge management system is that there was during a long period of time an underfunding of several areas of research that are critical to society.

In 2022, SSM provided the Government with a proposal for a national strategy regarding the Swedish knowledge management in the area of nuclear and radiation safety. The strategy includes an overall vision, broken down into five strategic areas with proposals for a total of 21 prioritised actions aimed at strengthening the knowledge management over the coming 10-year period. Many different actors, e.g. universities, the industry and other national authorities, have been involved in the process of developing the strategy and are also assigned roles in relation to various proposed actions. The proposal was based on conclusions from SSM's previous government assignments relating to national competence and it was also prompted by recommendations in the area of "Competence for Safety" that emerged from the IRRS missions in 2012 and 2022 (see section 8.12).

SSM is currently working to quantify the sector's need for competence and education, to enhance the attractiveness of careers in radiological protection and nuclear safety, to strengthen the education capacity, and to further develop collaboration between national authorities, universities and the industry in order to strengthen overall competence supply in the country.

8.10.3. International research activities

The major part of SSM's research funding goes to universities and consulting companies in Sweden. However, as an important complement to this, SSM also participates actively in many international research activities, mainly through EU/Euratom, OECD/NEA, NKS (Nordic Nuclear Safety Research) and bilaterally with other countries.

Ever since Sweden joined the EU, the importance of participating in joint European work has increased. In particular, SSM is actively participating (as Beneficiary) in the three major research partnerships in the Euratom Fission programme – PIANOFORTE (radiation protection), EURAD-2 (nuclear waste management) and CONNECT-NM (nuclear materials).

SSM has participated in a large number of different OECD/NEA joint projects over several decades, most of them in collaboration with other Swedish stakeholders, such as the NPP licensees, Westinghouse, Studsvik Nuclear AB and academic institutions conducting nuclear technology research. The strategic significance of participating in international projects, particularly in terms of competence development and consensus on nuclear regulation, is generally very high. In particular, Sweden is hosting two of these joint projects, SCIP (nuclear fuel performance) and SMILE (nuclear materials ageing).

Within NKS, nuclear safety research is performed within two programme areas: reactor safety and emergency preparedness.

Moreover, SSM has a close collaboration with other countries' regulators and TSOs, for instance Finland, France, UK and the US.

8.11. Communication

The Government ordinance with instructions for SSM states that 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 be to:

1. Promote health and prevent ill health,
2. Prevent acute radiation injuries and reduce the risk of delayed injuries due to radiation, and
3. Provide advice and information about radiation, its properties and areas of application, and about radiation protection.

8.11.1. Governance policy and communication

SSM's governance policy states that the Authority's role includes working proactively and preventively in many arenas – to develop, improve and promote nuclear and radiation safety, and to ensure compliance with legal and regulatory provisions. The governance policy further states that the Authority shall influence patterns of behaviour for improvement of nuclear and radiation safety within its mandates, making use of appropriate tools for influencing behaviours, and that the work should be perceived as beneficial to the party concerned. Communication and consultation are strategic tools used by the Authority for influencing behaviours and adding value on the part of stakeholders.

8.11.2. Communication policy and strategy

SSM shall, through information and transparency, contribute to providing the public with insight into all activities covered by its mandates, according to the Government ordinance with instructions for SSM. The Authority's communication policy specifies the responsibility of employees and managers for internal and external communication.

The overall aim of SSM's communication activities is to maintain and strengthen trust in the Authority and its mission. SSM's communication policy emphasises the organisation's key values: credibility, integrity and openness, which should permeate all communications by the Authority. The policy further states that, in order to maintain and strengthen trust in the Authority, SSM's communication work has to proceed from a high level of openness and visibility and should be adapted to the needs and conditions of target groups.

The policy also states that SSM acts through a communicative managerial and employee approach. Communication needs are evaluated and prioritised based on one or more of the following criteria:

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

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

8.12. 2022 IRRS review mission

The second full-scope IAEA IRRS mission to Sweden was conducted in November 2022 along with a back-to-back ARTEMIS mission during April 2023.

The IRRS mission concluded that Sweden has a comprehensive regulatory framework for nuclear and radiation safety, with SSM being a competent and independent regulator. The mission identified one good practice and several areas of good performance, including public awareness efforts, transparent licensing decisions, digital process improvements, and integrated safety assessments. However, challenges remain, particularly in terms of staffing shortages for key regulatory functions. The IRRS team provided recommendations for both the Government and SSM, emphasising the need for a national competence strategy, enhanced coordination among authorities, regulatory process improvements, and strengthened supervision measures. The IRRS team concluded that in addressing these recommendations Sweden's regulatory effectiveness in nuclear and radiation safety will be further enhanced.

Sweden is now carrying out the work necessary to address the recommendations and suggestions. The progress of these activities is documented according to standard procedures, aggregated annually, and will serve as the foundation for the follow-up mission. Sweden has requested coordinated IRRS and ARTEMIS follow-up missions to be conducted in the spring of 2027.

Article 9. Responsibility of licence holders

Each Contracting Party shall ensure that prime responsibility for the safety of a nuclear installation rests with the holder of the relevant licence and shall take the appropriate steps to ensure that each such licence holder meets its responsibility.

Summary statement for the article

Sweden complies with the obligations of Article 9.

Summary of significant changes and developments since the previous report

- WANO peer review activities and related development work are continuing at all plants (see section 9.2.3.1).
- IAEA SALTO reviews have been conducted for the Forsmark NPP and Oskarshamn NPP as a part of activities related to safe continued operation of the units (see section 9.2.3.2).

9.1. Regulatory requirements

The Act on Nuclear Activities (1984:3) is explicit about the prime responsibility for safety:

Section 3 in the Act on Nuclear Activities states that nuclear activities shall be conducted in a manner that fulfils all requirements on safety. Section 10 in the same act states that the holder of a licence for nuclear activities shall ensure that all necessary measures are taken to:

- Maintain safety, taking into account the nature of the activities and conditions under which they are conducted,
- Continuously perform assessment, verification and as far as reasonably achievable take measures to improve safety (and nuclear security),
- Provide for the safe management and disposal of nuclear waste arising in the activities or therein arising nuclear material which is not reused, and
- Provide for the safe decommissioning and dismantling of facilities in which nuclear activities are no longer carried out.

Section 13 in the Act on Nuclear Activities states that the licensee shall have the organisation, economical, administrative and personnel resources needed to be able to take all measures for safety and security according to the law, and that the licensee in this regard is also responsible for human resources, including appropriate qualifications and skills of hired contractors and subcontractors.

In Section 10 in the Act it is also stated that the holder of a licence for nuclear activities shall, in connection with radiological emergencies, threats or other similar circumstances, report without delay to the regulatory body such information that is of significance for the assessment of safety.

In addition, supervision by SSM shall ensure that the licensees maintain good control over the safety of the plants and that safety work is conducted with a satisfactory level of quality.

Chapter 3, Section 5 in the Radiation Protection Act states that those who are responsible for conducting activities that can cause exposure of people to ionising radiation shall take measures to keep radiation doses as low as reasonably achievable considering existing technical knowledge as well as economic and societal factors.

Chapter 2, Section 2 in SSM's regulations SSMFS 2018:1 states that all responsibilities, powers and collaborative relationships within the licensee's organisation that are related to radiation safety (or nuclear security), shall be defined and documented in the management system and known within the organisation.

SSM's regulations concerning design (SSMFS 2021:4), assessment (SSMFS 2021:5) and operation (SSMFS 2021:6) of NPPs specify the responsibility of the licensee through a number of fundamental requirements for safety management, design and construction, safety analysis and review, operations, nuclear materials and waste management and documentation including archiving. In addition, it is clearly stated within these regulations (SSMFS 2021:6, Chapter 2, Section 21) that safety shall be monitored and evaluated continuously in a systematic manner so that deficiencies that are of relevance to safety (or nuclear security) are identified and corrective measures devised. Moreover it is stated that continuous development of safety (and nuclear security) in accordance with set objectives and guidelines must be ensured.

In addition, it is clear from SSM's regulations (SSMFS 2021:6, Chapter 8, Section 2) that there shall be a prepared emergency organisation at an NPP. The emergency organisation shall be able, with the support of the emergency response plan, to handle a radiological emergency situation including any long lasting conditions.

SSM's regulations spell out three basic control principles, which clearly separate the roles of a licensee and the regulator:

- Review by SSM (in specified matters) after primary and independent safety review by the licensee.
- Notification of SSM (in specified matters) after primary and independent safety review by the licensee.
- Internal audits by the licensees according to their own management systems.

According to Chapter 7, Section 4 of SSMFS 2021:5, planned plant modifications resulting in changes to the SAR, Operational Limits and Conditions (OLCs), programme for limiting radioactive discharges, environmental monitoring programme, plan for physical protection or plan for emergency response shall be notified to SSM for review, before being implemented. After such a review SSM does not issue a formal approval, but has the mandate to prohibit the implementation of proposed changes if they are found to be unacceptable.

9.2. Implementation by licence holders

A number of measures being taken by Swedish licensees provide evidence for how they are taking prime responsibility for safety. The following subsections give examples of such measures where the activities are more or less ongoing.

9.2.1. Safety policies

The industry has adopted nuclear safety policies. Safety policies are described further in section 10.2.1.

9.2.2. Continuous improvements at the plants

The principles of continuous improvement as applied in Swedish NPPs are outlined in section 6.2. Licensees and owners ensure that the safety of their NPPs is regularly and systematically reassessed, to identify opportunities for further improvement of safety at their facilities by taking into account ageing issues, operational experience, most recent research results and developments in international standards. They also ensure that identified reasonably practicable safety improvements are carried out as appropriate and in a timely manner, and not limited to the scope and schedule of the PSRs.

9.2.3. International peer reviews

International peer reviews are performed on the initiative of the licensees. Experts from the Swedish NPP owners and operators also participate in international peer review missions including WANO, SALTO, OSART and other IAEA review missions. Participating as an expert in international peer reviews is considered to be of great value for both the individuals and their employer.

9.2.3.1. WANO peer review

Oskarshamn NPP

In September 2023, a WANO team comprised of experienced nuclear professionals from nine countries, conducted a peer review at Oskarshamn 3. The purpose of the review was to determine WANO type strengths and areas, in which improvement could be made. As a basis for the review, the team used the WANO Performance Objectives and Criteria. The goal of such peer reviews is to assist stations in achieving the highest standards of excellence in nuclear power plant operation. Operator performance observations, outage visits and design analysis, supporting the design informed review process, were performed in advance of the peer review. In total, eight areas for improvement were identified during the peer review.

Since 2022, the plant has been part of the Enhanced Performance Monitoring (ePM) service of WANO that provides members with a more continuous view of current performance and trajectory. The performance is monitored by WANO in close connection with the plant through a range of indicators. The aim is to help detect early signs of decline in performance and to address them rapidly, as well as to help high performing plants maintain their high performance. It is also used as a tool to guide other plants to improve more quickly and sustainably.

Forsmark NPP

A WANO peer review was performed at Forsmark NPP in October 2024. The purpose of the review was to determine strengths and areas in which improvements could be made. The review resulted in some identified areas for improvement (AFI). These identified areas were addressed in an action plan agreed between Forsmark and WANO.

In addition, Forsmark has implemented the ePM introduced by WANO as a measure to take the next step in the drive for excellence in nuclear operations. In ePM, a common set of indicators is used to monitor the safety and performance of the operators. The data and trends are used to analyse the performance and to provide a significant input for improvement plans.

Ringhals NPP

In November 2023, WANO performed a follow up on the AFI identified during the 2021 WANO peer review. Based on the results, Ringhals updated the improvement plan. Since the last full scope peer review at Ringhals NPP WANO has introduced the program Actions for Excellence (AfE) and ePM. Ringhals has implemented the process and is closely monitoring the progress for ePM indicators and AFI actions with the support of WANO. Ringhals is scheduled for a further WANO peer review in January 2026.

9.2.3.2. IAEA SALTO peer review

Oskarshamn NPP

In October 2024, IAEA conducted a SALTO peer review for Oskarshamn 3. The IAEA team observed that many of the ageing management and LTO activities already were in alignment with IAEA Safety Standards. The mission resulted in nine good performances and 12 areas for further improvement. The LTO project has been dealing with issues arising from the pre-SALTO mission, together with other actions needed for safe LTO of Oskarshamn 3.

A follow-up SALTO is tentatively planned for 2026. The aim is to ensure long-term and safe operation of Oskarshamn 3 and to meet the new requirements from SSM.

Forsmark NPP

Forsmark 1 and 2 passed 40 years of operation and subsequently entered LTO in 2020 and 2021, respectively. Forsmark 3 enters LTO in 2025. Forsmark initiated an IAEA SALTO peer review program in 2016 and has since then performed two pre-SALTO missions. A full SALTO was performed in 2023 for Forsmark 1 and 2 and a SALTO expert mission for Forsmark 3 was undertaken in March 2025 to complete the scope. Issues raised from the SALTO reviews are handled according to plan and will be followed up by IAEA in 2027.

Ringhals NPP

No IAEA SALTO peer review mission has been performed during this reporting period. The most recent SALTO peer review mission was performed at Ringhals NPP in 2018 and a follow-up mission was completed in 2020.

9.3. Regulatory review and control

SSM's regulatory activities involve fostering and verification of compliance. That means performing a number of inspections as a part of supervisory practices (see section 8.8).

The aim is to produce evidence on how the licensees apply principles of prime responsibility for safety in practice and in their daily work. In cases where inspections resulted in enforcement actions, these are followed up in order to check that the deviations have been given sufficient attention.

Reporting requirements are also an important aspect of the SSM's assurance that licensees continue to meet their responsibilities. According to regulations, licensees have to notify SSM of all plant and organisational modifications affecting conditions reported in the SAR, as well as modifications to the SAR itself and the OLC. The statement of the independent safety review made by the licensee must be attached to the notification.

If SSM is not satisfied with a notification, the licensee is required to supplement it, or SSM can impose further requirements or conditions on the proposed solution before it may be implemented. Further information on this process can be found under section 10.5.

Regarding severe accident management and mitigation of radiological releases, SSM carries out recurring inspections, reviews and assessments to verify the adequacy of the on site emergency preparedness and response, (EPR). Licence holders report changes to the emergency plan to SSM. In addition, SSM follows up exercises performed by licence holders through regulatory supervision.

Part III

General Safety Considerations



Article 10. Priority to safety

Each Contracting Party shall take the appropriate steps to ensure that all organisations engaged in activities directly related to nuclear installations shall establish policies that give due priority to nuclear safety.

Summary statement for the article

Sweden complies with the obligations of Article 10.

Summary of significant changes and developments since the previous report

- The new regulations covering design (SSMFS 2021:4), assessment (SSMFS 2021:5) and operation (SSMFS 2021:6) of NPPs, which entered into force on 1 March 2022, constitutes a comprehensive collection of regulations in areas of relevance to safety, provide a graded approach, and a closer adaptation to international standards developed by IAEA and WENRA than was the case with previous regulations (see section 10.1.2).
- SSM has continued to encourage an emphasis by licensees on systematic work methods and prioritisation of safety in decision-making (see section 10.5).

10.1. Regulatory requirements

In section 7.2, a comprehensive description is provided of national safety and radiation protection regulations. Section 7.2.1 summarises the current status of SSM's regulations for nuclear safety and radiation protection.

10.1.1. Examples of specific requirements in National Act and SSMFS

10.1.1.1. Act on Nuclear Activities (1984:3)

Section 3 of the Act on Nuclear Activities states that all nuclear activities shall be performed in such a manner that all requirements on safety (and nuclear security) are fulfilled, and that Sweden's obligations regarding non-proliferation are met. It also states that the competent authority has the authorisation to issue requirements as needed for such obligations to be met.

Section 3a of the Act on Nuclear Activities states that a nuclear facility should be designed, built, commissioned, operated and decommissioned in such a manner that radiological emergencies are avoided, and that the consequences of the emergency can be handled if a radiological emergency occurs.

Section 4 of the Act on Nuclear Activities states that the safety (and nuclear security) at a nuclear facility should be maintained through measures required to prevent failures in equipment, faults in equipment, human error, sabotage or other situations that can result in a radiological emergency, and to prevent the unlawful handling of nuclear material or waste.

Section 10 of the Act on Nuclear Activities states that the licensee is accountable for the safe (and secure) operation of the nuclear facility, and should continuously and systematically assess, verify, and as long as reasonably achievable, enhance the safety in the operations and the facilities where operation is performed. The Act also states that the licensee, in the event of a radiological emergency, a threat or other similar circumstance, immediately report to the competent authority any information necessary for the assessment of the situation.

Section 10a of the Act states that licensees shall, at least every ten years, perform a new systematic comprehensive assessment of safety (and nuclear security) (i.e. PSR) and how the safety of the plant complies with all applicable requirements. In this assessment, the licensee shall determine how safety can be upheld and improved until the next comprehensive assessment or until the facility has been decommissioned.

10.1.1.2. SSMFS 2018:1 Basic requirements for all licenced activities with ionising radiation

Chapter 2, Section 2 of SSMFS 2018:1 requires the use of a facility-specific implementation of “defence in depth” to achieve safety (and nuclear security).

Chapter 3, Section 1 of SSMFS 2018:1 requires that the operating organisation of all licensed activities involving ionising radiation be structured so as to ensure that safety (and nuclear security) can be achieved and maintained in both a short- and a long-term perspective. Also, Chapter 3, Section 2 of SSMFS 2018:1 states that roles, responsibilities, levels of authority and cooperation shall be defined for staff having tasks of importance for safety.

Chapter 3, Section 4 of SSMFS 2018:1 requires that a management system be implemented and kept up to date so that requirements on safety (and nuclear security) are met for all relevant activities. Also, Chapter 3, Section 5 requires that the management system uses established goals, strategies, plans and objectives for the organisation, to achieve this. Chapter 3, Section 6 requires that the leadership and management shall promote the culture required for the safe operation.

Chapter 3, Section 14 sets requirements for the purpose of systematically ensuring that all persons working in the licensed activities involving ionising radiation are given the working conditions needed to safely carry out their work. Chapter 3, Sections 14 and 15 further require that the licensee shall systematically assure that those who work in the operation are given the necessary prerequisites to work in a safe way. In achieving this, a Human-Techology-Organisation (HTO) perspective shall be applied. Both facility design and tools used during work, as well as the physical environment, shall be adapted to those who work in the operation and their tasks.

According to Chapter 3, Section 16, experiences important to safety, from own operation or other similar operation, shall be collected, assessed and used to improve safety. As a part of this, Chapter 3, Section 17 requires that persons working with the activities are encouraged to report events and conditions that could imply a safety risk.

10.1.2. General overview of requirements for priority to safety in SSM's regulations (SSMFS)

SSM has structured its regulatory requirements in three levels, where the top level for nuclear installations constitutes fundamental requirements that are applicable for all licensed activities with ionising radiation (SSMFS 2018:1). These basic requirements contain regulatory provisions common to all such activities and is intended to complement general requirements established in acts and ordinances. Chapter 2, Section 1 of these regulations states that measures shall be taken so that activities are conducted in a manner that ensures safety (and nuclear security) while Chapter 3, Section 3 further establishes requirements on the organisation needed to achieve this. Chapter 3, Section 6 of SSMFS 2018:1 establishes the basic requirements for a safety culture that pays attention to safety (and nuclear security) and that prioritises this using a graded approach. Some of these fundamental requirements are detailed, while other basic requirements are further developed for specific activities at lower levels within the hierarchy of the Code of Statutes.

At the second level of regulatory requirements there are provisions relating to the design, construction, assessment, reporting and operation of nuclear installations. Requirements at this level complements those at the first level, and in some cases also complement the underlying acts and ordinances. There are three sets of requirements for nuclear installations, which complement each other by addressing different aspects.

- SSMFS 2021:4 on the design of NPPs.
- SSMFS 2021:5 on the assessment of NPPs.
- SSMFS 2021:6 on the operation of NPPs.

Chapter 4 of the regulations on design of NPPs (SSMFS 2021:4) establishes basic design requirements using a graded approach, where items, manual tasks and organisational conditions most important to safety (or nuclear security) are given priority over those of less significance. After the basic identification and classification of all items, manual tasks and organisational conditions according to their significance (Chapter 4, Section 9 and 10), this graded approach is then used in establishing requirements on e.g. equipment reliability, scope and design of procedures, maintenance, surveillance and in-service inspections, as well as the management of plant modifications. Also according to Chapter 4, Section 8, measures taken to fulfil functions for safety (and nuclear security) shall be balanced so that functions do not impede each other and so that the best overall solution is found.

Chapter 2, Section 2 of the regulations on operation of NPPs (SSMFS 2021:6) states that all decision making important to safety (or nuclear security), shall be preceded by the preparation and advice necessary to ensure prioritisation and comprehensive coverage of safety (and nuclear security). Chapter 2, Section 3 regulates the role of an independent function within the licence holder for issues of priority to safety. The independent function has a three-fold role of being a proponent for the development of safety, a sentinel to ensure that operations comply with regulations, and an auditor of safe operations. The independent function must have the resources and competences required to perform its tasks. According to Chapter 2, Section 16 to 19 of SSMFS 2021:6, suspected or detected deficiencies, events and conditions of negative importance for safety (or nuclear security) shall be handled and managed according to their severity, using the categorisation found in Appendix 1 in the regulations. The requirements on reporting to SSM found in Chapter 9, Section 1 of SSMFS 2021:6 follow the same principle.

In Chapter 2 of SSMFS 2021:6 there are requirements on formulating goals and guidelines for operations in a measurable way (Section 1), and to continuously and systematically monitor and evaluate safety by using performance indicators. According to regulations in Chapter 2, Section 8 of SSMFS 2021:6, all modifications must be assessed for their importance to safety. For modifications with a non negligible importance for safety, a safety demonstration shall be performed.

According to Chapter 7, Section 4 of SSMFS 2021:5, SSM shall be notified of any modifications affecting the contents of or underlying basis for the for SAR.

At the third level of the regulatory requirements hierarchy there are provisions on specific aspects of design, construction and operation of facilities, whereby some of the requirements established at level 1 and 2 are complemented in different aspects. The level 3 requirements do not contain all aspects of design, construction and operation at level 1 and 2.

10.2. Implementation by licence holders

10.2.1. Safety policies

The industry has adopted nuclear safety policies. These safety policies are the highest level documents expressing key corporate values, and are valid for all nuclear operations. The policies express a fundamental perspective on matters of safety and establish levels of ambition and priorities, such as the following:

- Fostering a strong safety culture.
- Building a culture of continuous improvement.
- The contribution from all individuals.
- The key role played by leadership.
- Practising informed decision-making at all levels.
- Implementation of ALARA.
- Implementation of defence-in-depth.
- Ensuring effective EPR.
- Ensuring necessary financial, administrative and human resources.
- Recognising lessons learnt, operating experience, research and good practices to further improve nuclear safety.

10.2.2. Safety management provisions

All licensees have safety committees in order to review major and principal safety issues and to follow up and assess the safety situation at the plants.

All licensees have quite similar structure in place for safety management and review, where the responsibilities and levels of authority of the different levels of management are clearly defined.

The basic principles for all Swedish NPPs are the following:

- Safety management level 1 is responsible for the overall safety review process, and for specific safety issues forwarded to the manager from lower levels (2 and 3). Level 1 responsibility includes issuing policies, the safety management system and company directives for nuclear safety, as well as sanctioning deviations. Safety management level 1 is often represented by the plant manager.
- Safety management level 2 is responsible for long-term safety issues, manuals and procedures. Level 2 is also responsible for the unit-related safety reviews. Additionally, level 2 has to ensure that the unit Safety Analysis Report (SAR) is up to date and reflects sound safety practices. Level 2 performs follow-ups on deviations, trends and operating experience. Deviations from regulations, company norms and policies should be reported to safety management level 1. Level 2 also has the role of sanctioning procedures relating to the extent of work on safety-related equipment, and ensuring that documentation fulfils the requirements.
- Safety management level 3 is responsible for safe operation within the limits of procedures and technical specifications. Level 3 is also responsible for all work permits regarding safety-related equipment. Safety-related deviations should be reported to safety management level 2.

Independent safety reviews are carried out by the safety and quality departments. The management structure outlines:

- Reporting criteria and requirements.
- Criteria for regular and periodical (daily and weekly) operational meetings including criteria for shift change-over.
- Issues to be handled within the company's safety review committee.
- Requirements regarding plant modifications (technical and organisational).

All licensees have safety programmes in place as a part of the management system documentation. They contain priorities and schedules for technical, organisational and administrative measures to be implemented as a result of safety analyses, audits, safety culture surveys and other evaluations conducted at the plant.

10.3. Measures taken at the nuclear power plants

Ringhals NPP

The level of safety in plant operations is monitored in several ways, including the use of performance indicators. The quality indicators measure factors such as unplanned automatic scrams, fuel integrity, safety systems performance, safety culture, and work-related injuries. The indicators are periodically reviewed (monthly or quarterly) by the management team. Any deviation from expected performance is analysed and actions for improvement are decided on by the plant manager.

During the last three years, safety management has been adjusted in accordance with the Ringhals CEO's allocation of tasks across the organisation by introducing operation and design authority management. Safety issues with a direct impact on the safe operation of the plant are dealt with by the operation management, and safety issues without a direct impact on the plant are evaluated by design authority.

Safety management has been divided into four safety evaluation levels according to complexity and impact.

Forsmark NPP

The company policy sets safety as the highest priority. The policy is implemented in the management system and in the governance of the safety of the plant. The level of safety in plant operations is monitored in several ways, including the use of performance indicators.

Oskarshamn NPP

The level of safety in plant operations is monitored in several ways, including the use of performance indicators. The performance indicators are linked to the company's strategic goals.

The indicators are periodically reviewed (monthly or quarterly) by the management team. Any deviation from expected performance is analysed and actions for improvement are decided. Selected indicators, their results, and corrective actions to improve performance are presented to the board on a quarterly basis. All results are also presented on the intranet.

The concept of "Operational Excellence" is being used at the Oskarshamn NPP. Operational Excellence is an approach where everyone at the company strives to become a little better every day by understanding their task and how it relates to colleagues in other departments, units and groups, understanding how work can be improved in a methodical way, knowing what internal and external customers are asking for, working in a structured way with continuous improvements and trying to improve every day, where the goal is to achieve the company's vision and strategic goals.

10.3.1. Safety culture programmes

Maintaining a strong safety culture throughout an NPP's lifecycle is considered a vital aspect by the Swedish utilities. Safety culture is emphasised in the policies of the different plants and in their strategic planning. Management at all levels, including the managing directors, is involved in activities to enhance the safety culture and to stress the responsibility of all personnel to work actively in maintaining and developing the safety culture standard. For further information see section 12.2.1.

10.3.2. Use of WANO Performance Indicators

All NPP licensees in Sweden utilise the complete WANO programme of Performance Indicators including the WANO Indicator Index. They have additionally introduced WANO's Enhanced Performance Monitoring (ePM) service. WANO describes the ePM as a structured and systematic approach to engaging with and supporting member plants to ensure that performance is sustained at or above the industry performance goals while continuing to improve towards the industry standards of excellence.

10.3.3. Vattenfall's Corporate Independent Nuclear Safety Oversight (CINSO)

The CEO of Vattenfall conducts independent oversight of nuclear safety and performance through two functions independent from the operating organisation: the CINSO function, and the Nuclear Safety Council (NSC).

CINSO focuses on corporate performance in nuclear safety as well as on common nuclear safety related issues or concerns relevant for more than one licensee within Vattenfall nuclear operations. The CINSO group reports directly to the CEO of Vattenfall and is an independent function from the site-specific independent nuclear safety organisation (INSO functions) that report directly to the plant licensee CEO and the licensee Board. CINSO has the task of providing advice to the CEO of Vattenfall on the basis of an independent and diversified perspective. The independent oversight work should be strategic, enabling the CEO to be well-informed in matters that may have consequences for nuclear safety and performance. By reporting its findings, the CINSO function also provides added value to the Chief Nuclear Officer (CNO) of Vattenfall and the licence holders. The CNO reports directly to the CEO.

NSC consists of external (national and international) experts possessing extensive experience from the nuclear field. The members of the NSC are appointed by the CEO of Vattenfall, and the CEO is Chair of NSC. The NSC advises the Vattenfall CEO on matters of nuclear safety and performance from an external perspective. The CNO and head of CINSO participate in the NSC meetings.

10.3.3.1. Whistleblowing function

CINSO has a whistleblowing function, i.e. anyone within the Vattenfall organisation may contact CINSO regarding concerns on nuclear safety related issues.

The whistleblowing function has a broad scope and any serious concerns related to nuclear and radiation safety may be reported to CINSO, whether they concern technical matters, competence, safety management, safety culture etc., or cases of non-compliance by the line organisation.

10.3.4. Sydkraft Nuclear Power Sweden AB's (SNP) Corporate independent oversight (CINSO)

According to the Act on Nuclear Activities and requirements from SSM, the licence holder has the full responsibility for nuclear safety. This means that the licence holders have full responsibility for taking measures to comply with the legislation. Additionally, all nuclear activities at Uniper shall comply with the Uniper Nuclear Safety Policy, which also constitutes an important point of reference for CINSO.

CINSO is an independent function which reports directly to the CNO of Sydkraft, but also to SNP's board of directors and the managing directors of the plants. CINSO's purpose is to create an additional layer of defence in depth by advising top management on nuclear safety and performance. CINSO regularly performs nuclear safety assessments to identify areas for improvements and to give a second opinion to the line organisation's safety oversight. Processes and performances are systematically assessed, and identified gaps are reported to the line organisation for decision making and actions. Recommendations made by CINSO are followed until completion.

The basis for CINSO's process is to challenge safety performance above legal requirements to the level of international safety criteria and best practice. Activities are planned to ensure that all relevant nuclear safety aspects are covered, thus providing the means to work systematically and to be proactive.

Several different evaluations of the function of CINSO are regularly performed. Moreover, the effectiveness of the CINSO process is self-assessed annually.

Uniper also has a Nuclear Safety Council, UNSC, which serves as the highest independent review function within the organisation. UNSC consists of senior external nuclear experts and provides recommendations to the top management based on assessments of plant and corporate nuclear safety performance.

10.3.4.1. Whistleblowing function

The whistleblowing function at the Oskarshamn NPP is a way of reporting about irregularities or violations that affect people, organisation, society or the environment. It is also a way in which individuals can take responsibility for reporting unethical behaviour.

A report can be made by anyone who is, was or could be at some point working at or with the Oskarshamn NPP. It should relate to something within the business area of the Oskarshamn NPP. It is not necessary to have access to an Oskarshamn NPP computer or the intranet, a report can be made using the Oskarshamn NPP app, for example.

All information that goes in the report is protected and handled by a third part, and the person who is reporting remains anonymous.

10.3.4.2. Legislation board at OKG Aktiebolag

Uniper, as the owner, governs the Oskarshamn NPP through recommendations and business strategies.

The licensee for the Oskarshamn NPP (OKG Aktiebolag), assesses whether, and the extent to which, these recommendations and strategies comply with the regulatory requirements. This assessment, which is conducted by the legislation board, identifies gaps between Uniper's recommendations and strategies in relation to the regulations and the impact on the Oskarshamn NPP from the perspectives of current legislation and safety requirements.

10.4. Regulatory review and control

SSM performs a number of regulatory activities in order to verify that the licensees comply with the requirements and give adequate priority to safety (see section 8.8). The supervision programme (8.8.2) describes baseline supervision that is designed to cover every requirement at least once over a ten year period. Priority on safety-related issues is targeted to be assessed in most individual supervision activities. Examples of inspection areas include: licensee safety programmes, management of organisational changes, management of safety reviews, and management and assessment of incidents. The baseline supervision is complemented by an annually defined demand-based supervision, whereby SSM identifies potential needs for supervision to be carried out for a specific area ahead of schedule, or for an aspect that is not yet in the programme.

Another tool used for evaluating whether the licensees are assigning adequate priority to safety is the integrated safety assessment (see section 8.8.5). Results from all supervision activities performed for each licensee, typically over a period of two years, are assessed by a diverse SSM expert team. Among other aspects they review and assess the licensees' priority to safety. The integrated safety assessment provides a regularly updated and comprehensive regulatory assessment of safety (and nuclear security) at each facility.

Furthermore, SSM monitors the licensees' work on safety culture issues. Apart from being a part of the baseline supervision programme, safety culture is an aspect addressed in many inspections. The role of SSM in this context is to ensure that the licensees have a proactive approach to safety management in place. SSM expects the licensees to establish and maintain a strong safety culture. It is essential that the licensees react in a timely manner to indications of deficiencies in their safety culture.

At least once a year, the director general and department directors of SSM meet with the management group of each NPP to discuss current issues and safety priorities.

SSM has an established procedure with specified criteria to assess notifications of plant and organisational modifications, and to decide whether a modification is sufficiently important from a safety point of view to warrant detailed review (see section 14.3.5). The process of pre-reviewing of notifications by the licensee is an efficient and effective procedure that meets the expectations of SSM. It also ensures that SSM has the necessary regulatory overview over the modifications without having to review everything in great detail or to grant specific permissions. This has enabled SSM to allocate resources to more important safety tasks in accordance with a graded approach, while also retaining full insight into the measures taken by the licensees.

Through its supervision, SSM has concluded that the licensees have a satisfactory compliance with SSM's requirements regarding priority to safety.

Nevertheless, during the reporting period SSM has identified different challenges to the NPPs' priority to safety. These were linked to e.g. deficiencies in governance, communication, insufficient conservatism in decisions and in the governance and management of contractors.

During the reporting period, SSM has issued three injunctions regarding the NPPs priority to safety. The NPPs have complied with the injunctions, and SSM has closely monitored the continued developments in the area.

10.5. Actions taken by SSM to prioritise safety

One of the basic concepts of SSM's supervisory programme is to dedicate supervisory resources to key safety issues. The annual activity planning process has, as its starting point, current regulatory challenges, which are documented, as well as input from SSM's integrated safety assessments and other regulatory processes. The supervisory database in use is an important tool for integrated safety assessments, but it is also used to prioritise upcoming supervisory activities related to key safety issues. Inspection results, international experiences, research and other inputs may indicate that SSM needs to focus regulatory resources on specific facilities or safety issues.

Moreover, the provisions of Chapter 2, Section 8 of SSMFS 2021:6 enable SSM to apply a flexible approach to reviewing plant modifications, safety cases and technical specifications. The licensees are required to notify SSM of such modifications, as well as to notify SSM of all plant and organisational modifications affecting conditions reported in the SAR, including modifications to the SAR itself, and to the OLCs. The statement from the independent safety review conducted by the licensee must be attached to the notifications. SSM checks that the independent review report attached to the notification is of sufficient quality. Notifications dealing with new or complex technology are usually reviewed further by SSM, assisted by external experts if necessary. SSM must be notified of major plant modifications and their implications in the form of a preliminary safety analysis report, in order to systematically clarify all interactions with the existing safety case. Following commissioning and the first entry of the plant into routine operation, necessary findings are to be incorporated in the SAR, and the SAR shall be finalised so that it describes and represents NPP's as-built status.

Article 11. Financial and human resources

1. Each Contracting Party shall take the appropriate steps to ensure that adequate financial resources are available to support the safety of each nuclear installation throughout its life.
2. Each Contracting Party shall take the appropriate steps to ensure that sufficient numbers of qualified staff with appropriate education, training and retraining are available for all safety-related activities in or for each nuclear installation, throughout its life.

Summary statement for the article

Sweden complies with the obligations of Article 11.

Summary of significant changes and developments since the previous report

- The licensees have sustained a strong focus on maintaining staff and critical competencies (see section 11.2.2.1–11.2.2.3). However, at some plants the licensees face challenges in securing competence and staff for certain aspects of the operation, and for outages (see section 11.3).

11.1. Regulatory requirements

In section 7.2, a comprehensive description is provided of national safety and radiation protection regulations, and in section 7.2.1, a description of SSM's regulations for nuclear safety and radiation protection.

11.1.1. Examples of specific requirements in National Act and SSMFS

11.1.1.1. Act on Nuclear Activities (1984:3)

In order to hold a licence for nuclear activities, Section 13 of Act on Nuclear Activities requires that a licensee (or applicant) must have the economic, personnel and administrative resources needed to fulfil the requirements on safety according to the law, including any requirements issued by the competent authority. Section 13 further clarifies that the licensee is accountable for ensuring that any external resources providing services to the licensee having the required personnel resources, qualifications and competences.

In addition to this basic requirement on financial resources, licensees must pay a fee on each produced kWh to a state-controlled fund, the Nuclear Waste Fund, as directed by the Act on Financing of Management of Residual Products from Nuclear Activities (2006:647). This is to ensure that financing is available for future decommissioning and the management and disposal of spent fuel and nuclear waste, including the research, regulation and supervision needed for these activities. If there is insufficient assets in the Fund to pay for the costs, the licensees will nevertheless still be accountable for the costs. The power plant licensees shall also provide two separate financial guarantees as collateral in order to account for possible early shutdowns and for costs in connection with unforeseen events.

Licensees are furthermore required to pay regulatory and research fees levied by the regulatory body. These fees are laid down in ordinances and are payable to the Government, see also section 8.5.4.

As mentioned under 10.1 above, Section 3 of the Act on Nuclear Activities requires that the safety requirements be fulfilled in all nuclear activities. Section 13 of the same Act, further requires that licensees have the required operating organisation, financial, administrative and personnel resources to achieve this.

11.1.1.2. Requirements by the Swedish Radiation Safety Authority (SSM)

In Chapter 3, Section 10 of SSMFS 2018:1 there are requirements for staffing, competence and training of personnel for all activities of importance to safety. The licensee has to ensure that all those who perform work in facility operations have the competence and suitability needed for tasks of importance for safety or security. This also applies to contractors and sub-contractors. The way in which this is achieved must be documented. A systematic approach should be used for the definition of competence requirements, for providing assurance that individual competence requirements are met, and for planning and evaluation of safety-related training.

Chapter 3, Section 11 of SSMFS 2018:1 requires that the competence necessary for ordering, managing and evaluating contracted work should always exist within the organisation of a nuclear installation. Furthermore, long-term planning is required in order to ensure a sufficient workforce with adequate competence and suitability is available to undertake safety-related tasks. The requirement also states that, for safety-related tasks, the licensee must give careful consideration to the balance between the use of in-house personnel and contractors or hired staff.

In Chapter 3 of SSMFS 2021:6, most of the requirements on staffing and competence specific to the operation of NPPs are presented. The requirements specify the need for a systematic approach to documenting how to identify and achieve the competence needed for operating an NPP, in the short and long term. For all individuals with tasks of importance to safety the required competence must be confirmed on a recurring basis, with a periodicity appropriate to their importance for safety. For personnel in the main control room there are specific requirements on annual training and the use of full-scope simulator.

In SSMFS 2021:4 there are requirements on the competence needed for the design and construction of an NPP, including modifications to an existing plant. There are also requirements on the design and use of a full-scope simulator.

11.2. Implementation by licence holders

11.2.1. Financial resources

The majority owners of the Swedish NPPs are Vattenfall and Sydkraft NP, see section 1.3.2 and figure 2. The Swedish state is the sole owner of Vattenfall, while the owner of Sydkraft NP is the German energy company, Uniper SE.

Vattenfall and Uniper are two large electrical power utility companies in Sweden and elsewhere in Europe. In addition to the NPPs, they also have substantial assets in hydropower, thermal power and wind power. Both owner groups are financially stable and have good financial records.

To date, all safety investments in the NPPs are decided by the board of the reactor companies and have been financed by loans from the owner. A high safety level, demonstrated by a good safety record, is considered an essential component of the total business concept and as legal and commercial grounds for the licensees. Costs for safety improvements are considered an integrated part of the operating costs.

11.2.2. Staffing

The number of employees working for the NPP licensees has been changing somewhat over the past few years, see table 5. Consultants and contractors are not included in these figures. The number of contractors used during a unit refuelling outage, normally lasting between two to five weeks, is typically between 500 and 1,000. The decisions taken in 2015 by the plant owners to decommission in total four reactors at the Oskarshamn and Ringhals sites, and the subsequent initiation of decommissioning activities at the respective sites, have led to stepwise decreases of staffing numbers at those plants, while at Forsmark the number of employees has been relatively stable.

Table 5. Number of employees working for the licensees.

Operator	2024	2023	2022	2021	2020	2019	2018
Oskarshamn*	604	586	567	561	555	575	629
Forsmark	1,200	1,160	1,145	1,145	1,152	1,154	1,166
Ringhals**	1,059	1,023	977	1,017	1,194	1,277	1,375

* Note: Decision to decommission in 2015. Decommissioning initiated for two units in 2017.

** Note: Decision to decommission in 2015. Decommissioning initiated for two units in 2019 and 2020, respectively.

A challenging factor regarding the continued use of consultants is that only few of those who have experience from the start of the nuclear programme are now available.

The staffing and competence planning at the plants has been reinforced over the past few years. The need for high-level competence in specific areas has been identified and competence profiles have been defined. By comparing these profiles with the available expertise, the need for development and training of employees and for recruitment has been assessed.

The need to “rejuvenate” the NPP organisations is obvious, considering the average age of the staff. At Oskarshamn NPP, the average employee working today is 49 years old, the male/female ratio is about 80/20, and it is expected that about 3 % of the employees will go into retirement over the coming years. The situation is broadly comparable at Forsmark and Ringhals NPPs.

All licensees work actively to transfer knowledge to the next generation from those experienced staff soon to retire. The planning for this work builds on mapping of strategic competence needs and individual plans to replace key personnel. Other approaches include trainee programmes and the involvement of young engineers together with highly experienced staff in modernisation and development projects as well as in international R&D projects. Current competence planning at the different sites is described below.

11.2.2.1. Competence assurance at Oskarshamn NPP

Since last reporting period, no major changes have been made regarding the procedure for transferring competence at Oskarshamn NPP.

The short term objective is still to:

- In every group, create a plan for the upcoming need for transferring of competence; and
- From this plan, create individual plans for those who are expected to leave the company within the next few years.

The longer-term perspective remains to:

- Create an environment in day-to-day operations that stimulates transfer of competence.

During the autumn of 2015, the company board took a definitive decision to begin the decommissioning of units 1 and 2, starting immediately at unit 2 and after the summer of 2017 at unit 1. Consequently, many of the procedures regarding competence and staffing have been further developed in order for Oskarshamn NPP to meet the challenges of keeping two units in decommissioning and one unit in long-term operation. Oskarshamn NPP must be successful in maintaining strategic competencies and obtaining new competencies simultaneously.

Oskarshamn NPP has performed a staffing and competence analysis for the remaining business time frame for the period 2015–2050. The aim of this analysis was to assess the need for various competencies and estimate staffing levels during the entire expected life span of the company. The experience and the results from the transition within the company is that new working methods are being developed as a result of a reduced total workload, with fewer employees, and to address simultaneous production and decommissioning, with an increasing workload in the area of decommissioning. This means that analyses based on previous assessments gradually become out of date and there is a recurring need to reconsider parts of previous analyses. In accordance with Oskarshamn NPP’s routines, a review of the staffing analyses is carried out annually.

On a more detailed level, mapping of key competencies has been carried out at the company. This has given Oskarshamn NPP a comprehensive picture of key positions and individuals within the company, which in itself has provided a basis for planning strategies and conducting long-term development planning for the whole organisation in a more robust manner. Examples of activities that have been undertaken to address the challenge of staffing and competence within the Oskarshamn NPP and in the industry as a whole include strengthening of the brand, expanding contacts with the education system, and deepening collaboration with regional businesses and various types of industry. This includes the BWR Future initiative, an investigation in which Nordic licensees and suppliers jointly map available competences in the area of BWR technology. Oskarshamn NPP also needs to maintain an environment where employees are encouraged to move between different positions, thus developing their competence and leaving new positions open for others.

The need to supply appropriate levels of resource for additional, changed and existing competence areas requires a structured and goal-oriented work with competence assurance. It also requires an effective use of tools such as plans for competence development, competence transfer and succession planning. This applies to both the competence needed for the decommissioning of Oskarshamn 1 and 2 and the competence needed for the long-term operation of Oskarshamn 3.

Transition work at Oskarshamn NPP

The overall strategy for the transition work has been to create an image of Oskarshamn NPP that all employees are proud to be part of, and to enable those who have been let go by the company, and have the desire to start working for the company again, to do so if the possibility arises. Lately, former employees have been returning to Oskarshamn NPP.

In 2020, an annual process began for long-term competence management with the aim to meet and deal with the challenges and opportunities that follow from simultaneously operating one single unit in production and two units under decommissioning. As a result of this annual process, joint work has been established within Uniper Nuclear Sweden in areas such as competence assurance, employer attractiveness and supplier market. Work within these areas is ongoing and is planned to continue for as long as the decommissioning activities last.

11.2.2.2. Competence assurance at Ringhals NPP

Ringhals competence assurance vision is: *Right and Diverse Competence – As an employer of choice, we attract, retain and enhance the right competence for today and the future to ensure a sustainable long term competence supply.* To achieve this, Ringhals systematically and strategically works with competence supply processes.

All tasks at Ringhals NPP are analysed and evaluated to ensure the right expertise for the task and its impact on nuclear and radiation safety. These analyses form the basis for training programs and the need for retraining. Individual performance reviews regarding competence, training requirements, and skill enhancement occur annually and are registered in a digital system. Every year, a competence inventory is conducted for the organisation, and based on this, action plans are made to secure competence.

During retirement or resignation, knowledge transfer takes place as senior employees pass on their skills to junior employees. This is conducted systematically based on a competence exchange program, and since it can be a process that takes several years, it needs to be initiated well in advance before the end of an employment.

To develop the competence of employees, a suitable form of learning is used, such as classroom training, e-learning, on-the-job training, job rotation, or instructions. To ensure a systematic approach in managing competence and training needs, the IAEA's SAT methodology is utilised in the development of training (Systematic Approach to Training).

Increased focus has been placed on employer branding and student relations. To attract a diverse range of talents with different educations and skills, Ringhals has increased awareness of the variety of tasks and areas that it is possible to work within. It has also been important to promote an increased interest in technical education and establish a close collaboration with schools and educational institutions.

11.2.2.3. Competence assurance at Forsmark NPP

Competence assurance is of highest priority in daily work and a fundamental strategic issue for the safe and stable long term operation of the reactors. A long term strategic approach is used in the annual update of the staffing plan. A competence analysis is also updated annually in order to identify critical competences and the possible need for specific mitigating actions. An extensive task analysis is used to build the training programs for each competence. Managers are accountable to make sure the staff meets the necessary competence when required.

11.2.2.4. Training of nuclear power plant staff

All licensees have a systematic approach in place for training of operators. Training programmes are developed based on task analysis and definitions of required competence. A systematic method is also used to define the annual re-training that is required. The training programmes include theoretical courses, on-site training with experienced colleagues and full scope simulator training, as well as training performed in a workplace environment.

Control room personnel are subject to an internal promotion schedule in which the operators begin working as field operators. The qualification time to become a reactor operator is about five years, and to become a shift supervisor, a minimum of seven years.

The mandatory training programmes typically include basic courses in nuclear technology and safety, plant knowledge including systems, processes and dynamics, operational limits and conditions (Tech-Spec), radiation protection, plant organisation and work routines. Operational personnel are given extended courses on systems, processes and dynamics, transients and accident scenarios, operational procedures, emergency operating procedures, and Tech-Spec.

The control room operators receive about 10 days of annual re-training, partly on a simulator, divided into two periods: one that focuses on normal operation startup and shutdown procedures, and one on transients and accidents. All simulator sessions are evaluated systematically.

Competence assessments against specified criteria are performed each year by operations management. This is to check the required competence for the specific position and to define further training needs. Every third year, an extended check is also performed with regard to fitness for duty. This extended check is required for issuance of the authorisation, which is valid for three years. The systematic approach is being extended to encompass maintenance staff and other groups with tasks of importance for safety.

The line managers of the operating organisations are responsible for the training of their staff and for providing the necessary resources. KSU (the Swedish Nuclear Training and Safety Centre) has been contracted by the licensees to carry out most of the operator training and annual re-training. The training and competence follow-up systems are audited by the licensees on a regular basis to ensure that they fulfil specifications and requirements. Procedures for plant and safety documentation modifications ensure that such modifications are introduced into the training programmes. The annual training inventories ensure that domestic and relevant international operational experience is incorporated into the training programmes.

KSU has significant resources for training and production of training material. The total number of training days per year during the current reporting period varies in the range 4,000–5,000 days. KSU also has an extensive instructor training programme for its own staff with several qualification levels.

Since 2000, all operator training has been moved from the KSU central facility in Studsvik to local centres situated near the NPPs. Full-scale simulators for all operating reactors are now located at these local training centres.

The degree of training has decreased in the past few years due to the completion of the extensive modernisation programmes. The number of training days is estimated to be reduced yet further over the forthcoming five years due to the decommissioning of four units at Swedish NPPs. The need for future training in decommissioning activities is expected to slightly increase, though this estimation remains uncertain.

11.3. Regulatory review and control

As described in section 8.8.2, SSM has a supervision programme that covers human resource provision at the licensees' plants. Financial resources per se is not directly addressed by SSM but by another authority, the Swedish National Dept Office.

Through its supervision, SSM has concluded that the licensees achieve satisfactory compliance with SSM's regulatory requirements regarding the number of staff and their competence. The required systematic approach is in place to ensure long term staffing and competence, including health checks, as well as systems for ensuring the competence of consultants and contractors.

However, at some plants the licensees have challenges in securing competence and staff for parts of the operation, and for outages. Challenges in achieving a suitable balance between in-house personnel and contractors have also been identified.

Article 12. Human Factors

Each Contracting Party shall take the appropriate steps to ensure that the capabilities and limitations of human performance are taken into account throughout the life of a nuclear installation.

Summary statement for the article

Sweden complies with the obligations of Article 12.

Summary of significant changes and developments since the previous report

- The new regulations that entered into force in March 2022 require a systematic approach to Human-Technology-Organisation (HTO) to be considered already in the design process for NPPs (see 12.1.1).

Introduction

The area of human factors is often coupled with organisational factors to form “human and organisational factors” as a way to highlight the breadth of the areas covered and their interrelationship. Sometimes the term HFE “Human Factors Engineering” is used to describe the design aspect of this field. The Swedish nuclear industry has for some time used the term HTO, standing for a systematic approach to the area of Human-Technology-Organisation, in design as well as in operations. This term is also used in the SSM’s regulations, SSMFS.

12.1. Regulatory requirements

There are no specific requirements on human factors in the Act on Nuclear Activities. For requirements on human and administrative resources see section 11.

12.1.1. Examples of specific requirements in SSMFS

In the specific requirements for the design (SSMFS 2021:4), assessment (SSMFS 2021:5) and operation (SSMFS 2021:6) of NPPs, the role of the human is seen as part of a holistic perspective on what is required for the safe operation of an NPP. Furthermore, in the regulations on the design, assessment, and operation of NPPs, the term “human tasks” is introduced as a complement to passive and automated tasks assigned to equipment – putting emphasis on the human in the system, and thus the need for adequate resources and conditions for carrying out those tasks in the integrated system that is the NPP. The term human tasks is defined in SSMFS 2021:4 as tasks that involve a human identifying the need for, evaluating, and deciding on or implementing actions that fulfil or maintain the safety functions of areas, spaces, structures, systems and components or non-installed equipment.

SSMFS 2018:1 governs a wide range of requirements related to human and organisational factors, which in conjunction with requirements contained in SSMFS 2021:4, SSMFS 2021:5 and SSMFS 2021:6, impose extensive requirements relating to human factors on e.g.:

- Safety monitoring and follow-ups,
- The operating organisation and its design,
- Management system, including safety culture,
- Safety objectives and strategies,
- Responsibilities and levels of authority,
- Competence assurance, fitness for duty,
- Planning of nuclear activities,
- Design adapted to human capabilities and limitations,
- Operational experience feedback, and
- Event investigation.

Chapter 4, Sections 18–20 of SSMFS 2021:4 present general regulatory provisions related to incorporating human factors engineering principles in the design of an NPP, with specific requirements on control rooms and other operating positions in Chapter 7, Sections 21–24. The requirements describe the aim of minimising the likelihood for human errors, and ensuring that procedures and human tasks are included in the design, together with structures, systems and components. In Chapters 3 and 4 of SSMFS 2021:4, there are requirements on the process of design, construction and commissioning. The requirements in these chapters emphasise the importance of providing the necessary conditions for carrying out human tasks by making adapted choices regarding design solutions, materials and processes for manufacturing, installation and qualification. Chapter 3, Section 5 requires validation of human tasks before commissioning. Chapter 7 establishes requirements on the design of control rooms being adequate for the operators regarding e.g. ergonomics and usability, which shall be validated by integrated system validation (ISV), during design and commissioning.

In SSMFS 2021:5 on the assessment of NPPs there are requirements on including human tasks in the assessment of events and conditions (Chapter 3, Section 12), as well as probabilistic safety assessments (Chapter 4, Section 3). There are also requirements on human tasks being included in the SAR and OLCs.

In the regulations on the operation of NPPs (SSMFS 2021:6) there are requirements on taking human factors into account in an assessment of the implications of changes to the facility or its operations (Chapter 2, Sections 8 and 9). In Chapter 3 there are requirements on the systematic approach to securing competence for manual tasks of importance to safety, including personnel in the main control room and the use of full scope simulators in training. In Chapter 2, Section 21 there is a requirement on the systematic monitoring and evaluation of the facility's design and its fitness for purpose. In Chapter 5 of SSMFS 2021:6, there are requirements on the operations of the NPP and routines and other aids being adapted for the intended users and situations.

12.2. Implementation by licence holders

Maintaining a strong safety culture in the operation of NPPs is considered vital by the Swedish utilities, and this is emphasised in the policies of the different plants and in their strategic plans. Management at all levels, including the managing director, is involved in activities to enhance the safety culture and to stress the responsibility of all personnel to work actively in maintaining and developing the safety culture standard.

Furthermore, the concept of the systematic approach human tasks “Human-Technology-Organisation” (HTO) has become an established component in the nuclear safety work of all Swedish NPPs, with the support of policies, allocation of responsibilities and organisational structures. Currently, all the licensees have HTO specialists with a behavioural science background or similar industrial field experience in their independent safety review functions (see section 14.2.5). All licensees have specialist teams whose work focuses on human and organisational issues. The responsibility of these teams is to gather competence (both technical and behavioural) and to work with HTO issues, experience feedback, safety culture, management development and organisational issues. Typically, HTO competence is used within the licensee organisations for the following activities:

- Review of plant modifications, especially control room design issues,
- Review of organisational modifications,
- Event analysis,
- Safety culture programmes, and
- Specific development and analysis projects.

Swedish licensees use a set of specific methods for analysis of human factors events and trends. The analyses are based on both the Human Performance Enhancement System (HPES) model and behavioural science expertise. Lately, recent developments in the field of event analysis have been utilised, such as Functional Resonance Analysis Methodology (FRAM).

All licensees take into account the human factors perspective in plant modifications, through Human System Interface (HSI) analysis. To ensure that the work performance of operators and other personnel is not negatively affected, HSI is applied by means of several analyses and by dealing with known issues in the existing configuration. The modifications are ultimately subject to a verification and validation process in order to ensure safe operation. Generally, the human factors engineering process is very similar to the US NRC's Human Factors Engineering Program Review Model, NUREG 0711.

All licensees have formal procedures for assessment and review of organisational changes. These procedures ensure that relevant safety aspects are considered when such changes are notified to SSM and reviewed in the same manner as technical changes.

R&D projects in HTO have been conducted over the years on:

- Design assessment of control rooms,
- Operability verification,
- Assessment of plant changes,
- Non-destructive testing from a human factors perspective,
- Development of methods for human reliability assessments,
- Event analysis,
- Good practices in control rooms,
- Evaluation of control room function during outages,
- Team training of control room operators,
- Safety culture surveys,
- Safety diagnosis of the plant organisation,
- Assessment of organisational modifications,
- Resilience engineering in maintenance outages,
- Human performance tools in maintenance, and
- Learning from successes in maintenance (i.e. Safety II).

Research in the area of HSI, i.e. on best practices in main control rooms and research on operators' need for computer-based tools, is being conducted at the Norwegian Institute for Energy Technology (IFE) in collaboration with utilities in Sweden and Finland. Research on Resilience Engineering (RE), Human Performance (HuP) and learning from successes in maintenance is performed jointly by IFE, the VTT Technical Research Centre in Finland and Ringhals NPP in Sweden, and is sponsored by Nordic Nuclear Safety Research (NKS).

12.2.1. Ongoing activities

Oskarshamn NPP

Ever since Oskarshamn NPP's long term programme for improving safety culture was implemented in 2004, the company has worked with these aspects in a systematic way. Periodical investigations, such as a safety culture survey and a meta-analysis, have been carried out regularly. Other activities involving all staff, such as workshops discussing different topics regarding safety culture, have been popular events that brought about good discussions.

Oskarshamn NPP is still using the work- and behaviour simulator for managers and workers that shows how expectations and requirements fit into a real-world setting. The simulator takes multiple theoretical areas (such as safety culture, human performance, work safety, FME and waste management), ties them together and shows how they apply at a simulated plant work place.

The simulator has been utilised during normal operations but a special focus has been applied to training ahead of outages where the majority of internal and external personnel with work connected to the outage has been involved.

A human performance simulator was developed at Oskarshamn NPP in 2018. The aim of the simulator is to have employees practice in different areas such as human performance tools, foreign material exclusion and personal protective equipment use. Since 2018 the simulator has been improved based on experiences over the years. The same areas are still relevant and the simulator has been extended to include for example, professional behaviour, and information about Pre-Job Briefing (PJB) and Post-Job Debriefing (PJD).

At Oskarshamn NPP, weekly safety messages have been distributed for discussion by the entire organisation from 2014. From 2024 the format changed into a safety dialogue, which initially is based on WANO's 10 Traits of a Healthy Nuclear Safety Culture.

Forsmark NPP and Ringhals NPP

A comprehensive evaluation of safety culture is performed at each site every four years, complemented by a mid-term bi-annual safety survey. The evaluation follows a Vattenfall corporate procedure for assessing safety culture, and consists of both quantitative and a set of qualitative methods. One of the inputs is the outcome of the safety culture survey, which follows WANO's ten traits for a strong safety culture. Other sources of input for the comprehensive evaluation of safety culture include a summary of feedback from group discussions following the safety culture survey, interviews and a value-based analysis of governing safety documents, reports and event reports. The integrated analysed result is presented to a senior Safety Culture Forum for assessment, and feedbacked to the organisation for development of concerned areas and topics.

Plant modifications undergo expert HSE analysis (Human System Engineering) to support ergonomics and operational functional design and interfaces.

Organisational development of organisational structures, roles and responsibilities undergo expert HOF analysis (Human & Organisational Factors) and review prior to deployment.

12.3. Regulatory review and control

As is described in section 8.8.2, SSM has a supervision programme, where the area of human factors is included. The programme includes supervision of human factors or human performance in e.g.

- management systems,
- organisations and organisational change,
- safety culture, and management for safety and nuclear security,
- operational decision making,
- competence, training and staffing, including fitness for duty,
- working conditions for safety, and
- modernisation and modification of facility or operation.

Most supervisory activities take into account both governance and operation.

Through its supervision, SSM has concluded that the licensees have a satisfactory compliance with SSM's requirements regarding the HTO approach being considered in the design, assessment and operation of NPPs. SSM's supervision has identified a decrease in the number of temporary changes to facilities, which is assessed as positive for human performance.

However, in supervision undertaken during the reporting period, SSM identified certain events that indicate inadequate conditions relating to human performance, e.g. insufficient communication between maintenance and operations. This has been assessed as a possible contributor to challenges in quality assurance. SSM has also identified an increase in human factors related (HTO) events, while another identified issue has been a lack of systematic approach to taking advantage of earlier experiences in preparing for or performing specific tasks.

12.3.1. Human factors research

SSM funds research in human factors, and also provides funding for doctoral and postgraduate studies. Under the reporting period SSM has supported an associate professorship in Human-Technology-Organisation. SSM is an active member in the joint OECD/NEA Halden HTO Project in Norway (Human-Technology-Organisation).

12.3.2. National culture

A Country-Specific Safety Culture Forum (CSSCF) has been developed jointly by the Nuclear Energy Agency (NEA) and the World Association of Nuclear Operators (WANO) to provide countries with a forum for dialogue and reflection on how the national attributes of a given country can influence nuclear safety culture. SSM was involved in the development of this forum, and hosted the very first CSSCF in January 2018². Since then, the forum has been held in Finland 2019, Canada 2022, Japan 2023 and Switzerland 2024, with CSSCF reports from each country. Through the CSSCF reports, both country-specific and collective knowledge about safety culture in the nuclear sector is gained. At the Swiss forum in 2024, SSM's director general participated in a panel discussion as an international expert.

² Country-Specific Safety Culture Forum Sweden, NEA report no. 7420, 2018.

Article 13. Quality Assurance

Each Contracting Party shall take the appropriate steps to ensure that quality assurance programmes are established and implemented with a view to providing confidence that specified requirements for all activities important to nuclear safety are satisfied throughout the life of a nuclear installation.

Summary statement for the article

Sweden complies with the obligations of Article 13.

Summary of significant changes and developments since the previous report

- The new requirements regarding routines for the procurement of products and services enable SSM to address the issue of NCFSI in its supervision (see section 13.1.1.2).

13.1. Regulatory requirements

13.1.1. Examples of specific requirements in National Act and SSMFS

13.1.1.1. Act on Nuclear Activities (1984:3)

Section 4 of the Act on Nuclear Activities states that the safety at a nuclear facility should be upheld through, among other things measures required to prevent failures and faults in equipment that can result in a radiological emergency.

Section 10 of the Act on Nuclear Activities states that the licensee is accountable for the safe (and secure) operation of the nuclear facility, and should continuously and systematically assess, verify and, as long as reasonably achievable, enhance the safety in the operations and the facilities where operation is performed.

Section 16a of the Act on Nuclear Activities gives the regulatory body the mandate to monitor how the safety requirements are followed in relation to activities conducted by suppliers or their secondary suppliers and contractors or their subcontractors, or other parties delivering services to the licensees.

13.1.1.2. SSMFS 2018:1 Basic requirements for all licenced activities with ionising radiation

Chapter 3, Section 4 of SSMFS 2018:1 sets requirements on the implementation of an integrated management system taking into account all requirements on the licensed activities. The management system, including the necessary routines and procedures, must be kept up to date and be documented.

In Chapter 3, Sections 7 to 9 of SSMFS 2018:1 there are requirements on independent internal audits being performed according to a programme, and the management of identified deviances. The audits should have continuity and auditors should have good knowledge about activities being audited. Audit intervals should take into account the safety significance of the different activities and special needs that can arise. Normally, all audit areas should as a minimum be audited every four years. The auditing activity itself and the management function of the plant should also be periodically audited.

In Chapter 3, Sections 16 to 19 of SSMFS 2018:1 there are requirements on the management of operational experience, events that have occurred and conditions discovered, with an importance for safety. Furthermore, Chapter 3, Section 11 requires the licensee to have the competence needed to procure, govern, lead and assess the results of any work performed by an external part (e.g. contractor).

The requirements in Chapter 2, Section 3 of SSMFS 2021:6 specify that the licensee shall have an independent part of the organisation, supported by the top management, with the function of independent review and supervision of compliance with all requirements on safety (and nuclear security) for the design and operation of the power plant. This part of the organisation shall also be SSM's point of contact with the licensee.

Requirements in Chapter 2, Section 4 of SSMFS 2021:6 specify that the scope, design and layout of all procedures, shall be adapted to their importance to safety (or nuclear security) and to the conditions in which they are expected to be used. Further detailed requirements on operating procedures are found in Chapter 5, Sections 6–13 of SSMFS 2021:6.

Chapter 2, Section 7 of SSMFS 2021:6 requires routines for the procurement of products and services to include how suppliers are audited, how operational experiences from suppliers are obtained, and how follow-up and evaluation of products and services rendered are performed. The requirement can be used in supervision to address the issue of NCFSL.

The regulations in SSMFS 2021:6 also establish scope, actions and expectations for specific required programmes, that must be implemented to coordinate administrative and technical actions for the purpose of monitoring, maintaining and improving safety (and nuclear security). Chapter 2, Section 5 requires such programmes to be systematically developed and updated.

Other requirements of importance to quality assurance, are Chapter 3 of SSMFS 2021:4, containing specific requirements on the management and quality assurance of design and construction work; and Chapter 2, Section 8 of SSMFS 2021:6, which together with Chapter 7 of SSMFS 2021:5 establishes requirements on safety demonstration for quality assurance during implementation of modifications at the NPP.

13.2. Implementation by licence holders

13.2.1. Current development of management systems

All the licensees have integrated management systems in place and work continuously to improve their systems.

Forsmark NPP

Continuous improvement of the management system is a priority, including a high level of involvement and commitment from the management team.

Forsmark NPP has clarified the responsibility for the line organisation's structure and process governance, as well as line organisation responsibility for implementation of external requirements and for reducing the number of functions for internal requirements.

Forsmark NPP is in compliance with IAEA GSR Part 2, Leadership and Management for Safety. A management system review was commenced to identify potential gaps when the new issue of GSR Part 2 (updated from GSR-3) was published.

Ringhals NPP

Ringhals' management system is an integrated, modernised and user-friendly management system, which is compliant with IAEA requirements through compliance with SSM's regulations. The management system includes steering, governance, evaluation and development to fulfil objectives, goals, strategies and comply with requirements derived from nuclear as well as industry standards.

Oskarshamn NPP

No structural or principal changes regarding management and governance have been made to the management system during the current reporting period. However, development has taken place within the framework of existing principles for management and control.

Decisions made include the development of a new process-oriented management system. This work is in progress, with planned implementation during 2025. An introduction is ongoing, focusing on methods for process mapping in the organisation.

Procedures for requirement management and requirements handling have been mapped, and associated routines have, in connection with this, been simplified and adapted to the processes.

13.2.2. Audit programmes

The audit programmes ensure and confirm that the requirements are met.

Forsmark NPP

At corporate level, audit programmes support to ensure and confirm that requirements from the owners are adhered to, as well as that the right level of governance is in place, at both corporate and NPP level.

Processes are in place for performing audits and running audit programmes. These processes are used to monitor how well the management system is implemented at different levels and applied to the organisation, as well as the efficiency of the system to ensure quality and safety. Such internal audits are performed on a regular basis so that all areas are covered over a three-year period. Audit teams consist of individuals who are experienced in audits, in addition to an audit team leader. The audit programmes being run fulfil the requirements for independent assessment stipulated in IAEA Safety Guide GS-G-3.1.

Forsmark also utilises different methods for self-assessment. The management system at all plants requires performance of self-assessments at different levels in the organisation. Methods for performing self-assessments are based on IAEA Safety Guide GS-G-3.1.

Ringhals NPP

Ringhals has processes for audits and audit programmes. These and other processes monitor how well the management system is implemented and applied. Safety is an important part of the audit scope. As per SSM regulations audits are performed on a regular basis to ensure that all processes are audited at least once every three years. The audit teams are led by Lead Auditors. The Lead Auditors and auditors have audit experience and business standard training. The audit programmes being run fulfil the requirements for independent assessment stipulated by IAEA requirements through compliance with SSM regulations.

Ringhals also utilises different methods for self-assessment. The management system requires self-assessments at different levels within the organisation. The processes for self-assessments are compliant with IAEA requirements through compliance with SSM's regulations. Management reviews are performed in accordance with SSM's regulations, ISO 14001:2015 and ISO 45001:2018 requirements.

Oskarshamn NPP

Staffing of internal audit teams are all part of the safety and quality department. Audit teams are led by lead auditors who work within the section for internal audit within the safety and quality department. Auditors are continuously educated to ensure quality and development. The audit process itself applies the human performance tools for reinforcement of safety and quality. The audit findings are registered in the CAP system.

13.2.3. Audits of suppliers

Audits of suppliers are carried out jointly and in cooperation between the Swedish licensees. Swedish licensees have a joint working group for shared development of procedures and methods for supplier audits. The working group meets two or three times per year addressing relevant topics, e.g. supply chain management and NCFSI. A shared procedure is used for executing a supplier audit, which is maintained and developed as a collaborative effort between the Swedish licensees.

13.3. Regulatory review and control

As described in section 8.8.2, SSM has a supervision programme, where the area of quality assurance is included.

One way of reviewing and controlling quality assurance is through the supervision of the licensees' management systems, organisations, and organisational change management. The purpose of the baseline supervision of the management system is to monitor the current status and progress of the licensees' principles for, and their systematic work on, their respective systems. This is to ensure that their management systems direct, control, evaluate and develop the organisation's activities. Another purpose is to determine whether the management system is suitable, up-to-date, accessible and effective. A further purpose of these baseline inspections is to determine the current status of the licensees' organisations and their systematic work to ensure that they have an organisation with an appropriate design for maintaining nuclear and radiation safety now and in the long term, as well as to assess the suitability of the organisation. The supervision also includes looking into licensee management of organisational changes.

Furthermore, SSM conducts continuous supervision of the licensees' internal audit processes. The results of internal audits are covered in most inspections and reviews of specifically defined technical areas, and are sometimes the subject of inspections focusing specifically on audit programmes.

Through its supervision, SSM has concluded that the licensees comply with SSM's requirements regarding quality assurance. SSM has identified a decrease in the amount of temporary changes to the facilities, and an ambition to decrease the number of open error reports, which is assessed as positive from a quality assurance perspective. The Swedish NPPs maintain a good ability for continuous improvements of their operation and assuring quality in the design and operation of their facilities.

Article 14. Assessment and Verification of safety

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

- (i) Comprehensive and systematic safety assessments are carried out before the construction and commissioning of a nuclear installation and throughout its life. Such assessments shall be well documented, subsequently updated in the light of operating experience and significant new safety information, and reviewed under the authority of the regulatory body.
- (ii) Verification by analysis, surveillance, testing and inspection is carried out to ensure that the physical state and the operation of a nuclear installation continue to be in accordance with its design, applicable national safety requirements, and operational limits and conditions.

Summary statement for the article

Sweden complies with the obligations of Article 14.

Summary of significant changes and developments since the previous report

- Sweden has maintained a strong focus on ageing issues and long term operation, as well as regulatory supervision in this area (see section 14.3.2–14.3.4).

14.1. Regulatory requirements

14.1.1. Requirements for Comprehensive and Systematic Safety Assessment

Requirements on identifying events, event sequences and conditions that are of importance to safety together with associated assessment are defined in Chapter 2, Section 1 in the regulations (SSMFS 2018:1) on basic requirements for all licensed activities with ionising radiation. The requirement for keeping the assessment up to date is also defined in SSMFS 2018:1.

Requirements on safety assessment, safety (and nuclear security) reviews and reporting to SSM are defined in Chapter 3–6 of the regulations concerning assessment of NPPs (SSMFS 2021:5) and in Chapter 9 of the regulations concerning operation of NPPs (SSMFS 2021:6). The requirements for a programme for monitoring and assessment of safety (and nuclear security) during operation is defined in Chapter 2 of SSMFS 2021:6.

14.1.1.1. Documented safety assessment and Safety Analysis Report (SAR)

Events and conditions that are important for safety (and nuclear security), shall be identified and evaluated before a facility is constructed, during its operation, and during decommissioning. The implementation and fulfilment of safety requirements shall according to Chapter 5, Section 1 of SSMFS 2021:5 be documented in a comprehensive safety assessment. According to regulations for the assessment of NPPs, Chapter 5, Section 2 of SSMFS 2021:5, a central part of this assessment is the Safety Analysis Report (SAR), whose required content is described in annex 2 of SSMFS 2021:5. For other nuclear facilities, corresponding requirements are found in Chapter 4, Section 2 and annex 2 of SSMFS 2008:1. In addition to deterministic analyses, the facility shall be analysed using probabilistic methods in order to provide a more complete picture of the overall safety level.

A preliminary SAR is required to be prepared and approved before a facility may be constructed, and for an existing facility before major refurbishing, rebuilding work or major modifications are carried out. The SAR must be renewed before commissioning, and supplemented based on experience from trial operations before the facility may be taken into routine operation. The SAR shall contain information as specified in the regulations and be subject to safety reviews before submission to the regulator. All stages of the SAR shall be reviewed and approved by SSM. Thereafter, the SAR shall be kept up to date.

The SAR shall reflect the site and the plant as built, analysed and verified, and give an overall presentation of how current safety (and nuclear security) requirements are met.

14.1.1.2. Programme for monitoring and assessment

Chapter 2, Sections 5 and 20 of SSMFS 2021:6 state that a licensee must have an implemented operating experience programme. The programme shall include procedures and plans for e.g. the compilation of operating experiences relevant to safety as well as monitoring of relevant scientific and technical developments. According to Chapter 2, Section 21 of SSMFS 2021:6, when an NPP has been taken into operation, the safety (and nuclear security) of the facility shall be regularly and systematically monitored and assessed for the plant operation as a whole. Performance indicators shall be used to provide the licence holder with an up-to-date picture of safety performance in order to identify potential safety improvements. Such safety improvements can be technical as well as organisational. A comprehensive annual follow-up and assessment of this work is required, which shall be reported to SSM. Also Chapter 2, Section 5 of SSMFS 2021:6 requires that deficiencies and identified possible improvements in implemented programmes are continuously managed when identified.

14.1.1.3. Periodic Safety Reviews (PSR)

General requirements regarding PSRs are stated in Section 10a of the Act on Nuclear Activities (1984:3). Section 10a states that a licensee shall, at least every ten years, conduct a systematic overall re-assessment of safety and radiation protection and how these meet the requirements of the Act, the Environmental Code and the Radiation Protection Act, as well as those regulations and decisions that have been issued under these laws. In the systematic re-assessment, the licensee shall account for how safety and radiation protection will be maintained and may be improved until the next overall assessment or until the facility has been decommissioned. Special consideration shall be given to

- The conditions under which the activities are conducted,
- How equipment and facilities are affected by operations and ageing,
- Experiences from those activities and similar activities, and
- Developments in science and technology.

Chapter 8 and the associated annex 3 of SSMFS 2021:5 present detailed requirements on the conduct of PSR. The regulations specify that the PSR shall cover 10 safety (and nuclear security) review areas. SSM formally decides when the PSR shall be submitted and requires that a licensee presents a plan for conducting the PSR in order to reach consensus concerning overall arrangements including the scope of the PSR, the methods used in the analyses, etc. SSM maintains a dialogue and hosts meetings with the licensee during the entire PSR process. When the results of a PSR are submitted to SSM, SSM conducts comprehensive reviews and assessments of the submitted reports and a selection of their references. In some cases SSM compares the statements made by the licensee with findings from regulatory supervision. SSM's process for PSR review is in line with IAEA Safety Guide SSG-25, Periodic Safety Review for Nuclear Power Plants (2013), and the amended EURATOM Nuclear Safety Directive. The regulatory assessments of the PSRs are submitted to the Government.

As mentioned, the PSR shall aim at ensuring compliance with the current design basis and identify further safety improvements by taking into account developments in science and technology. Reasonably practicable safety improvements must be implemented in order to maintain the level of safety and to ensure that older facilities can achieve a level of safety comparable to that of new nuclear facilities. Thus, the PSR process is an important instrument for ensuring safe long-term operation of nuclear facilities in Sweden, see section 14.3.2.

14.1.1.4. Long Term Operation (LTO)

Operating licence for NPPs in Sweden are granted with an indefinite term, i.e., operation is allowed for as long as the licensee meets requirements set by applicable laws, government ordinances, regulations of the nuclear regulatory authority and conditions attached to the initial licence.

Therefore, no specific authorisation is needed for LTO. Instead, the potential for continued operation of an NPP beyond the duration for which it was originally designed and analysed is assessed in connection with the PSR. The period of operation beyond the original design life is referred to as “continued operation”. A key aspect for justifying continued operation is for the licensee to show that the identified time limiting ageing analysis (TLAA) meet the criteria established. Another key aspect is for the licensee to show that comprehensive programmes for ageing, surveillance, maintenance, chemistry, in-service inspection (ISI), etc. are implemented. The ageing management programme shall coordinate all ageing management measures. This is stated in Chapter 6, Section 10 of SSMFS 2021:6, which can be summarised as follows.

“The ageing management programme shall for all SSCs important to safety or nuclear security; identify relevant ageing mechanisms, evaluate their effects, and develop the necessary preventive or mitigating measures. The programme shall coordinate measures with the programmes for maintenance, surveillance, in-service inspection, chemistry, environmental qualification and other relevant programmes.”

Furthermore, as with the TLAAs, environmental qualifications of structures, systems and components (SSC) need to be confirmed for the extended period of operation.

14.1.2. Requirements for verification by surveillance, testing and inspection

Sweden has since the beginning of its nuclear programme had specific requirements for surveillance, testing and in-service inspection to ensure that the operation and the structural integrity of the reactors comply with design requirements and operational limits and conditions (OLCs).

Chapter 2, Section 5 of SSMFS 2021:6, includes requirements on implementation of programmes for maintenance, surveillance and in-service inspection of SSCs important to safety (or nuclear security) in order to ensure that they meet the safety requirements. Chapter 6, Section 1–2 of SSMFS 2021:6 furthermore establish the required aim and extent of these programmes. The programmes shall be systematically designed with objectives adapted to the design and operation of the NPP. Chapter 2, Section 5 of SSMFS 2021:6 requires that continuous experience feedback and review shall be included in each programme in order to keep them up to date. Chapter 6, Section 3 of SSMFS 2021:6 sets the basis for preventive maintenance and functional testing according to the surveillance programme. According to Chapter 5, Section 2 of SSMFS 2021:6, required functions shall be verified through functional testing before structures, systems and components are taken into operation following maintenance or other interventions. The testing shall reflect consequences of a fault and the probability of this fault occurring. The functional testing has to be carried out with a frequency and scope that provide confidence that the equipment will fulfil its required function as credited in the safety analysis. The functional tests shall reflect the conditions that are expected when the function is required. If this is not possible, an analysis shall show that the safety function is verified sufficiently despite limitations of the testing.

Detailed requirements for mechanical components are defined in the regulations concerning mechanical components in certain nuclear facilities (SSMFS 2008:13). These regulations contain requirements for the use of mechanical components, limits and conditions, safety assessment of defects, accreditation of inspection bodies and laboratories, ISI and control, repair, replacement and modification of components, as well as on compliance control and annual reporting to SSM.

SSMFS 2008:13 requires certain inspections and inspection intervals for specified components, such as the reactor pressure vessel and its nozzles. In addition to such compulsory inspections, the NPPs are required to allocate the mechanical components in the plants to a number of inspection groups. The inspection groups determine the extent of ISI. The programme, resulting from the use of the principles, shall be reviewed by an accredited inspection body to certify that the programme complies with the regulations and any additional SSM decision rulings. Three inspection groups, A, B and C, are used. Group A includes components with the highest relative risk, and C those with the lowest. The relative risks can be assessed using qualitative or quantitative methods. In inspection groups A and B, the non-destructive inspection systems that are used shall be qualified by a non-destructive testing (NDT) qualification body to detect, characterise and size any existing defects to the required standard. Apart from the division into inspection groups, mechanical components must be divided into four quality classes. The principles for this shall also be approved by SSM. The division into quality classes shall take into account the safety significance of the integrity of each mechanical component for safety in all plant states up to, and including, design basis accidents. The quality classes determine the design requirements and quality assurance measures needed for repairs, replacements and plant modifications.

An accredited inspection body is required to review the inspection programmes in detail, and issues certificates of compliance with SSM's regulation. In addition, a qualification body, approved by SSM, qualifies the NDT systems used and certifies their suitability for the component and application in question. The laboratories conducting the inspections must be accredited for the tasks and methods they use with regard to quality systems, technical procedures and competence by the Swedish Board for Accreditation and Conformity Assessment (SWEDAC). SWEDAC makes annual inspections and follow-ups of the accredited inspection bodies. SSM, as the competent authority for nuclear matters, supports SWEDAC in this supervision of the inspection bodies.

14.1.3. Requirements for safety reviews and safety demonstrations

During operation of an NPP, Chapter 2, Section 2 of SSMFS 2021:6 requires that all decisions significant for safety, are adequately and comprehensively prepared and informed in order to prioritise safety. Furthermore, Chapter 2, Section 6 of SSMFS 2021:6 requires that all works to be performed at an NPP have to be prepared and controlled by an administrative system, to verify that the work does not entail unacceptable risks and that OLCs are not exceeded.

Chapter 6 of SSMFS 2021:5 specifies requirements for licensees' safety reviews. The objective is to ensure that all relevant aspects of safety (and nuclear security) have been taken into account and that all relevant requirements concerning the design, function, organisation and activities of a facility are met. The review shall be carried out systematically and be documented. Furthermore, the management system shall specify when and how safety reviews are to be carried out and the criteria used to determine what issues to be reviewed.

The review is to be performed in two steps. The first step, the primary review, shall be carried out within the parts of the licensee's organisation that are in charge of the specific issues. The primary review should typically address motives for implementing a measure, in addition to presumptions and delimitations, verification and validation of analysis methods, and the accuracy of the results. The second step, the independent review, shall be carried out by a safety review function, established for this purpose and having an independent position in relation to the organisation responsible for the specific issues. The independent review should not duplicate the primary review, but rather apply a different perspective and focus on how a matter has been handled, whether all relevant aspects have been considered, and whether all relevant safety requirements have been met. Both of the review steps should ascertain whether the planned measures maintain or improve the level of safety.

Chapter 7 of SSMFS 2021:5 specifies requirements for licensees' safety demonstrations for plant modifications. The objective is to provide evidence that a proposed solution can be implemented and commissioned in such a way that the safety requirements are fulfilled. The safety demonstration shall be adapted to the characteristics, scope and intended application of the proposed solution. The safety demonstration shall address e.g.:

- background, purpose and overall description of the proposed solution,
- the organisation, competence, responsibilities and powers for the development of the proposed solution,
- identified safety aspects relevant to the proposed solution, and
- justifications, arguments and evidences showing that the identified safety aspects have been addressed and that the applicable safety requirements are fulfilled.

A plan for preparing the safety demonstration shall be developed and in certain cases notified to SSM.

14.2. Implementation by licence holders

14.2.1. Safety Analysis Reports (SAR)

Safety requirements included in the SAR are regularly assessed for their applicability, and the licensees have specific procedures in place regarding evaluation of new or revised codes and standards.

These procedures include:

- Maintenance,
- Component qualification,
- In-service inspection/ISI, and
- Surveillance programmes.

As an example, the licensees have specific norm committees that hold periodical meetings to evaluate new codes and standards.

14.2.1.1. Deterministic Safety Assessments (DSA)

The safety analyses of Swedish plants presented in the original SAR were from the beginning essentially structured according to US rules. The events analysed were divided into different classes depending on the expected frequency and significance (severity). The highest class contains the design basis accident (DBA), typically a large loss of coolant accident such as a double-ended guillotine break of the largest pipe cooling the reactor.

The methods and methodologies in the safety analyses were essentially based on 10 CFR 50.46 Appendix K. Design criteria to be fulfilled included limited fuel cladding damage and no zirconium-water reaction (i.e. maximum cladding temperature of 1,204°C). Although the DBA did not include core melt at that time, it was postulated that a large proportion of the fission products would be released into the containment. It was subsequently shown that the containment leak tightness was sufficient for limiting radioactive releases to the environment.

The introduction of the severe accident mitigation requirements in 1986 implied the introduction of a new class of accidents, including severe fuel damage (core melt), and the safety analyses were extended to show that the acceptance criteria for these cases were met.

The regulation SSMFS 2008:17 issued in 2005, now superseded by SSMFS 2021:5, resulted in a need to update and extend certain analyses and tasks. These were included in the reactor-specific modernisation plans (see section 6.2) and completed by December 2015. The reviews and updates mainly consisted of a few external events and several beyond design basis events.

Major updates of the deterministic safety analyses have also been made for reactors that have had power uprates, see section 6.3.

14.2.1.2. Probabilistic Safety Assessments (PSA)

All nuclear power reactors have completed level 1 and level 2 PSA studies, including all operating modes and virtually all relevant internal and external hazards for the sites.

The PSA models are expected to be updated every year if there have been plant modifications during the past year that have an impact on the PSA result. Full updates of the PSA studies are expected every three years. In principle, the licensees are progressing towards application of a “Living PSA” approach. PSA results are also used routinely by the licensees to support decisions concerning significant modification of the designs, modification of operations, documentation and assessment of events.

As mentioned in previous national reports, the numerical PSA figures are not regarded as a definitive and exact value of the actual risk level. There are no regulatory criteria related to numerical PSA results, although the licensees have internally developed such safety objectives. The studies are required to be sufficiently detailed, comprehensive and realistic to enable identification of weaknesses in designs, and must be used for assessment of plant modifications, modifications of technical specifications and procedures, as well as the risk significance of events.

PSA may be used to evaluate plant modifications. For example, it was used as a tool to plan measures for compliance with the regulations SSMFS 2008:17. Generally, these modifications covered: measures to protect against common cause failure (CCF), actions to improve fire protection, improvement of operator support, and improvements to maintenance and testing.

Extensive development of the methods and tools for PSA has been performed over the years. As a result, up-to-date software and considerable expertise is at hand both within the Swedish utilities, the regulator, and consultancies/contractors. One item of particular importance is the reliability databases accumulated from operational experience. These databases are available in the reliability data handbooks “The Reliability Data of Components in Nordic NPPs” (the T Book), and “Reliability Data for Piping Components in Nordic Nuclear Power Plants” (the R Book). The T Book provides specific reliability data of high quality for a large number of components since 1977. The R Book provides high quality data for piping components, and is utilised to distribute pipe break frequencies and to categorise pipe breaks in different categories. Data relating to CCF are compiled in the CCF reliability book (the C Book). Extensive compilation of CCF data is also performed within the OECD/NEA ICDE project. These sets of dependency data are transferred into the domestic PSA models when delivered from the OECD/NEA project. None of the books are readily available, but the T Book can be purchased³. Access to the R Book and the C Book is possible via the Nordic PSA Group (NPSAG)⁴.

14.2.2. Periodic Safety Reviews (PSR)

The licensees are required to submit a PSR of each reactor at least every ten years. The review must verify that the plant complies with the current safety requirements and has the prerequisites for safe operation until the next PSR, taking into account advances in science and technology. The analyses, assessments and proposed measures shall be reported to SSM.

The licensee must inform SSM when the planning starts. The licensee meets with SSM to discuss the proposed scope, contents and methodology of the PSR. Typically, the review is organised in project form involving 15–20 staff members from the licensee. One goal is to include a few young engineers in every project in order to transfer knowledge. The total work effort encompasses around 8–10 man-years per PSR.

Ageing management is an important topic in the PSRs. When performing the PSR, long-term operation must be addressed specifically, and it must be demonstrated (through sufficient analyses) that the plant is able to operate safely beyond the designed lifetime, typically 40 years, referred to as LTO.

The Act on Nuclear Activities stipulates that a licensee must continuously and systematically evaluate and, as far as reasonably practicable, improve the level of safety in its activities and facilities. Therefore, the PSR is not expected to identify any major needs for enhancement of nuclear safety, but to provide an opportunity to make an overall assessment of the safety and performance of the plant and organisation as a part of the efforts on continued improvements.

14.2.3. Safety programmes

All licensees have safety programmes in place, as required by SSM’s regulation. The programmes are part of the management system’s documentation, and are a result of safety analyses, audits, safety culture surveys and other evaluations performed at the plant. The programmes contain priorities and time schedules for future technical, organisational and administrative measures.

³ Contact TUD@vattenfall.com.

⁴ See www.npsag.org.

14.2.4. Verification by surveillance, testing and inspection

A number of different verification programmes are implemented in order to ensure that the physical state and the operation of the nuclear installation continue to be in accordance with its design basis, safety requirements, and its operational limits and conditions. The programmes are broken down into these groups: surveillance, in-service inspection, preventive maintenance, and safety reviews.

14.2.4.1. Surveillance

The OLCs are developed to ensure that plants are operated in accordance with design assumptions. This document is discussed in more detail in connection with Article 19. The OLC document also clarifies the types and frequency of functional testing for verification that components and systems are ready for operation. These tests are carried out in accordance with documented procedures, and all test results are reviewed and documented.

Special attention has been given to verification of the operability of safety systems when going from shutdown to a power operating mode. This verification is ensured today by using a large number of parameters, computerised tools and new procedures. Operability is discussed further in section 19.2 and 19.3.

14.2.4.2. In-Service Inspection (ISI)

Swedish licensees use a shared document that serves as an industry standard for undertaking in-service inspections. This document is divided into general, technical, quality control, and ISI requirements, and has facilitated the development of plant-specific documents in these areas.

Organisations required for qualification of NDT systems and techniques, as well as for carrying out and evaluating such inspections, have been established in accordance with regulatory requirements. SQC serves as an independent body for qualification of NDT systems to be used by NDT companies that operate at Swedish NPPs.

The regulations require all safety-related components to be assigned to specific inspection groups related to their safety significance. The assignment to inspection groups is documented together with relevant information concerning the inspection in question. The assignment is reviewed and approved by the plant organisation. The overall objectives of the total inspection programme and the fulfilment of the requirements of the regulations are also reviewed by a specifically accredited inspection body. The information concerning inspection group assignments and inspection areas is maintained by the plant organisation in a database, and forms the basis for the creation of the inspection programmes to be performed at given inspection times.

The inspection group assignment is reviewed annually, and updated if deemed necessary, depending on plant modifications, defects or degradation found in Swedish or other NPPs, or new and relevant research findings.

14.2.5. Safety reviews

In order to verify that the operation of an NPP is in accordance with the applicable national safety requirements and standards, different types of safety reviews are performed regularly at the plants. The SSM regulations require a dual safety review for all safety-related issues at the plant, e.g. operational events, changes in OLCs, plant modifications, etc. First, a primary review is carried out by the operations department that is primarily responsible for reactor safety. If needed, resources from other departments are utilised.

A second review that is autonomous is then performed by an independent department or function within the licensee's organisation. This independent department or function is not allowed to be involved in the preparation or execution of the issues under review.

The objective of the secondary review is to assess whether the primary review included the relevant types of analyses and investigations, and whether they are of sufficient quality, rather than repeating the primary review. Certain issues, according to the regulations, require application or notification to the regulator. Both the primary and the independent reviews are carried out according to written instructions developed specifically for the purpose.

A third type of review is performed by the safety review committees and councils at different organisational levels. There are review committees on operating unit level, as well as on power plant level (see section 10.2.2). These consist of individuals representing different disciplines in order to achieve a broad view of the subjects discussed. The members are appointed based on their personal qualifications and knowledge. In some committees and councils, one or more external members also take part.

Committees working on operating unit level deal with daily operational matters of safety, such as event and scram reports, operational experience from other plants, and safety issues linked to OLC and plant modifications. Committees working on power plant level focus on issues of principle, such as a safety policy and strategy, the plants' adherence to the Authority's regulations, and general reviews of safety and quality activities.

14.2.6. Ageing management and Long Term Operation (LTO)

Implementation and development of ageing management at the NPPs have been ongoing efforts over more than a decade, starting when requirements were introduced in the national regulation SKIFS 2004:1 in 2005. Preparations for LTO, i.e. operation beyond the design lifetime (typically 40 years), have been performed following review reports published by SSM in 2012 and guidance from the IAEA. Presently four reactors in Sweden are in LTO, see table 6. Note that operation beyond the original designed lifetime for a Swedish reactor does not result in a licence renewal. The licence to operate is not limited in time. Instead, Sweden applies a range of means to ensure that a nuclear reactor can continue to operate safely. One of these means is supervision, another is the PSR, which according to Swedish law must be presented every ten years. The PSR shall assess and ensure that any nuclear facility holding an operating licence is able to operate safely during the next ten years.

Table 6. Swedish reactors to enter LTO.

Reactor	Commencing LTO
Forsmark 1	2020
Forsmark 2	2021
Forsmark 3	2025
Oskarshamn 1	2025
Ringhals 3	2020
Ringhals 4	2022

Key elements for assessing ageing are based on the nine attributes contained in the IAEA's safety standards, "Ageing Management and Development of a Programme for Long Term Operation of Nuclear Power Plants" (SSG-48), which are similar to the ten elements described in the Generic Ageing Lessons Learned (GALL) Report (NUREG-1801). In order to check consistency, Swedish licensees have used IAEA's generic lessons learned report⁵ (SRS 82) and NUREG-1801, as described in the EU-TPR ageing assessment⁶.

All licensees (as well as SSM) participate in the IAEA IGALL program. The program develops and provides common internationally agreed basis for what constitutes an acceptable ageing management programme, as well as a knowledge base on ageing management for the design of new plants and design and safety reviews. It also aims to serve as a roadmap relating to available information on ageing management.

To enable an international assessment of the overall ageing management programmes, all licensees have made use of the IAEA SALTO or pre-SALTO review service, see section 9.2.3.2. The SALTO peer reviews are important steps as part of the technical details of managing ageing issues, as well as creating a company-wide awareness of the necessities and requirements of operating the plants past their originally intended lifespan.

⁵ Ageing Management for Nuclear Power Plants: International Generic Ageing Lessons Learned (IGALL), IAEA Safety Reports Series No. 82

⁶ 2017:36, Topical Peer Review 2017. Ageing Management, Swedish National Assessment Report.

Ringhals NPP

Ringhals NPP has worked on implementing and developing methods for ageing management at the plant. It also adopted the IAEA methodology (SRS-57) for justifying LTO at an early stage. Initially, this work was done as part of an extension of the PSR for the oldest reactors, Ringhals 1 and 2, but subsequently also covered units 3 and 4. The work within the LTO project covered a review of the existing ageing management as well as identification, reviews and updates of TLAAAs for the remaining time of planned operation.

Oskarshamn NPP

At Oskarshamn NPP, a project was earlier formed to develop the existing Ageing Management Program to meet the requirements from SSM. As a guide for the newer regulations, the IAEA SSG-48 was used. The work within the project resulted in an updated program for Aging Management as well as new scoping, article groups and Ageing Management Reviews. The project also handled all relevant TLAAAs during 2021. An IAEA pre-SALTO review was carried out in 2022. The SALTO was conducted in October 2024.

Forsmark NPP

Forsmark NPP has developed overall ageing management programmes by compiling information from pre-existing programmes, such as maintenance, component/environmental qualification, in-service inspection obsolescence and chemistry programmes (i.e. Plant Programmes). By using these programmes, a great deal of experience, gained from the operation of the plants as well as external ageing-related experience, has been implemented. The overall ageing management programme has therefore naturally become an interdisciplinary programme linking the ageing perspective in a range of programmes, while also keeping them in tune with safety requirements and reliability over time. In order to verify the scope of systems, structures and components, and to review the ageing management for operating the plants beyond the originally intended lifespan, Forsmark has been reviewed by IAEA in a series of SALTO-reviews and with independent peer reviews by staff from other sites. The review has included an update of the licensing basis documentation regarding analyses that use time-based assumptions.

14.2.6.1. Organisation of the ageing management work

Each site has organised its ageing management work in different ways. These different approaches are described below.

Ringhals NPP

Handling of ageing-related degradation and damage as described in the ageing management programme requires access to support and information from closely related programmes and activity areas.

The ageing management programme functions on an interdisciplinary level through existing programmes and provides a link that fulfils the ageing perspective in all programmes. The related programmes are:

- Maintenance
- Component qualification
- In-service inspection/ISI
- Surveillance and monitoring
- Chemistry
- Operations
- Radiation protection
- Obsolescence

The maintenance department is responsible for dealing with and developing the ageing management at Ringhals. A team coordinates and supervises the ageing management programme. The team's responsibilities are to:

- Document the overall ageing management process
- Ensure that the programme for ageing management is complete
- Coordinate activities related to ageing management
- Evaluate and optimise the efficiency of the programme
- Exchange experiences with external organisations
- Ensure that experiences and results from R&D relating to ageing management are forwarded to the parties concerned
- Ensure that information and training within the area are available and conveyed to the right persons
- Report to the management

Oskarshamn NPP

Handling of ageing-related defects and degradation as described in the ageing management programme requires access to support and information from closely related programmes and activity areas.

The ageing management programme functions on an interdisciplinary level through existing programmes and provides a link that fulfils the ageing perspective in all programmes. The related programmes are:

- Maintenance
- Component qualification
- In-service inspection/ISI
- Surveillance testing
- Chemistry
- Operations
- Radiation protection
- Obsolescence

The engineering department is responsible for coordinating the ageing management.

In order to manage the above requirements, a coordinating group has been established.

The coordination group is responsible for overall ageing management and handles subjects such as:

- Events and deviations that may have resulted in forced ageing and thereby degradation of function and performance.
- New knowledge of the status of the facilities based on the outcome of testing activities.
- New knowledge of material and ageing effects.
- New knowledge of the supplier market and access to replacement components.

Forsmark NPP

The responsibility for coordinating overall ageing management is assigned to the engineering department. Since ageing management is a common concern, with collective responsibilities, it involves staff in many plant departments. Forsmark has implemented collaboration groups in the areas of civil engineering, ventilation, electrical, I&C and mechanical equipment with the purpose of developing interdepartmental coordination in ageing management.

Part of the engineering department's configuration management activities is the responsibility to develop and maintain systematic ageing management analyses for systems, structures and components that are important for safety. This includes identification and documentation of relevant degradation mechanisms and ageing effects for relevant SSCs.

The maintenance department is responsible for conducting a continuous review of the maintenance programmes and In-Service Inspection, including ageing management-related activities. The maintenance department is also responsible for management of obsolescence and the establishment of a programmatic approach.

The operations department is responsible for surveillance testing, routine trending of results from testing and status monitoring/reporting of vital activities as part of detecting effects of ageing.

The human resources department is responsible for training of staff in detecting ageing-related degradation and competence management.

14.3. Regulatory review and control

SSM continuously reviews and inspects work performed by the licensees. Section 14.3 describes some general approaches regarding regulatory control in this area, and gives examples of recent supervision.

14.3.1. Safety Analysis Reports (SAR)

Generally, SSM reviews SARs in relation to applications for power uprates or notifications (see section 10.5) relating to, for example, significant plant modifications or new analysis methods. SSM may also initiate SAR reviews at any time, regardless of incoming updates. SSM may also impose new assessments to prove requirement fulfilment, for example due to increased knowledge through research projects, international collaboration, and/or own investigations.

SSM's reviews have the aim of verifying that the SAR reflects the facility as it is built, analysed and verified, as well as that it demonstrates how current requirements on design, function, organisation and activities are met. Since the previous report, SSM has reviewed a number of SAR updates.

14.3.1.1. Deterministic Safety Assessment (DSA)

In the following cases, SSM reviews the DSA:

- As part of power uprate reviews.
- When a licensee notifies the Authority (see section 10.5) of new analyses due to e.g.
 - » New fuel types,
 - » Plant changes, or
 - » New or modified analyses.
- As a response to injunctions issued by SSM for new analyses to prove requirement fulfilment, for instance when new safety issues have been raised that are not covered by the current SAR.

Some examples of SSM's review activities performed during the current CNS review period are presented below.

Forsmark 1 review before test operation

During the current reporting period SSM has reviewed and approved the application for test operation for power uprate of Forsmark 1, in two steps, first for 3,075 MWt and later for 3,253 MWt. Prerequisites were that Forsmark 1 and 2 are sister-plants and share underlying reference reports to each plant's SAR. Forsmark 2 has already been power up-rated in a corresponding way, obtaining SSM approval for routine operation in 2020. SSM focused its review of the SAR for Forsmark 1 on the differences that exist between the plants.

Inspections of safety analysis and the Safety Analysis Report (SAR)

During the current reporting period SSM has carried out inspections of work related to the SAR at each licensee; Oskarshamn, Forsmark and Ringhals. The inspections are a part of SSM's ordinary supervision and concluded that the requirements generally were met. However, SSM identified some shortcomings, primarily regarding currency. These were all judged to have little safety impact.

Robustness of structures and components in the lower drywell of the containment

An example, mentioned in the last report, where SSM has required new assessments to prove requirement compliance is an injunction in 2018 on the licensees of Forsmark and Oskarshamn to analyse the robustness of structures and components in the lower drywell of the containment against impulse loads that might occur in a case of steam explosions during a severe accident.

In 2021, SSM concluded that the licensees had not been able to show that the locks in the reactor containment have a sufficient margin against the loads from a steam explosion in connection with a severe accident. SSM has ordered the licensees to develop action plans ensuring that the locks have a load capacity of 30 kPa against steam explosions. Since the last reporting period, SSM has reviewed both the actions plans and the proposed measures to ensure sufficient robustness of the locks. SSM's review is completed and the measures have been implemented.

14.3.1.2. Probabilistic Safety Assessments (PSA)

As of 2014, the licensees submit a yearly report to SSM that includes information regarding the PSA status as well as relevant information regarding plant changes, method changes, R&D, and operational experience of importance for the plant-specific PSAs. The yearly report also includes statements on the use of the PSA in various applications, e.g risk follow-up, evaluation of allowed outage times and planning of the yearly outage period. Every third year, the yearly report is replaced by a full PSA that is notified to SSM. SSM's PSA supervision includes reviews of updated PSAs, living PSA reporting, treatment of fire and other hazards in the PSA, topical meetings with licensees, and inspections. The safety analysis work including PSAs are part of a baseline inspection with a return frequency of three years. One important part of SSM's PSA supervision is to observe the processes used by the licensees, for instance to ensure that PSAs are used in all relevant applications.

The PSAs for Forsmark 2 and Ringhals 4 have been reviewed within the scope of applications for authorisation of routine operation following the power uprates. Certain aspects of PSA review are also part of SSM review of the utilities' PSRs.

14.3.2. Periodic Safety Reviews (PSR)

14.3.2.1. Forsmark 3 PSR

In January 2022, SSM received a plan for conducting the PSR for Forsmark 3. SSM considered that the submitted plan and methodology adequately described the scope and direction of the work Forsmark NPP intended to undertake. However, SSM emphasised that particular attention would be given to assessing TLAAAs during its review of the PSR, as the reactor would exceed 40 years of operation before the next PSR. Forsmark NPP submitted the PSR for Forsmark 3 in February 2024. SSM's review had not been finalised at the time of this report.

14.3.2.2. Oskarshamn 3 PSR

In 2019, SSM decided that the licensee of Oskarshamn 3 should present the results of its TLAAAs review by the end of 2021, since the reactor would pass 40 years of operation before the next PSR. SSM has received the TLAAAs and they are currently being reviewed.

14.3.3. Inspection and testing of plant Structures, Systems and Components (SSC)

14.3.3.1. The Swedish third-party control system

As mentioned in section 14.1.2, the Swedish system regarding inspection and testing of mechanical devices is based on the regulator, SSM, having set up a framework (through its regulations) encompassing principles, methods and modes for inspections and testing. An accredited inspection body and qualification body are involved in the process. These bodies undergo annual inspections conducted by SWEDAC for evaluation of the accredited inspection bodies. SSM, as the competent authority for nuclear matters, supports SWEDAC in this supervision of the inspection bodies.

Accreditation approval of the only qualification body in Sweden (SQC) was renewed in 2016, although subject to terms and conditions. These were followed up at an inspection performed in 2022, along with previous inspection findings. The conclusion was that the licensee complied for the most part with the regulatory requirements.

14.3.3.2. Surveillance programmes

Since the previous report, SSM has reviewed surveillance programmes for the reactor pressure vessels of Ringhals 3–4 and Forsmark 1–3. The licensees complied for the most part with the regulatory requirements.

14.3.3.3. Chemistry programmes

Since the previous report, SSM has performed inspections of the chemistry programmes at Ringhals 3–4, Forsmark 1–3 and Oskarshamn 3. The inspections are part of the baseline supervision programme and the detailed requirements are stated in Chapter 6, Section 8 of SSMFS 2021:6. Inspections of chemistry programmes has never been done before and the conclusion was that the licensees complied for the most part with the regulatory requirements.

14.3.3.4. Functional tests

Since the previous report, SSM has performed supervision at Ringhals 3–4, Forsmark 1–3 and Oskarshamn 3 within the area of functional tests as part of the baseline supervision programme.

14.3.4. Ageing management

14.3.4.1. Ageing management programmes

As stated in section 14.1.1.4, Chapter 6, Section 10 of SSMFS 2021:6 requires an integrated programme for management of degradation due to ageing. The programme needs to include all structures, systems and components that are of importance for safety. This includes mechanical, electrical, I&C components and concrete structures.

In the past ten years, SSM has performed reviews and inspections of the programme for ageing management at all Swedish NPPs. The results of these reviews and inspections were described in 2019 in Sweden's EU Topical Peer Review (TPR) on Ageing Management. SSM also noted that the licensees had identified a need for further improvements, these were compiled into an action plan that was submitted in ENSREG's 1st TPR Swedish National Action Plan (NAcP).

The NAcP was reviewed by SSM in 2021 and SSM concluded that all licensees now have an overall ageing management programme that fulfils SSM's requirements and international expectations. SSM also concluded that the Swedish licensees' work on the action plans has been good and that the remaining measures to be taken in implementation of the action plans do not have a significant impact on safety. These remaining actions will be handled by the licensees in relevant programmes and followed up by SSM within the framework of the baseline supervision programme. SSM therefore considers that the TPR process for aging management is finalised.

14.3.5. Safety reviews

SSM supervises the licensees' safety reviews most frequently when reviewing notifications. However, inspections are also performed from time to time.

14.4. Vienna Declaration on Nuclear Safety (VDNS)

This section, in reference to Article 14 of CNS, describes how Sweden implements relevant measures and performs safety analyses in enhancement of the fulfilment of principles of the VDNS.

During the current reporting period, the focus of the regulatory body and licensees alike was on ensuring safety functions and safety barriers through maintaining a strong focus on ageing issues. As an example, supervision of the programmes for surveillance of reactor pressure vessels (RPV) and the chemistry programmes were carried out. The ageing management programmes were also subject to several IAEA SALTO review missions and the results were incorporated.

An important instrument for implementing the second principle of the VDNS is the PSR process. Furthermore, an emphasis was placed on the importance of preparation and assessing safety on the part of all reactors that will be facing their end of design lifetime in order to ensure safe LTO. For this purpose, an extended PSR has been used specifically in the area of ageing to require analyses and reporting on matters related to plant safety status, and to prove continued safe operation until the next PSR.

Sections 14.2.1 through 14.2.6 present the licensees' implementation of the regulatory requirements. Relevant regulatory activities are reported in sections 14.3.1 through 14.3.5.

Article 15. Radiation Protection

Each Contracting Party shall take the appropriate steps to ensure that in all operational states the radiation exposure to the workers and the public caused by a nuclear installation shall be kept as low as reasonably achievable and that no individual shall be exposed to radiation doses which exceed prescribed national dose limits.

Summary statement for the article

Sweden complies with the obligations of Article 15.

Summary of significant changes and developments since the previous report

- SSM's new Code of Statutes, SSMFS, covering operation (SSMFS 2021:6) of NPPs have more detailed requirements on activities for radiation protection of workers as well as the public. These include e.g. a long term dose reduction programme (ALARA programme) for occupational exposure, use of dose constraints, use of radiation zones, and requirements on workplace and individual monitoring. SSMFS 2021:4 establishes more specific requirements regarding the design of the NPPs to enable radiation exposure of workers and members of the public to be kept as low as reasonably achievable (see section 15.1).
- The baseline supervision has been carried out as planned where all requirements were largely met, but with a number of areas for improvement (see section 15.4).

15.1. Regulatory requirements

15.1.1. Occupational radiation protection (RP)

Swedish occupational RP requirements governing nuclear facilities are in accordance with the binding requirements of the Radiation Protection Act.

SSM's regulations SSMFS 2018:1 contain basic requirements relating to occupational RP in connection with all activities involving ionising radiation, including workers at nuclear facilities. Chapter 4 of SSMFS 2018:1 contains general requirements on facility design, workplace radiation monitoring, RP competences, categorisation of workers, occupational dose monitoring and assessment, as well as health surveillance of workers.

The requirements are based on the fundamental principles of RP as defined by the International Commission on Radiological Protection (ICRP): justification, optimisation and application of dose limits.

Chapter 4 of SSMFS 2018:1, is supplemented with more specific requirements in SSMFS 2021:4, specifying requirements on design of NPPs, to enable radiation exposure to workers and members of the public to be kept as low as reasonably achievable. The more detailed requirements for NPP operation in relation to RP of workers as well as the public are mainly found in Chapter 4 of SSMFS 2021:6. In addition to previous requirements, this chapter also includes requirements on the use of a dose reduction programme (ALARA programme) for occupational exposure, use of dose constraints, use of radiation zones, and requirements on workplace and individual monitoring. The previous requirements on appointment of RP managers at nuclear facilities have been removed from the new regulations for NPPs, since the requirements on an organisational function for RP expertise, as stipulated in SSMFS 2018:1 are assessed to be sufficient.

Requirements on reporting to SSM any deficiencies in RP of workers, events that lead to a substantial increase in releases of radioactive substances or occurrences of unexpected concentrations of radioactive substances in the environment, have been clarified in Chapter 9, together with annex 3 of SSMFS 2021:6.

15.1.2. Protection of the general public and the environment

Chapter 5 of SSMFS 2018:1 contains general requirements on the protection of members of the public and the environment from exposure to ionising radiation. More specific requirements relating to the design of NPPs are established in SSMFS 2021:4, to enable radiation exposure to workers and members of the public to be kept as low as reasonably achievable. Chapters 2 and 4 of SSMFS 2021:6 relating to safety in NPP operation include more detailed requirements on the protection of members of the public and the environment, as well as requirements on monitoring programmes.

The requirements comprise a dose constraint on effective annual dose to the public from discharges of radioactive substances to the environment, and require monitoring of releases of radioactive substances to water and air. Unmonitored releases to air shall be avoided as far as reasonably possible, but those that do occur shall be assessed and documented.

Compliance with the dose constraint is demonstrated by calculating the annual dose to representative individuals. A more site specific methodology for calculating such doses was approved by SSM in 2019. The methodology is used for calculating the dose to representative persons in three different age groups from annual releases integrated over a 100-year period, with the calculated dose consisting of the sum of the effective dose from external exposure and the committed effective dose from internal exposure. The methodology includes adoption of the ICRP's recommendations for the "representative person" (instead of critical group).

The discharge limit is achieved by restricting the radiation dose to the public. Sweden has no statutory radionuclide-specific discharge limits. The dose limit for members of the public is 1 mSv per year. Hence, in order to protect the public, a dose constraint of 0.1 mSv per year is applied per site for discharges of radioactive substances to the environment in order to establish site-specific limits on authorised releases.

Releases through the main stacks of nuclear power reactors shall be controlled by means of continuous radionuclide-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 radionuclide-specific measurements of gamma and alpha-emitting radioactive substances as well as, where relevant, strontium-90 and tritium.

Limitation of releases shall be based on optimisation of RP and by applying the Best Available Technology (BAT) in order to limit and further reduce the releases of radionuclides.

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

Environmental monitoring in the areas surrounding nuclear facilities is currently performed according to monitoring programmes determined by the licensee and initially approved by SSM. The licence holders are thereafter responsible for further developing and maintaining the site-specific environmental monitoring programmes at the site.

The programmes specify the type and sampling frequency, sample treatment, radionuclides to consider, reporting etc. Sampling is performed at and outside the sites. Samples are analysed by staff of the nuclear facilities, or by external laboratories that have adequate quality assurance systems. To verify compliance, SSM performs inspections and evaluates laboratory performances. The laboratories take part in proficiency tests and bilateral inter-laboratory comparisons on random sub-samples to check compliance with measurements performed by SSM or by another independent laboratory.

NPP licensees report annually to SSM on adopted or planned measures to limit or reduce releases of radioactive substances, with the aim of achieving specified target values.

According to the regulatory requirements, releases of radioactive substances to the environment, as well as results from environmental monitoring, shall be reported once a year to SSM. Events that lead to a substantial increase in releases of radioactive substances from a nuclear facility must be reported to SSM as soon as possible, together with a description of the actions taken to reduce the releases.

Clearance of materials, rooms, buildings and land related to practices involving the use of ionising radiation is regulated in SSMFS 2018:3, which stipulates detailed requirements for clearance procedures.

15.2. Implementation by licence holders

The following sections describe the current situation at Swedish nuclear facilities. The sections selected provide relevant examples of the ongoing work.

15.2.1. Organisation of radiation protection (RP) at the NPPs

RP resources are centralised at Swedish NPPs, though normally a few individuals are assigned to specific units. Plant operators frequently hire external RP personnel, particularly during outages. The percentage of hired RP personnel during outages can be as high as 70–80 %. During normal operation, it is approximately 30–40 % at Forsmark, 20 % at Ringhals and 25 % at Oskarshamn.

RP responsibilities reflect the organisational structure. The RP sections are responsible for performing assessments and providing other RP services. The responsibility to comply with instructions rests with management in the line organisation. Planning and allocation of resources are carried out within the overall processes for production, refurbishment, outages, project work, etc., except for special services (e.g. dosimeter service, whole-body counting, RP instruments, some monitoring and surveillance, etc.). The senior management plans RP work in conjunction with the overall management of the plant, and particularly in connection with overall health and safety activities.

Ringhals NPP and Forsmark NPP

Ringhals and Forsmark have cohesive groups for operational RP for all units at each site. The groups have competence and a succession plan, with a clear career path, that gives additional development opportunities within the profession.

Oskarshamn NPP

There are two separate RP organisations at Oskarshamn NPP, one for RP within the decommissioning project of the two oldest reactors, and one RP organisation for the remaining reactor in operation as well as other operating facilities.

The two RP organisations work with their respective activities; decommissioning and production, but try to align their work and therefore have a common evaluation forum for status regarding RP and for a common evaluation of RP events, since the same rules for categorisation and classification of events exist, regardless of business orientation.

Both at the decommissioning department and the production department, a focus has been placed on creating RP organisations with a higher proportion of own staff than has previously been the case.

Difficulties exist regarding hiring RP resources from contractor companies in sufficient numbers and with sufficient competence and experience.

15.2.2. Internal procedures for radiation protection (RP)

Work is continuing to harmonise procedures at and between sites. This includes behaviour-related instructions, such as procedures and rules for RP, usage of prescribed personal protective equipment in radiation and contamination controlled areas, and controls on the frequencies of contamination alarms and housekeeping in general. Some examples of focus areas are clearance of materials, measurements of equivalent dose to the lens of the eye, enhancing practical training of exposed workers in the controlled areas, enhancing the process of making dose prognoses, as well as categorisation of RP-related events and incidents.

15.2.3. Radiation protection (RP) education and training

Due to the national regulations in the field of RP, site-specific instructions and procedures are in the process of being adjusted accordingly. Examples of changes include use of a dose reduction programme (ALARA programme) for occupational exposure and use of dose constraints, which has also existed before but is more prominent now.

Ringhals NPP and Forsmark NPP

Competence Councils are established between Forsmark and Ringhals in order to deal with common educational issues within the RP area. A training programme for RP personnel in the area of clearance has been developed together with the other NPPs in Sweden. Targeted RP training is held within the plant renewal projects where the need exists. Regarding handling radioactive sources, Ringhals has improved and refined the provision of training.

At Forsmark NPP an ALARA training and education programme for staff involved in the plant modification and renewal process has been developed. The training and education programme is intended for personnel involved in planning and construction of plant modifications as well as the project managers.

Oskarshamn NPP

A simulator for practical training, set up in an authentic environment, is used by in-house staff and contractor workers at Oskarshamn. This offers opportunities to carry out practical training in an authentic environment, with a focus on personal RP.

15.2.4. Activities to prevent spread of contamination

Ringhals NPP

Ringhals has installed personal identification at all exit monitors located at units 3 and 4. The purpose was to improve handling of PCE (Personal Contamination Events) in order to more effectively gain control over radioactive contamination in the controlled area and protect the individuals involved.

Ringhals previously reported on ongoing work to improve procedures for clearance measurements. There are currently several clearance stations equipped with HPGe detectors. An average of around 300 radionuclide-specific measurements are performed each year, and very few of them exceed the clearance limits. This indicates that the clearance process works well in all stages regarding sorting, packing, smear tests, etc.

Forsmark NPP

At Forsmark, work has been carried out to take into account international guidelines on detection and control of alpha activity. This includes, among other things, mapping of alpha activity levels inside the facilities. Mobile filters are now used to filter the air from radioactive aerosols as close to the source as possible. Furthermore, card readers in personal monitors are used for easier identification of contaminated personnel. A web-based interface simplifies the follow-ups of personal contamination registered by the personal monitors.

Oskarshamn NPP

At Oskarshamn, there is a continued high focus on preventing the spread of radioactive contamination, by following up and mapping contamination incidents in the event of alarms in the personal monitoring, and by carrying out remediation for preventive purposes. If an individual sets off an alarm when exiting, this information is also communicated to the manager responsible.

A special focus is placed on the number of contamination alarms during monitoring related to the number of passages. Target values have been established for the number of alarms, adapted to the nature and scope of the activities.

15.2.5. Measurements of radionuclides in reactor systems

Online dose rate measurements at several locations are carried out in order to continuously monitor changes in dose rates. During outages, supplementary measurement campaigns are performed as input for determining additional protective measures during the outage, but also to assess long-term trends in specific measurement programmes.

Ringhals NPP

At Ringhals NPP, surface activity measurements (SAM) have been conducted at all plants since 1990. Measurements are performed using collimated gamma spectroscopy equipment. It has been established that most nuclides contributing to dose rate have decreased over the years due to operational and chemical controls. When the trends of certain radionuclides in the reactor system decreases, in particular Co-60 and Co-58, other radionuclides may become more relevant with regard to dose to individuals. For Ringhals 3 and 4, two radionuclides of interest have been the appearance of Ag-110m and Sb-124. Both nuclides are showing fluctuation from year to year because their actual source is temporary. These nuclides do not necessarily contribute significantly to the exposure of all individuals during refueling, because there are differences in physical behaviours such as deposit and transport. As an example, Ag-110m deposits mainly on system surfaces with lower temperatures, and therefore radiation mapping is easier as well as measures to reduce worker doses. The driving force in analysing and implementing countermeasures is planned, discussed and handled in Ringhals PWR source term group. Online radionuclide-specific measurements of system surfaces and reactor water are not installed yet at Ringhals 3 and 4, but preparation of design documentation is underway. The main reason for online-specific measurement is to have access to real time data in order to effectively analyse fluctuation in, for instance, source terms.

Forsmark NPP

All the Forsmark units have radionuclide-specific gamma measurement systems installed with online monitoring of gaseous fission products in the condenser's off-gases. This monitoring is used for early detection of fuel failures and to identify a leaking fuel bundle in the core.

During the annual outage of each Forsmark unit, radionuclide-specific gamma measurements are performed on pipes and heat exchangers at selected locations. The measurements show the amount of radioactivity that is present as internal contamination, and the radionuclides that contribute to the dose rate at the measurement location.

Oskarshamn NPP

For the reactor in operation, Oskarshamn NPP has continued to work on the problems surrounding the moisture content in the steam. Dose rate and contamination have increased in several systems and there is an investigation into the cause of how the moisture content of the steam affects the plant's contamination and the dose load on the staff. Discussions have been held about the long-term consequences for the plant.

NSSAM (Nuclide Specific Surface Activity Measurement) are being carried out on a yearly basis, during the period of outage.

15.2.6. Dose reduction and ALARA programmes

All NPPs continue to make improvements to their RP activities by using the principle of optimisation of protection in a long-term perspective, as well as in day-to-day work. During the previous review period, greater attention was already being given to reducing high individual exposures as a complement to focusing on collective doses. This work is continuing. Dose statistics for a ten-year period are presented in section 15.3.1.

The alpha value is used when applicable for assessing cost-effectiveness of RP optimisation measures. In case there is a possibility to achieve a greater overall benefit, the monetary sum may be increased. An assessment is made on a case by case basis.

Ringhals NPP

System decontamination, conducted at Ringhals 1 and 2 was finalised in early 2022 as a preliminary stage in the ongoing decommissioning work.

The main focus for the ALARA committee remains to conduct supervision over the continuation of long-term RP development. The committee also evaluates ALARA plans and objectives for individual and collective doses, and follows up RP activities. The committee members are made up of managers who have personnel working in the controlled area or who can affect the design and/or conditions in the controlled area, together with RP experts.

A number of dose constraints have been implemented, and will be revised as an optimisation tool to reduce high individual doses. The measure is proving effective in contributing to a low number of high individual doses.

The main focus of the activity is to spread the responsibility for and dedication to ALARA among the departments outside the RP department. Also, the management of ALARA plans has been strengthened. The ALARA plans, one from each department, have to be reviewed by the ALARA committee before approval. For projects with a collective dose prognosis greater than 0.8 manSv, a specific ALARA plan must always be established.

At Ringhals 3 and 4, fuel decontamination has been performed annually.

Regarding dosimetric information of interest, Ringhals has developed methods, measures and routines for handling situations with presence of alpha and beta emitters. Regarding alpha, which may be of interest during an intake, documentation is developed from the EPRI alpha guidelines. In the same manner, with help from ISO-standards, calculation and measures in situations with skin dose have been revised.

Forsmark NPP

In line with the ALARA-programme, Forsmark has developed, for example, requirements for cobalt content in fuel components and in order to reduce emission of radioactive noble gases, undertaken a system function investigation of the off-gas delay system.

The alpha value of 10 million SEK/manSv is still valid at Forsmark NPP, however a plan to update and develop this is in place. Work is on-going and a decision for a new value is foreseen for 2025.

The use of the EPD system has progressed using further reduced/fine-tuned dose alarm limits for work in spaces with low dose rates. A list of spaces, systems and jobs with a high risk of overexposure has been developed and used when planning RP measures.

When working with Foreign Material Exclusion (FME), which involves prioritising where the focus should be placed, classification lists were developed for different systems to facilitate maintenance work at all three facilities. Already in the preparation stage, these classification lists make it possible to plan the appropriate type of measures before, during and after the work. For complex works, templates are available so that the responsible work group, together with the FME staff, can in advance produce structured FME plans that describe in detail how the works are to be carried out in order to minimise the risk of adding foreign objects. Checklists and certificates help employees to carry out all key tasks. As a final safety measure, FME staff make final checks using their own specially trained staff to ensure purity after work has been completed.

Oskarshamn NPP

When deciding on measures to limit exposures, Oskarshamn uses an alpha value, that is re-calculated annually according to the consumer price index, and which follows a decision in the company's ALARA committee from 2016. The alpha value in 2025 is 14.6 million SEK per saved manSv. An assessment can also be made on a case by case basis.

The main focus of the ALARA Committee at Oskarshamn is to monitor the long-term development of RP. The committee evaluates the strategies for the control of individual and collective doses and monitors RP in connection with activities, projects and measures, with a main focus on overall and facility-specific ALARA plans. The members of the committee are managers who have staff working in the controlled area, or who can influence the design and conditions in the controlled area, together with RP experts.

A number of planning values for dose and dose rate have been implemented as an optimisation tool to reduce high individual and collective doses. Internal dose constraints have been established for individual doses on a daily, monthly and annual basis, and for dose rates. The measure has significantly reduced the number of high individual doses. The recommendations from the common ALARA benchmark are gradually implemented on an annual basis.

Each department head has the full and undivided responsibility for doses received in their respective operations. They are also responsible, through their RP organisation, for producing dose predictions and subsequently for following up outcomes against the prognosis. The main focus of the ALARA operations is that responsible and executing organisations, operating in the facilities, should feel the responsibility and commitment of ALARA and the dose outcomes for their respective staff.

An extensive project with the FME has been carried out in order to prevent foreign substances or objects from ending up in the reactor systems. Oskarshamn works proactively to keep process systems free of foreign objects. The work with FME promotes nuclear safety, protects the integrity of the fuel, contributes to reduced radiation dose, through reduced contamination, contributes to the health of the components and the reliability of the equipment, reduces unplanned stops and reduces remedial maintenance. An established and well-functioning FME program is a cost-effective way of reducing the risk of fuel damage, caused by wear and tear, and thus constitutes an important ALARA measure.

Within the decommissioning project, dose-reducing measures have been carried out such as sludge suction from the bottom of the reactor tank, dismantling of probe bottles, extra flushing of pipe systems, removing of point sources in systems and shielding with lead mats. Several activities during decommissioning have been challenging due to higher dose rates than expected. Activities have also, on several occasions, taken longer than planned, and therefore measures have been taken, including revised methods, with the intention of keeping exposures as low as reasonably achievable.

15.2.7. Programmes to reduce the release of radioactive substances

Plans and action programmes remain in effect for the purpose of reducing releases of radioactive substances from NPPs to the environment. Some examples of measures implemented are given here.

All sites have programmes for separation and minimisation of different types of waste water. This has altogether resulted in reduced volumes of waste water as well as reduced activity discharges.

Efforts to avoid fuel failures are ongoing and include education and training, as well as introducing new techniques to stop foreign debris from entering reactor systems.

Ringhals NPP

Since 2014, Ringhals 3 and 4 have been free from any fuel damage. For this reason, they have been able to maintain low activity release rates to the environment. Both units now have very low levels of tramp fissile material on the core (below detection limit).

In 2023, Ringhals launched a new programme for long term reduction of airborne and waterborne radioactive releases. The basis for the measures taken during the first years was a benchmark including European and US plants (PWRs). The Programme, including its goal, indicators and measures, is followed up by the ALARA committee.

Recent follow up for Ringhals 3 and 4 shows historically low releases of radioactive substances to water in 2024. Related initiatives include reduction of antimony source terms, improved separation and management of chemically contaminated water and radioactive water, and the use of waste handling coordinators during outage, as well as the modernisation of the Ringhals NPP liquid waste processing facility, which serves all the units.

However, the reduction rate of airborne releases for Ringhals 3 and 4 has levelled off during the past 10 years. Existing installations for delaying and reducing releases of radioactive gases have been working as intended for most of the period, but in-depth analysis shows that further reduction of > 50 % of noble gases would be possible on Ringhals 4 by performing reconstruction already implemented on Ringhals 3.

At Ringhals NPP, the annual dose to the “representative person” is mainly due to C-14. Releases of other radionuclides contribute less than 10 % of the total dose. Releases to water account for approximately 1 % of the total dose calculated to the representative person.

Forsmark NPP

Forsmark works actively to reduce emissions to air and water. The work with reducing fuel failures and identifying leakages has given a positive trend and the emissions have decreased.

Forsmark NPP has under a number of years had problems with fuel failures. Extensive work has been made to solve the problem. Forsmark has received external help with the development of general routines and controls. In 2021 and until 2024 all three units in Forsmark were free of fuel failures which was the longest period of non fuel failure operation.

Discharges of radioactivity to the water recipient has been kept at very low levels for recent years.

Oskarshamn NPP

The decision to decommission the two oldest units at Oskarshamn NPP has reduced the releases from the site. For the two facilities under decommissioning, plans have been specially developed for monitoring and limiting releases and with special focus on the various work packages that occur during the decommissioning.

For the remaining reactor still in operation, the focus is to continuously follow up releases to air and water, where higher emissions to air have been found than budgeted for and which could be attributed to fuel damage.

When preparing the budget, fuel damage is not taken into account. A program for long-term limitation of emissions of radioactive substances exists, which reports reference and target values for radioactive emissions and on a monthly basis focuses on: emissions within budget, emissions exceeding the internal accumulated monthly budget and emissions exceeding the internal annual budget or target values.

Within the decommissioning projects, higher emissions to air have occurred compared to budget, an outcome that is linked to more extensive and longer times for the implementation of certain sub-steps.

The budget for emissions to air from decommissioning activities is reported in accordance with the estimated emissions reported to SSM in the sub-partial reports. There are no target values for these reactors and emissions are monitored on a monthly basis, with a focus on budget, emissions that have exceeded the internal accumulated monthly budget, and emissions that have exceeded the internal annual budget.

15.2.8. Other events and activities during the review period

Improving the precision of the dose prognosis is a continuous work at all three NPPs.

Ringhals NPP

As a result of less maintenance and fewer large projects involving reactor systems along with stable or decreasing source terms, the power plant has faced a notably lower CRE (collective radiation exposure). Along with lower individual doses and a fewer number of man hours, this challenges the system of dose prognosis.

To guarantee that personal dosimeters, both TLD and EPD, are used as prescribed, implementation of technical and physical barriers is ongoing. This activity will ensure that the correct dosimeterset is used when entering a controlled area.

Decommissioning activities are in progress for Ringhals 1 and 2 with, for example, dismantling of steam generators and pressuriser at Ringhals 2, while at Ringhals 1 the main work from a RP point of view is focused on volume reduction of reactor internals.

Forsmark NPP

The plans for LTO on all three reactors have resulted in an increased need for maintenance of contaminated systems and components, which in turn creates a need for efficient ALARA planning and implementation of ALARA measures.

Identification and encapsulation of damaged fuel rods and removal to the intermediate fuel storage are ongoing. This is to minimise leakage of activity to the storage basins.

Oskarshamn NPP

In conjunction with outages, the “safety team” have been represented in the reactor facility, by using personnel from different parts of the Oskarshamn organisation, and with a strong focus on raising their level of occupational safety by means of prioritising safety ahead of schedule, rules and identified risks related to operations, stopping tasks that seem to pose risks, and rectifying and reporting risks and events. The purpose has been to reinforce the overall safety culture and this work will continue during future outages.

During the 2020 outage, it was found that high dose rates were obtained when opening systems, and there were high levels of contamination in the systems which remains a challenge to this day.

An investigation is underway into these phenomena and their possible links to used fuel types, contaminants in spreading material, and the moisture content of the steam. The investigation is being led by the execution organisations on the operational and technical side. Together with the support of, and data from, the company’s source term group, the investigation seeks to establish the root cause of problems when opening systems, especially ahead of the upcoming longer outage, when the organisation will again need to open up systems.

Based on the results through the root cause analysis, measures will then be implemented in ALARA terms.

Instructions for categorisation, classification, reporting and analysing of RP incidents are used within the company and have been adapted to meet SSM’s requirements for reporting to the Authority, for both operational and decommissioning activities. The instructions have recently been updated with a clarification of which events must be reported to the authority in writing, according to a certain level of consistency and with a time criterion of seven days.

It should also be noted that Oskarshamn on a weekly basis informs the authority verbally about all RP-related events, that have occurred.

15.3. Impact and results of radiation protection measures

15.3.1. Occupational exposure

Figure 10 shows occupational collective radiation doses at Swedish NPPs during the period 2015–2024. As can be seen, the annual total collective dose has decreased during the last decade. The level has, however, been fairly stable for the last four years and there are several reasons for this. The main source of occupational exposure is external radiation from Co-60 on the surface layers in primary reactor systems. A continuous effort for many years to reduce production and distribution of Co-60 has resulted in a decrease of radiation levels in the work environment. Another explanation for the decrease in exposure is the decision to permanently shut down some of the oldest reactor units. Oskarshamn 2 was permanently shut down in 2016 and Oskarshamn 1 in 2017. Ringhals 2 was shut down in 2020 and Ringhals 1 in 2021. Phasing out reactor operation led initially to less workload inside controlled areas and therefore less occupational exposure. During the last four years there has been some increase at Oskarshamn due to decommissioning which has created more workload inside controlled areas.

The more elevated collective doses for 2015 illustrated by figure 10 are associated with major modernisation work carried out at Ringhals and Oskarshamn.

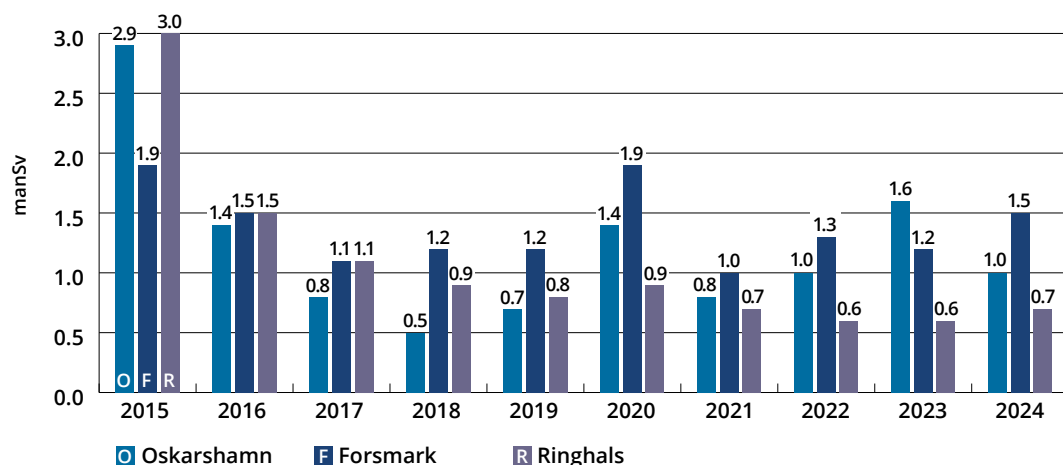


Figure 10. Collective radiation doses (manSv) at Swedish NPPs in operation during the period 2015–2024.

Internal exposure of workers at the NPPs in operation continues to be rare. A total of five workers have registered an internal dose in the last 10 years, with the highest committed effective dose being 0.6 mSv. The low number of intakes of radionuclides reflects low contamination levels and effective safety procedures.

A selection of statistics on occupational doses at Swedish NPPs during the same time period is shown in table 7. As can be seen, there is a significant decrease in the number of individuals exceeding 10 mSv per year, which is considered to be an effect of the operators specific focus on reducing doses to the most exposed workers, e.g. by the use of dose constraints. In addition, no worker has received an annual dose exceeding 20 mSv in the last 10 years, while the average annual effective dose has largely been kept below 2 mSv with a slightly increasing level due to decommissioning activities. Data are also presented from monitoring of eye exposure. This monitoring program was introduced in 2019 when the new dose limit came into force.

Table 7 Occupational dose statistics for Swedish NPPs.

Year	Total collective dose (manSv)	Average dose (mSv)	Highest annual dose (mSv)	Number of persons with dose >10 mSv	Number of persons with dose ≥0.1 mSv	Highest annual dose to lens of eye (mSv) ⁷	Number of persons with dose to lens of eye >10 mSv
2015	7.9	1.5	14.2	34	5,091		
2016	4.4	1.3	16.4	5	3,510		
2017	3.0	1.1	10.6	2	2,705		
2018	2.6	1.0	9.7	0	2,470		
2019	2.8	1.1	13.6	8	2,511	15.1	13
2020	4.1	1.4	12.4	6	2,851	13.6	12
2021	2.8	1.1	10.2	1	2,459	10.2	1
2022	2.8	2.9	9.4	0	2,529	15.0	10
2023	3.4	2.7	10.4	3	2,841	10.9	7
2024	3.2	2.5	10.4	2	2,870	5.7	3

15.3.2. Doses to the public and releases to the environment

The annual dose limit for members of the public is 1 mSv per year (effective dose) as set out in the Radiation Protection Ordinance (2018:506). In order to assure sufficiently protection of the public, SSM has issued a site-specific dose constraint for releases of radioactive substances from nuclear installations to the environment. The dose constraint of 0.1 mSv per year is independent of the number of release points at the site. There are no regulatory limitations for releases of specific radionuclides. Figure 11 shows effective dose to representative person of the public resulting from releases of radionuclides during the period 2010–2024 at Swedish NPP sites.

⁷ Monitoring of dose to lens of the eye started in 2019.

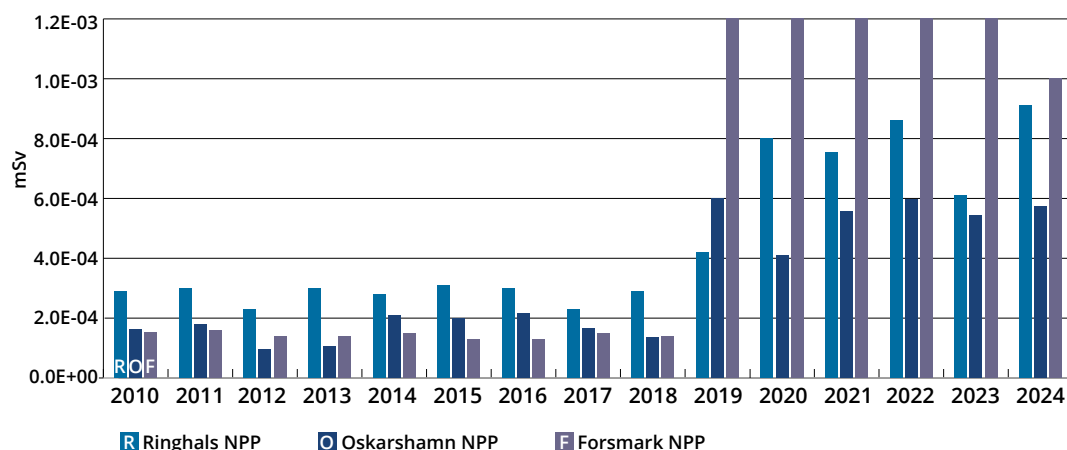


Figure 11. Estimated radiation dose (mSv) to representative person from release of radionuclides from Swedish NPPs. The increase in 2019 is due to the change of methodology used for dose estimations and does not imply an increase in the actual discharges from the NPPs.

Efforts to reduce releases of radioactive substances, by administrative and technical means, have been effective, and the released activity amounts, as well as the corresponding calculated doses to the representative person, have decreased or remained at the same level in recent years. The increase in estimated dose observed in 2019 is due to the change of methodology used for dose estimations and does not imply an increase in the actual discharges from the NPPs. The increase in estimated dose is also small compared to the stipulated dose constraint at 0.1 mSv per year.

Releases to water and air from Swedish reactors are for the most part at the same level as releases from other reactors of the same type and size in other countries. Further actions to reduce gaseous and liquid effluents are planned.

The concepts of reference values and target values are used as management measures as part of applying BAT for reducing releases of radionuclides. The values are defined by the licensees through the application of procedures to establish targets for measurement values that are considered reasonable to achieve over a certain period of time, taking into account existing technical knowledge. They are valuable for achieving the long-term objective of reducing releases and effluents of radioactive substances.

15.4. Regulatory review and control

The requirements building up the baseline supervision plan are divided into six fundamental aspects (see 8.8.2.1).

The baseline supervision plan describes the supervision groups that are carried out each year for NPPs in operation. The supervision groups are carried out every three, five or seven years, based on the risk importance of the group.

Between 2022–2024 the following groups were inspected:

- Work in the facility, including operational RP, issuance of radiation work permits and RP activities at operation and maintenance departments.
- Environmental monitoring, including aspects of sample preparation, measuring, reporting results and also instructions and resources mainly in personnel and work facilities.
- Protection of workers, including external and internal dosimetry, internal transports of radioactive material, and other work activities specific to RP.

Examples of findings from supervision completed in recent years are:

– Work in the facility

In general, all requirements were met, but with some areas for improvement. A shortcoming was that areas with a risk of overexposure were not always documented and known in the organisation. It was also not clear to all RP personnel that they could report incidents anonymously via the Corrective Action Plan reporting (CAP) system. In addition, specific protective equipment was also not specified in the safety instructions, but it was stated in the workarea that RP personnel should be contacted. Furthermore, it has been difficult to ensure data authorisation for hired RP personnel prior to the outage, which complicates the conditions for access to, for example, logbooks, the document system, and the CAP system.

– Supervision of Environmental monitoring

In the new legislation for NPPs issued in 2021, the responsibility for formulating the programme for environmental monitoring was transferred from the authority to the plants. The new programmes were then revised and approved by SSM. In 2023, the new approved programmes entered into force and during 2024, SSM followed their implementation by inspections at all Swedish NPPs (Ringhals NPP, Forsmark NPP, Oskarshamn NPP). The compliance with the new regulations and programmes was good at all three sites. SSM covered aspects of sample preparation, measuring, reporting results and also instructions and resources mainly in personnel and work facilities. Some of the facilities had evaluated the former programme in more detail and also done some work in evaluating their process for measuring which SSM considered to be good practice. SSM also found that this area is somewhat vulnerable in terms of competence provision. One facility had a single competence and another had challenges in recruiting new personnel due to scarcity of the relevant competence in Sweden.

– Protection of workers

All requirements were largely met, with a number of areas for improvement, where sometimes documents and practices did not always correspond in cases where changes to protective equipment were made. The number of risk observations that came to the attention to the safety department was lower than the actual occurrence, which overall can lead to reporting of events and conditions in accordance with the requirement not being carried out or being carried out with a delay.

In addition to the baseline supervision plan, inspections are carried out on an on-going basis to monitor activities at the NPPs related to RP. Normally, these include meeting workers and representatives of the RP management as well as inspection of work activities during outages.

SSM's regulatory control also includes review of various documents submitted by the licensees, eg. annual reports on RP and releases of radioactive substances.

Article 16. Emergency Preparedness

1. Each Contracting Party shall take the appropriate steps to ensure that there are on-site and off-site emergency plans that are routinely tested for nuclear installations and cover the activities to be carried out in the event of an emergency. For any new nuclear installations, such plans shall be prepared and tested before it commences operation above a low power level agreed by the regulatory body.
2. Each Contracting Party shall take the appropriate steps to ensure that, insofar as they are likely to be affected by a radiological emergency, its own population and the competent authorities of the states in the vicinity of the nuclear installation are provided with appropriate information for emergency planning and response.
3. Contracting Parties which do not have a nuclear installation on their territory, insofar as they are likely to be affected in the event of a radiological emergency at a nuclear installation in the vicinity, shall take the appropriate steps for the preparation and testing of emergency plans for their territory that cover the activities to be carried out in the event of such an emergency.

Summary statement for the article

Sweden complies with the obligations of Article 16.

Summary of significant changes and developments since the previous report

- SSM has developed new regulations, which entered into force 1 March 2022 (see also Article 7). All requirements for emergency preparedness and response (EPR) for NPPs in operation are integrated into the new regulations (SSMFS 2021:4, SSMFS 2021:5 and SSMFS 2021:6). Because of the new regulations, the SSM regulation SSMFS 2014:2 concerning emergency preparedness at nuclear facilities have been revised and no longer include requirements for NPPs in operation (see section 16.1.1).
- A new Ordinance (2022:524) on Emergency Preparedness and Measures of Authorities Responsible for Surveillance in Heightened Preparedness entered into force on 1 October 2022 (see section 16.1.2).
- Following the extension of the emergency planning distance (EPD) around Swedish NPPs from 50 km to 100 km in July 2022, radiation monitoring capabilities within the County Administrative Boards in the affected counties have been substantially enhanced through the implementation of a new vehicle-based dose rate systems with real-time data integration into RadGIS (see section 16.2.2 and 16.2.3).
- A development project (ETAPP), regarding electronic transmission of NPP parameters, has been completed by SSM and Swedish NPPs. ETAPP is fully running and implemented in support of education, training and exercises (see section 16.2.2 and 16.3.1).
- At the end of 2024, SSM completed an investigation proposal on radiological acceptance criteria regarding exposure of the public to ionising radiation from new nuclear power reactors (see section 16.2.2).
- Development and improvement activities have been carried out by licence holders to ensure compliance with new regulations from SSM (see section 16.3.1).

- Russia’s full scale invasion of Ukraine has prompted SSM to review and strengthen its own and, by extension, Sweden’s ability to deal with nuclear or radiological emergencies. The outcomes of the Authority’s activities are valid both for peacetime emergency preparedness and for heightened alert situations (see section 16.6.3).
- Nordic guidelines on *Protective Actions in a Nuclear or Radiological Emergency* have been developed by the Nordic radiation protection and nuclear safety authorities (see section 16.6).

16.1. Regulatory requirements

Requirements related to emergency situations and emergency plans for nuclear facilities are included in several legally binding documents:

- The Act on Nuclear Activities (1984:3) regarding general provisions on emergency response in the event of an accident at a nuclear facility,
- Ordinance on Nuclear Activities (1984:14) regarding general provisions on emergency response in the event of an accident at a nuclear facility,
- The Radiation Protection Act (2018:396) regarding general provisions on radiation protection, including during radiological emergencies,
- Radiation Protection Ordinance (2018:506) regarding specific provisions on radiation protection, including dose limits and reference levels to be applied,
- SSM’s regulations (SSMFS 2008:1) concerning safety in nuclear facilities,
- The Act (2023:407) on Important Public Announcement,
- Ordinance (2023:579) on Important Public Announcement,
- The Healthcare Act (2017:30) (off-site EPR),
- SSM’s regulations (SSMFS 2018:1, Chapter 2) concerning basic requirements for all licensed activities with ionising radiation,
- SSM’s regulations (SSMFS 2021:4) concerning design of NPPs,
- SSM’s regulations (SSMFS 2021:5) concerning assessment of nuclear safety (and nuclear security) for NPPs,
- SSM’s regulations (SSMFS 2021:6) concerning operation of NPPs,
- MSB’s regulations (MSBSF 2017:3) on information in emergency situations where there is a risk of radiation,
- The Civil Protection Act (2003:778) regarding protection against accidents with serious potential consequences for human health and the environment (on-site and off-site EPR),
- Civil Protection Ordinance (2003:789) regarding protection against accidents with serious potential consequences for human health and the environment (on-site and off-site EPR),
- Ordinance with instructions for SSM (2008:452) (off-site EPR),
- Ordinance (2022:524) on the Emergency Preparedness of State Authorities,
- Ordinance on Total Defence and States of Heightened Alert (2015:1053) (off-site EPR).

16.1.1. Requirements for on-site activities

In Sweden, the state authorities MSB, SSM and the County Administrative Boards, together with municipalities, have the authority to regulate the on-site EPR arrangements of operating organisations.

SSM’s regulations on on-site emergency preparedness use the concept of emergency preparedness categories (1, 2, and 3) based on the IAEA’s emergency preparedness categories. The regulations involve the application of a graded approach depending on the radiological hazard at the facility.

As far as on-site EPR is concerned, the Civil Protection Act and Ordinance stipulate general requirements applying to facilities that conduct dangerous activities. The Act requires preventive measures and emergency preparedness to be established by the owner or operator of a facility that conducts dangerous activities.

The Act on Nuclear Activities contains general provisions on emergency response in the event of an accident 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. The Radiation Protection Act has requirements regarding protection of people and the environment from the harmful effects of radiation during an emergency. The act also has requirements regarding protection of workers.

Through the Ordinance on Nuclear Activities and the Radiation Protection Ordinance, the Government has assigned SSM the mandate to issue specific regulations for licensees in the fields of nuclear safety and radiation protection. The Radiation Protection Ordinance regarding reference levels to be applied in the case of a nuclear or radiological emergency includes also requirements for optimisation.

Chapter 2, Section 4 of SSMFS 2018:1 states that all activities involving sources that can cause a radiological emergency shall be placed (by SSM) in one of the emergency preparedness categories 1, 2, 3 or 4 (where category 4 is used for activities such as transport of nuclear material). These categories are later used to apply a graded approach of requirements for EPR. Chapter 2, Section 5 of SSMFS 2018:1 further requires that the licensee for an activity shall have a prepared EPR organisation corresponding to their assigned category. The organisation and the actions to be taken in case of emergency shall be documented in an emergency response plan, along with instructions for the on-site emergency response organisation, including the chain of command, relevant facilities, resources and coordination of emergency response activities (both on-site and off-site). EPR shall be tested through exercises, and lessons learned shall be used for improvement.

The regulations on design of NPPs (SSMFS 2021:4), clearly state that the design of such a plant shall take the needs for effective EPR into consideration. This is achieved mainly through specifying emergency response as an important function, and by the use of specified emergency scenarios (including long-lasting situations and simultaneous emergencies at several nuclear facilities at the same site), to be considered in the design of both the facility and its equipment, and of the human tasks needed. The design of an NPP shall also include the capability to set up a logistics centre at a location distant from the main site. This logistics centre shall have capabilities for serving as the forward control point for transports of personnel and equipment to and from the facility during an emergency, including facilities and equipment for dosimetry and decontamination. SSMFS 2021:4 also include requirements on electronically delivered real time process data from NPPs to SSM.

For NPPs, Chapter 5, Section 5 of SSMFS 2021:5 presents more detailed requirements on the contents of the site emergency response plan as directed by SSMFS 2018:1, including e.g. description of and references to procedures, facilities, mobile equipment, technical assistance to operational staff, and coordination with off-site organisations.

Requirements on emergency response organisation, response time, criteria for alarm for different emergency classes, and protective equipment are established in Chapter 8 of SSMFS 2021:6. Chapter 8, Section 10 of SSMFS 2021:6 also contains requirements relating to the initiation of transfer of process data to SSM during emergencies, as required by Section 10 of the Act on Nuclear Activities.

For other nuclear facilities the regulation SSMFS 2014:2 uses the concept of emergency preparedness categories (1, 2 and 3) based on the IAEA's emergency preparedness categories, which introduces the application of a graded approach depending on the radiological hazard at the nuclear facility.

16.1.2. Requirements for off-site activities

The overarching objective of the Civil Protection Act is civil protection for all of Sweden with consideration given to local conditions – for life, health, property and the environment, against all types of incidents, accidents, emergencies, crises and disasters. The act defines the responsibilities of individuals, local authorities and Government in cases of serious accidents, including radiological accidents. The act also contains provisions on how rescue services shall be organised and operated, and stipulates that a rescue commander with a specified competence, and far-reaching authority, is to be engaged in all emergency response operations.

The Civil Protection Ordinance states that County Administrative Boards are responsible for emergency response operations in cases where the public needs protection from a radioactive release from a nuclear installation, or in cases where such a release seems imminent. The ordinance also states that SSM shall advise on radiation measurements and coordinate and assist with radiation protection assessments for rescue services. The ordinance contains general provisions concerning emergency planning as well as more specific requirements on reporting obligations, information to the public, responsibility of the County Administrative Board for planning and implementing public protective measures, content of the off-site emergency plan, competence requirements for rescue commanders, precautionary action zone (PAZ), urgent protective action planning zone (UPZ) and extended planning distance⁸ (EPD) around major nuclear facilities. The County Administrative Board is required to have an off-site nuclear emergency response plan. MSB is responsible at a national level for coordination and supervision of preparedness for an off-site emergency response to radioactive releases.

The ordinance with instructions for SSM (2008:452) contains provisions imposed on SSM that apply in the case of a nuclear or radiological emergency. SSM's role in the Swedish emergency management system is mainly to provide advice on radiation protection in the event of a nuclear or radiological emergency, maintain a national expert response organisation for monitoring, and provide information on the technical state of nuclear installations in the case of an emergency.

A new Ordinance (2022:524) on the Emergency Preparedness of State Authorities entered into force on 1 October 2022. The ordinance replaces the ordinance (2015:1052) on Emergency Preparedness and the Measures to be taken by Designated Authorities in the Event of Heightened Alert. The aim of the new Ordinance is to ensure that government authorities at national and regional level work to reduce vulnerabilities in society and develop a good capacity for handling their tasks during emergencies, crisis and cases of heightened alert. Ordinance (2015:1053) on Total Defence and States of Heightened Alert contains provisions on civil defence during periods of heightened alert.

16.2. National structure

The Swedish emergency management system is based on three principles:

- The principle of responsibility – meaning that the entity that is responsible for an activity under normal conditions also should have this responsibility in the case of an emergency.
- The principle of parity – meaning that to the extent possible, operations should be organised in the same way during emergencies as under normal conditions.
- The principle of proximity – meaning that emergencies should be dealt with where they occur and at the most local level possible in society (the affected municipality or county).

Furthermore, the Swedish emergency management system distinguishes between authorities having jurisdiction in a specific region (municipality, county or country) and authorities having mandates in specific areas of expertise, for instance SSM in the fields of radiation protection and nuclear safety. The system is based on collaboration and coordination between authorities, according to the general principles and jurisdictions. MSB has the task of supporting coordination between the public sector and various stakeholders. MSB has developed recommendations for the shared foundations of collaboration and management, which will contribute to an improved capability to cope with emergency situations in Sweden. The aim is to provide guidance to authorities on joint methods and approaches for enabling shared direction and coordination.

The national contingency plan for dealing with nuclear or radiological accidents is currently under revision and is expected to be completed during spring 2025. This national plan describes basic conditions, such as applicable legislation and the authorities involved in dealing with an incident, in addition to these authorities' mandates. The plan also describes national coordination and liaison between competent 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 the contingency plan, a national action plan is in place for improvements to emergency preparedness work.

⁸ A planning zone (EPD*) is applied instead of an extended planning distance (EPD) in Sweden for existing facilities. In the planning zone, radiation monitoring and evacuation of the public based on monitoring results (i.e. relocation) should be prepared as specified by the IAEA. In addition, sheltering and distribution/intake of iodine thyroid blocking (ITB) should also be prepared if justified. Since geographically prepared plans are a prerequisite for effectively implementing sheltering and distribution/intake of ITB, a zone with clear geographical boundaries is applied instead of a circular distance.

The County Administrative Boards are responsible for EPR of the public and environment in the event of an accident at a nuclear facility. The Board appoints an emergency response commander. The responsibility for directing emergency services also rests with the County Administrative Board in the affected county or counties, unless the Government decides otherwise. Surrounding each NPP, a precautionary action zone (PAZ), urgent protective action planning zone (UPZ) and extended planning distance⁹ (EPD) are established. Here, predistributed potassium iodide tablets are available for iodine thyroid blocking, and predistributed information describes urgent protective actions in the event of a nuclear emergency. Residents inside the PAZs and UPZs are provided with special radio receivers. These are used for warning residents in the event of an emergency at the NPPs. The County Administrative Board is also responsible for measurements and managing decontamination activities following a nuclear emergency involving fallout.

The Government is responsible for emergency management at a national level. The Government's mandate is primarily concerned with strategic national issues while 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 the crisis communication is credible. The State Secretary to the Prime Minister is responsible for leading the overall crisis management process, assessing the need for coordination at the Government Offices, and when necessary, convening a meeting of the Strategic Coordination Group that comprises state secretaries at the ministries whose activity areas are affected. The Government Offices has a special Director General and a secretariat for crisis management. They support the State Secretary to the Prime Minister and develop, coordinate and follow up crisis management. The Director General's responsibilities include ensuring that the Government Offices make necessary preparations for crisis management. This may include early warning of a situation that may develop into a crisis, or training and exercises to increase general crisis management capacity. The Crisis Management Coordination Secretariat monitors developments both nationally and internationally around the clock. It is able to raise an alert and produce comprehensive status reports and an overview of the combined impact on society of all individual events. After a crisis situation, the Secretariat should be able to follow up and evaluate the measures taken.

According to Ordinance (2008:452) with instructions for SSM, SSM is charged with the responsibility to give advice on radiation protection in connection with a nuclear or radiological emergency. SSM shall also provide technical advice in the event of a nuclear or radiological emergency. Furthermore, SSM shall provide expertise as well as knowledge and decision support within the area of radiation protection, including dispersion prognoses, radiation monitoring and radiation protection assessments.

SSM is Sweden's National Competent Authority (NCA). In a radiological or nuclear emergency, SSM provides recommendations and expert advice to authorities on protective actions, radiation protection assessments, dispersion prognoses, radiation monitoring, and assessment of technical conditions at an NPP. SSM also maintains and leads a national expert organisation for radiation monitoring.

Each authority shall, upon request from the Government, provide the information necessary for comprehensive situational assessments. These include 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, to provide the information needed in order to give an overview of the situation. A number of authorities, organisations and laboratories will work together, or operate as supporting functions to the national organisations mentioned above, in the event of a radiological emergency.

⁹ A planning zone (EPD*) is applied instead of an extended planning distance (EPD) in Sweden for existing facilities. In the planning zone, radiation monitoring and evacuation of the public based on monitoring results (i.e. relocation) should be prepared as specified by the IAEA. In addition, sheltering and distribution/intake of iodine thyroid blocking (ITB) should also be prepared if justified. Since geographically prepared plans are a prerequisite for effectively implementing sheltering and distribution/intake of ITB, a zone with clear geographical boundaries is applied instead of a circular distance.

Participating or responsible authorities that have liaison roles for crisis management include the Swedish Food Agency (SLV), whose areas of responsibility include food and drinking water and the Swedish Board of Agriculture (SJV), whose areas of responsibility include feed and animal protection. Other authorities that have responsibilities during crises and that liaise with SSM, or receive advice and recommendations from SSM, include the County Administrative Board, MSB, the Swedish Board of Health and Welfare, the Swedish Customs, the Swedish Meteorological and Hydrological Institute (SMHI), the Swedish Police Authority, the Swedish Coast Guard, Regions, the local emergency response leader and medical personnel. In the event of a radiological or nuclear emergency, SMHI will provide SSM with data and computational resources to perform dispersion calculations, regardless of whether it occurs domestically or abroad.

In recent years, the Government has decided to build up its civil defence in view of security-related developments around Sweden. This includes 10 emergency service sectors, covering over 60 authorities, i.e. authorities with special significance for public emergency preparedness and total defence, including SSM. Within the sector there is ongoing work to identify potentially missing necessary capabilities, and establishing arrangements and interactions between concerned authorities, where those are missing. The sector-responsible authority leads the work of coordinating measures, both in preparation for and during peacetime crises and heightened state of alert and war. The following emergency service sectors are:

- Financial security
- Electronic communications and post
- Energy supply
- Financial services
- Supply of basic data
- Health, care and nursing
- Food supply and drinking water
- Public order and security
- Emergency services and protection of civilians
- Transport

MSB, the Swedish Food Agency, Board of Agriculture, Swedish Defence Research Agency and SSM collaborate closely within the national expert group on decontamination and remediation of radionuclides (NESA) in which a representative of the County Administrative Boards is also appointed. The purpose of NESA is to collect and share information on different aspects of remediation among the participating organisations, other central authorities and the County Administrative Boards. MSB is also responsible for guidelines on remediation and food production in the event of fallout of radioactive substances in Sweden.

As mentioned earlier, MSB has a responsibility in preparedness work to assist in coordinating preparedness measures taken by local, regional and national authorities. MSB also provides competent authorities with communication networks to be used during extraordinary events. MSB has the overall responsibility for Raket, the Swedish national digital radio communication system for connection of national emergency services and other stakeholders in the fields of civil protection, public safety and security, emergency medical services and healthcare during emergency situations. The Raket system is used by municipalities, counties, national agencies, licensees and commercial entities. MSB also assists the Swedish Government Offices by providing documentation and information in the event of serious crises or disasters, and by providing methods for crisis communication and coordination of official information to the public.

Sweden's structure for emergency preparedness and response for nuclear emergencies is shown in figure 12.

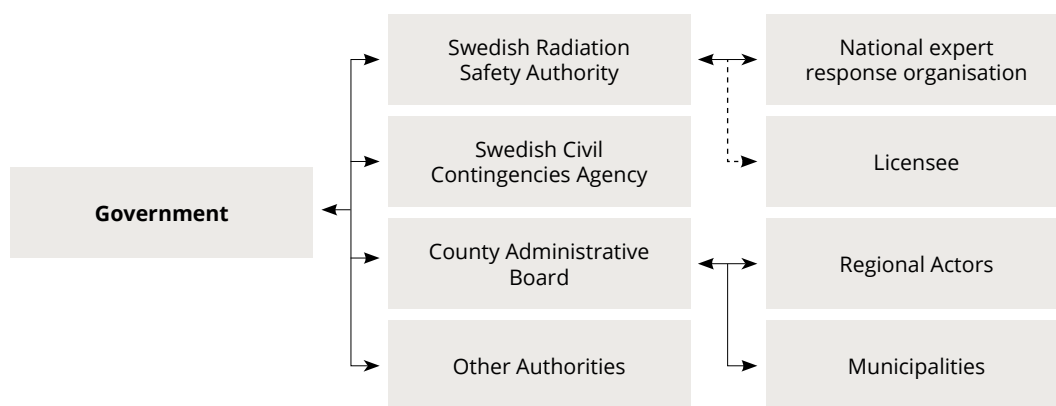


Figure 12. The Swedish national structure for emergency preparedness and response for nuclear emergencies.

In the event of a nuclear emergency abroad, any affected County Administrative Board still has a responsibility to provide information and take potential protective actions in their region as per the principle of proximity. SSM's role as an advisory authority is maintained in the event of a nuclear emergency abroad.

16.2.1. Alerts

In the event of a nuclear emergency at a Swedish NPP (belonging to emergency preparedness category 1), the licensee is responsible for immediately contacting the national alarm centre (SOS Alarm Sverige AB). In its turn, SOS Alarm will alert the authorities and organisations responsible for emergency management. See figure 13.

In the event of an emergency at a nuclear facility classified as belonging to emergency preparedness category 2, the alert sequence is similar, with some differences in terms of the role of SOS Alarm.

In the event of a radiological or nuclear emergency abroad (with a possible request for assistance), the alert goes to SMHI, which is the national point of contact (National Warning Point, NWP). Upon an alert SMHI will, through SOS Alarm, contact the officer on duty at SSM. The officer on duty at SSM then contacts the Government ministry offices and the central and regional authorities having roles and responsibilities in the initial phase of a nuclear accident or incident.

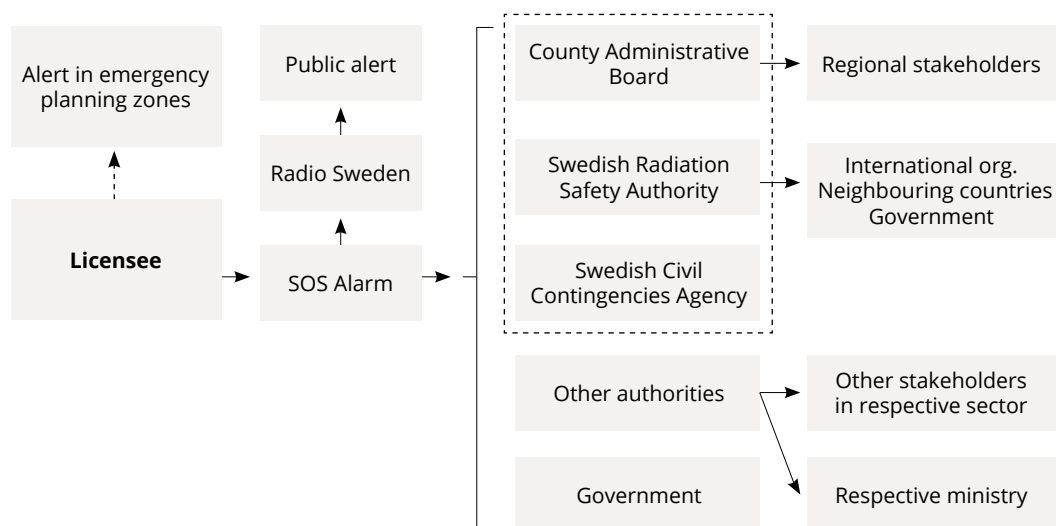


Figure 13. Current sequence for communicating an emergency event at a Swedish NPP.

16.2.2. Emergency preparedness strategy

A new Radiation Protection Act and new appurtenant ordinance came into force on 1 June 2018 as part of the implementation of Council Directive 2013/59/Euratom. The new legislation strengthened the requirements in the field of EPR. Among other things, the Government has, in the radiation protection ordinance, set reference levels for the public in emergency exposure situations. Generically justified and optimised protection strategies for different postulated events have been developed by SSM for nuclear facilities in emergency preparedness categories 1 and 2 (cf. SSM Report 2017:27e) in consultation with MSB, relevant County Administrative Boards, and other involved authorities and stakeholders. The protection strategies are based on identified hazards and potential consequences at each nuclear facility, including generic criteria for public protective actions derived from the reference levels, as well as operational criteria and default triggers.

To support an optimised protection strategy, SSM has developed decision support diagrams that provide guidance for making decisions on public protective actions in the event of a nuclear emergency at the Swedish NPPs, taking the inherent uncertainties of such events into account. The decision support diagrams are based on emergency class and recurring evaluation of the situation, and lead to a recommended course of action given the present knowledge of the situation. The decision support diagrams were developed in close collaboration between radiological experts, the authorities responsible for nuclear emergency response planning, and the final decision makers. Methodologies developed by SSM from a review of the Swedish emergency planning zones and distances were used in the development. Development of this decision support has continued.

A development project which was signed by the director general of SSM and the managing directors of the NPPs in the autumn of 2012 regarding electronic transmission of NPP parameters is now fully running (ETAPP).

The Swedish Government tasked SSM in 2015, in consultation with MSB and other authorities, to review emergency planning zones and distances for ionising radiation activities. In 2017, SSM proposed new zones and distances, including sensitivity analyses for multiple reactor incidents. In 2018, MSB was commissioned to propose changes to the Civil Protection Ordinance. New zones (PAZ and UPZ), and an extended planning distance¹⁰ (EPD) around Swedish NPP (increased from 50 km to 100 km) was decided by the Government in 2020, and were implemented on 1 July 2022.

A strategy for radiation monitoring in the event of an accident at a Swedish NPP has been developed by SSM, MSB and the County Administrative Boards. The strategy focuses on radiation monitoring at the regional level. Work is ongoing to broaden the scope to cover national resources, as well as other nuclear and radiological emergencies.

At the end of 2024, SSM completed an investigation proposal on radiological acceptance criteria regarding exposure of the public to ionising radiation from new nuclear power reactors. The purpose of the investigation was to develop proposals for radiological acceptance criteria for public exposure as a basis for level 2 regulations relating to assessments using deterministic methods for events and conditions in event classes H2–H5 for new nuclear reactors and, if possible, other reactor technologies (see also section 7.2.2). The proposals follow international practices as closely as possible.

16.2.3. Radiation monitoring

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

MSB has during 2022–2024 distributed new hand-held instruments for radiation monitoring to all Swedish municipalities and County administrative boards.

¹⁰ A planning zone (EPD*) is applied instead of an extended planning distance (EPD) in Sweden for existing facilities.

Sweden has a gamma monitoring network that presently has 28 permanent stations spread throughout the country. The stations are designed to provide warnings and rapid information about radiation levels. Each gamma station continually records the dose rate and can be monitored online. If the integrated dose or dose rate exceeds a pre-defined alarm level, notifications are automatically transmitted to RadGIS where, depending on the alarm, further actions will be taken by the officer on duty at SSM. The alarm level is set to detect deviations from prevailing normal conditions. During 2025 and 2026 the gamma monitoring network will be upgraded with new spectroscopic stations.

In addition to the national gamma monitoring network, local stations are installed around the NPPs in Sweden. These monitoring stations provide information on the dose rate at 90 locations around the NPPs. While the national gamma monitoring network is primarily used as an early information system, the local stations will provide fast, reliable and automatic information on dose rates in the event of an accident at a Swedish NPP. Data from the stations can be used to verify and follow a potential release and to assess the adequacy of implemented protective actions. Figure 14 shows the local monitoring stations set up around the Forsmark NPP.

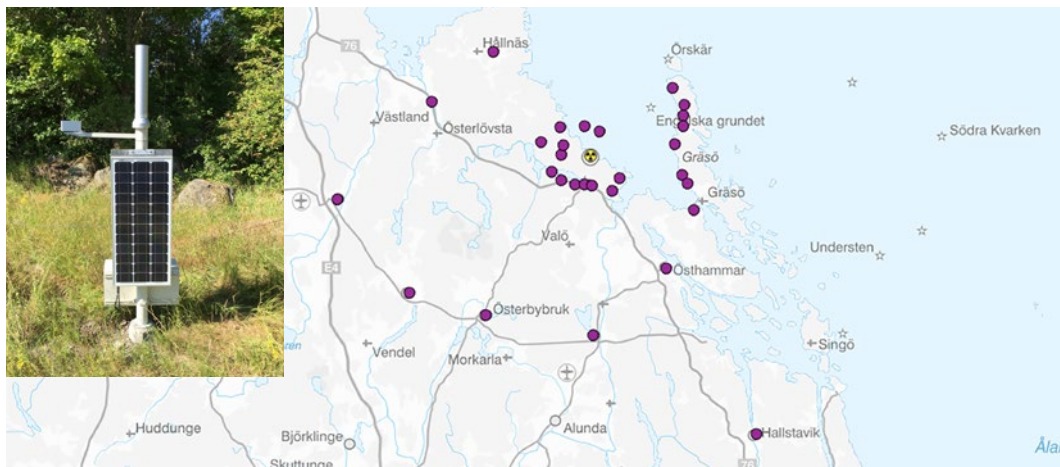


Figure 14. Local monitoring stations around the Forsmark NPP (the inset shows a monitoring station).

Sweden also has six permanent air sampling stations operated by the Swedish Defence Research Agency (FOI) and a Comprehensive Nuclear-Test-Ban Treaty (CTBT) station located in Stockholm. These stations continuously sample the air in order to collect any airborne radioactive materials. The detection system is sufficiently sensitive to measure activity levels in the order of a few $\mu\text{Bq}/\text{m}^3$ and consequently is also used for environmental monitoring.

As the County Administrative Boards are responsible for protecting the public during and after a nuclear emergency, the Boards' emergency response planning also encompasses monitoring. Monitoring of dose rates and collection of air samples for the purpose of public protective actions are performed by local emergency services from municipalities within each county at predefined locations or routes. During a nuclear emergency, the relevant County Administrative Board coordinates response and monitoring activities with the national expert response organisation and government authorities in accordance with the organisational chart shown in figure 15.

Radiation monitoring organisation

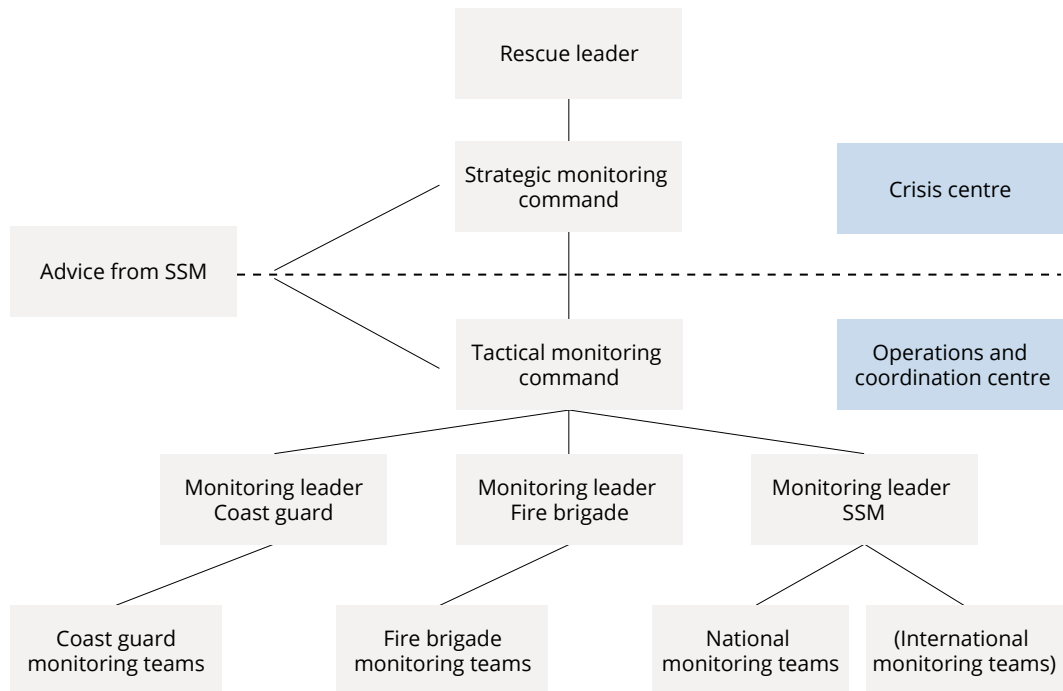


Figure 15. The Swedish radiation monitoring organisation which is set up in preparation for a possible nuclear emergency.

The national expert response organisation comprises government authorities, organisations and laboratories that have expertise in radiological assessment and radiation monitoring. This organisation, coordinated by SSM, has as its main purpose to perform radiation measurements. Figure 16 shows the location of contracted authorities, organisations and laboratories that have capabilities encompassing laboratory analysis and field monitoring, mobile and airborne monitoring, weather forecasting and plume dispersion prognoses. In addition to the tasks belonging to the national expert response organisation, individuals engaged in this response organisation may also have a role in providing expert advice during the response.

Swedish expert response organisation:

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



Figure 16. National expert response organisation for nuclear and radiological emergencies.

16.3. Implementation by licence holders

Concerning on-site EPR, the licensees at all sites are working on measures to fulfil the SSM requirements that entered into force on 1 July 2018. More specific information regarding the work performed is provided below.

16.3.1. Activities at each site

Forsmark NPP

At Forsmark NPP, documentation has been developed to manage abnormal events. This documentation consists of early support strategies for the operational management for coping with: slowly developing incidents, extreme weather conditions, emergency situations such as loss of the ultimate heatsink, station blackout (loss of all external and internal power), and long-term loss of alternate power. The strategies may or may not lead to a declared emergency level.

Forsmark has built a new severe accident management guideline based on IAEA Safety Standards. This SAMG gives good support for decision making in a severe accident. The SAMG contains strategies for Forsmark 1, 2 and 3 for how to deal with the reactor, the containment, the reactor building and also for the spent fuel pools. The SAMG addresses both ordinary operation and outage. The work was finished in 2020 and has since then been implemented in exercises.

A fully mobile logistics centre has been established. The purposes of the centre include receiving equipment, provide personnel with protective equipment, dosimetry services (EPD), screening for external and internal contamination, decontamination of personnel, cars, trucks and equipment, rotation of on-site personnel, and receiving heavy equipment prior to transport to the NPP.

In 2022, new regulations came into force in Sweden requiring the plant to prepare for large unfiltered early releases as well as multi-unit events with damaged infrastructures. Adjustments to meet these requirements are on-going.

Ringhals NPP

The project aiming to provide electronic transmission of process data to SSM (ETAPP) has been successfully completed since last national report.

Training and validation regarding the updated Severe Accident Management Guidelines (SAMG) package for Ringhals 3 and Ringhals 4 has been accomplished in the graphic simulator (GSIM). Personnel from operations and from the emergency response organisation (RIHAB) have been trained in usage of the updated guidelines.

Development and improvement activities have been carried out to ensure compliance with new regulations from SSM. These activities include, for example, an update of the analysis of needed competencies and skills in RIHAB and the development of a new method for evaluation of competencies and skills and assignment of powers. Work has also been carried out in order to ensure and verify for example alternative locations for the establishment of logistic centre, assembly points for emergency personnel, and storage of equipment and materials.

The functional readiness of RIHAB – staffing, premises and equipment – is assessed weekly and reported to the operations management. Deviations from what is expected are identified and followed up.

A combined cyclical plan for training and exercises has been implemented. Exercises are performed according to the regulation and to address identified needs. Twice a year, in January and September, training and continued education are offered to all personnel in RIHAB. Continued education includes, for example, information about new routines, lessons learned from exercises and other sources, and discussions with peers about situations and dilemmas. Each training session also contains a practical exercise.

Oskarshamn NPP

Post-Fukushima improvement work in the field of emergency preparedness has been implemented. One example is represented by Oskarshamn NPP's off-site operational support centre. The latest command management technology, such as sound and video equipment etc., has been installed in the off-site operational support centre. The off-site operational support centre's technology is identical to that of the pre-existing on-site operational support centre. The off-site operational support centre is located in the town of Oskarshamn, about 30 kilometers from the NPP. In the event of an emergency, the Engineer on Duty (EoD) will, following an assessment of the situation, select which of the operational support centres to operate. The two operational support centres give the opportunity for shared management and relocation, if necessary.

Another example of a post-Fukushima improvement is a mutual agreement that has been concluded by Swedish NPPs regarding protective equipment. Furthermore, the mutual agreement concluded previously on pooling resources during an event will provide additional reinforcement at the affected plant.

Oskarshamn NPP places great emphasis on good performance from the response organisation during stressful conditions. Consequently, all personnel belonging to the emergency response organisation, are trained and retrained annually in command and control methodology. This arrangement works well, as was confirmed during various exercises carried out with the emergency response organisation. Oskarshamn NPP assigns ten members of staff to the emergency preparedness organisation, who are available around the clock.

Oskarshamn NPP has conducted internal audits, SSM has conducted compliance inspections and WANO has conducted a peer review in the area of emergency preparedness. Great emphasis was placed on corrective actions in the development areas of the EPR organisations, an aspect that was identified from Oskarshamn's internal audit as well as from SSM's inspection. The development areas identified are currently being managed in the existing development plan for the EPR arrangements.

Another outcome of the nuclear accident in Fukushima in 2011 was that the requirements for emergency equipment were made more stringent at Swedish NPPs. Among other things, it is the responsibility of the licensees of NPPs to have capability to establish a logistics centre during an emergency. The logistics centre is to serve as a hub for transporting personnel and equipment to and from the site in the event of a serious accident. This requirement came into force on 1 March 2022. For this reason, Oskarshamn has established a logistics centre at a former airport, and has an organisation set up to provide assistance at this centre.

There has been strengthened focus on severe accident management. Several new instructions have been introduced and exercised by the shift crews and Technical Support Centre (TSC) in the simulator. Existing routines (EOPs and SAMGs) have been updated, verified and validated. SAMG routines have been trained and exercised by the shift crews and TSC.

Another improvement is that process data from Oskarshamn NPP is delivered electronically in real time to SSM. The application (ETAPP) used for displaying process data has also been used to develop and record simulated emergency scenarios for training and exercises. This has been developed as a joint project between the NPPs in Sweden, and will be used in future exercises to improve the skills of the emergency response organisations.

16.3.2. Exercises

A number of on-site functional exercises are conducted annually at all nuclear sites. Specific plans are in place for these exercises. Exercised functions for example include accident management, communication within the emergency response organisation, environmental monitoring and sampling, assessment of core damage and source terms, and assessment of the total environmental consequences of a scenario. Local follow-up exercises from the major national exercise have also been carried out.

Forsmark NPP

At Forsmark NPP, training, retraining and exercises are carried out according to predetermined plans for staff involved in EPR work. The exercises have needed to adapt to the circumstances of the pandemic.

In addition to the annual functional exercises, the Forsmark NPP conducts unannounced call-out drills a number of times each year. The purpose of the drills is to evaluate the performance of the emergency response organisation.

During 2022–2024 Forsmark has performed emergency exercises at each unit. This year the “Sea Eagle” exercise 2025 is carried out in three stages and continues into next year. In addition to Forsmark NPP and SSM, there are around thirty other actors who will join the exercise. The three different sessions will be: alarms and warning, management and protective action, and radiation measurement.

Ringhals NPP

Ringhals aim for exercises is to be as realistic and reality-based as possible and to involve both internal and external participants in order to practice cooperation and communication. This aim is applied both for large exercises and for smaller. Evaluation reports are compiled after each exercise. Improvement actions are prioritised, scheduled, addressed and followed up in the corrective action database.

Drills are planned annually with a three-year perspective, with the coming year in detail. Key improvement actions coming out of these exercises are presented in the evaluation reports for each exercise. A number of on-site functional exercises are conducted annually according to plan. Unannounced call-out drills are conducted annually. The purpose of the call-out is to evaluate the response capabilities of the emergency organisation (RIHAB).

In November 2023, a large exercise involving almost 200 individuals was carried out at Ringhals. Participating in the exercise were all RIHAB roles, shift operating team in the simulator, maintenance, fire protection, security personnel, SSM, Svenska kraftnät, County Administrative Board in Halland, The Swedish Police Authority and Vattenfall (CS&R and BU Generation).

Oskarshamn NPP

At Oskarshamn NPP, training in emergency response is based on an exercise and training plan. Each function within the emergency preparedness organisation regularly conducts internal exercises in order to strengthen its capacity. The plan is continuously monitored, and reported on at meetings of Oskarshamns NPP’s emergency preparedness council. Training activities are adapted to the content, structure and time aspects emerging from needs and experiences. This is in addition to adaptation to other parties’ exercises, or events that are considered valuable for the emergency response organisation. Adaptation is carried out by selecting a scenario, as well as by means of quick and flexible planning.

During the reporting period, two larger exercises have been held, of which one included the logistics centre. The exercises were performed in 2022 and 2024 and involved, in addition to Oskarshamn NPP, also external parties such as SSM and the County Administrative Board.

In 2024, a large nuclear power exercise (KKÖ24) was carried out in Kalmar County. The exercise focused on increasing knowledge about the changed emergency zones around the NPP in Oskarshamn and the protective measures that may be decided in the event of a nuclear accident.

The exercise was divided into different elements, where one of the goals was to increase knowledge about the emergency zones for local actors and the neighbouring County Administrative Boards that are now included in the expanded emergency zones. The elements included an alarm and start-up exercise, seminar days on deciding on protective actions and evacuation, and a field exercise with a focus on radiation measurement and establishing a field site after a radioactive release.

The County Administrative Board of Kalmar County participated in the exercise as the organising actor, other actors were the Oskarshamn NPP, county administrative boards and municipalities in neighbouring counties. But also national authorities and organisations such as SSM, MSB, the Coast Guard, the Swedish Transport Administration, Swedish Police Authority and the Swedish Armed Forces participated.

16.4. Regulatory review and control

Regulatory supervision has shown that on-site emergency preparedness at Swedish NPPs is acceptable, and that the main requirements are implemented. Findings in the inspections have not led to any action by SSM as they have been dealt with timely by the licence holders. The focus of regulatory review and control during this period has been on:

- Exercises in emergency preparedness and crisis management in radiological emergencies.
- Training in emergency preparedness and crisis management in radiological emergencies.
- Information to workers on the meaning of alarm signals in radiological emergencies, the location of the evacuation assembly point, and routines to be implemented in radiological emergencies.
- Routines for activities to be performed at the evacuation assembly point.

In some instances findings in regulatory supervision have led to immediate actions from the licensees. Examples of findings are shortcomings in protocols for testing of alarm systems, and adequacy of uninterrupted power supply to the alternative control centre. Other findings are that not all roles in the emergency organisation have been tested in exercises, and not all exercises have been evaluated after being performed.

16.5. National exercises

A number of emergency response exercises of varying scope are conducted annually in Sweden. These exercises vary in complexity from limited scope to full-scale exercises. Periodical tests of the alerting systems between the power plants and the authorities are performed each year.

Every other year, a full-scale exercise is held at one of the three nuclear power sites to check the planning and capability of the on-site and off-site organisations. Full-scale exercises are designed to enable evaluations of regional level command and national inter-agency cooperation. Often, full-scale exercises are also used to test international communications, for instance USIE¹¹ and ECURIE¹². The respective County Administrative Board where the plant is located has the responsibility for planning these exercises, often with the assistance of MSB. SSM participates in planning and evaluation. Usually, 15 to 30 organisations participate in these exercises, including SSM and the Government.

In recent years, a number of annual, exercises of limited extent have been held, which primarily include an NPP site, a County Administrative Board, and SSM. These exercises require relatively little planning, though they provide a good opportunity for training, as well as testing of shared development concepts. The aim is to conduct one of these exercises for each NPP site on an annual basis. These more limited exercises also help to develop continuity in the collaboration between the NPPs, SSM, and the County Administrative Boards.

In addition, SSM conducts a number of more limited functional exercises every year. Exercised functions include, for example, assessment of core damage and source terms, prognosis and assessment of environmental consequences and doses to the public as part of a scenario, and arrangements for national and international notification and communication. Yearly timetables are in place for these exercises.

The expert response organisation is exercised annually in field monitoring exercises and by participating in laboratory intercomparison measurements. SSM has a central role in organising these exercises. SSM also uses the exercises to train its own field assessment teams. The contracted organisations within the expert response organisation maintain their own equipment and arrange for internal education and small-scale exercises.

Sweden has a long tradition of participating in international emergency response exercises. This allows for testing of aspects relating 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 the European ECURIE exercises.

¹¹ USIE is IAEA's Unified System for Information Exchange in Incidents and Emergencies.

¹² ECURIE is the interface to the EU early notification and information exchange system for radiological emergencies.

16.6. International arrangements

Sweden has ratified the International Convention on Early Notification and the Convention on Assistance in the Case of a Nuclear Accident. Moreover, Sweden has bilateral agreements with Denmark, Norway, Finland, Germany, Ukraine and Russia regarding early notification and exchange of information in the event of an incident or accident at an NPP in Sweden or abroad. An agreement at regulatory body level has also been signed with Lithuania.

In 2024, Nordic guidelines on *Protective Actions in a Nuclear or Radiological Emergency*¹³ have been developed by the Nordic radiation protection and nuclear safety authorities. The new guidelines provide a common Nordic starting point for the practical application of protective actions for Nordic national authorities responsible for radiation protection in the event of a nuclear or radiological emergency.

16.6.1. Measures taken to inform neighbouring states

SSM has been appointed a Competent Authority (CA) in accordance with the IAEA Convention on Early Notification in the Case of a Nuclear Accident (INFCIRC/335) and EU Council Decision (87/600/Euratom) on early notification. SMHI is the designated National Warning Point (NWP), providing availability around the clock. SSM and SMHI use the ECURIE information system for information exchange within the European Union, and the USIE system for notification and information exchange with IAEA and between the IAEA member states. In addition, as described in section 16.5, Sweden participates regularly in ConvEx and ECURIE exercises and routinely includes arrangements for early notification in national exercises.

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

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

16.6.2. Assistance

Sweden has registered national field and laboratory resources with the international response and assistance network (RANET), managed by the IAEA under the Convention on Assistance in the Case of a Nuclear Accident (INFCIRC/336).

In 2022 SSM responded to a request for assistance from Ukraine. SSM donated a number of advanced radiation monitoring instruments to Ukrainian authorities.

¹³ Nordic Radiation and Nuclear Safety Series 02:2024, Protective Actions in a Nuclear or Radiological Emergency.

16.6.3. Nuclear accidents abroad

As demonstrated by the impact on Sweden following the Chernobyl accident in 1986, Sweden can be affected by radiological consequences from a nuclear accident that takes place abroad. SSM has continued to conduct dispersion and dose calculations for various scenarios involving a nuclear emergency in Ukraine. The main focus has been on potential consequences for Sweden, but also on the impact in the vicinity of nuclear facilities in Ukraine and neighbouring countries.

Russia's full scale invasion of Ukraine has prompted SSM to review and strengthen its own and, by extension, Sweden's ability to deal with nuclear or radiological emergencies. The outcomes of the Authority's activities are valid both for peacetime emergency preparedness and for heightened alert situations.

In the event of a nuclear accident abroad, the County Administrative Boards affected still have the responsibility to provide information and take potential protective actions in their respective counties. SSM's role as an advisory authority is maintained in the event of a nuclear accident abroad.

Part IV

Safety of Installations



Article 17. Siting

Each Contracting Party shall take the appropriate steps to ensure that appropriate procedures are established and implemented:

- (i) for evaluating all relevant site-related factors likely to affect the safety of a nuclear installation for its projected lifetime;
- (ii) or evaluating the likely safety impact of a proposed nuclear installation on individuals, society and the environment;
- (iii) for re-evaluating as necessary all relevant factors referred to in sub-paragraphs (i) and (ii) so as to ensure the continued safety acceptability of the nuclear installation;
- (iv) for consulting Contracting Parties in the vicinity of a proposed nuclear installation, insofar as they are likely to be affected by that installation and, upon request providing the necessary information to such Contracting Parties in order to enable them to evaluate and make their own assessment of the likely safety impact on their own territory of the nuclear installation.

Summary statement for the article

Sweden complies with the obligations of Article 17.

Summary of significant changes and developments since the previous report

- SSM's new Code of Statutes, SSMFS, covering design (SSMFS 2021:4) of NPPs give more detailed requirements on site specific characteristics that must be considered in design and construction. Emphasis has been more placed on maintaining an up-to-date identification and analysis of external hazards and conditions and, hence e.g. the effect of climate change at the site must be considered. Also, a comprehensive review of identified events and conditions is expected in conjunction with the PSR (see section 17.1).
- Potential impacts of climate change have been addressed and evaluated. Since all Swedish NPPs are located on the coast, sea-level rise has specifically been considered. In general, the NPPs are found to be well prepared against impacts of climate change, at least under what reasonably may be regarded as a very long but nevertheless foreseeable time to come (see section 17.2.1.10).

17.1. Regulatory requirements

Chapter 2, Section 1 of SSMFS 2018:1 requires that events and conditions important to safety (or nuclear security) shall be identified and assessed by the licensee before any activity or operation begins. The assessment of these events and conditions shall form the basis for the measures needed to meet all safety (and nuclear security) requirements. There are no distinctions between internal or external events and conditions in this requirement, so site specific characteristics including e.g. natural phenomena or human induced situations and activities that might affect the safety (or nuclear security) of the activity must be considered.

With basis in Chapter 2, Section 1 of SSMFS 2018:1, the level 2 regulations for NPPs give more detailed requirements on site specific characteristics that must be considered in design and construction of such a plant. Annex 1 to Chapter 4 of SSMFS 2021:4 specifies the type of events and conditions important to safety that shall be considered in design and construction of an NPP:

- Geological conditions
- Geotechnical conditions
- Geophysical conditions
- Hydrological conditions
- Meteorological conditions
- Biological conditions
- External fires or explosions
- Solar storm or meteorite
- Aircraft accident
- Transport accident
- Possible interactions between the NPP and other facilities or activities

Identification of these events and conditions shall be kept up to date and hence e.g. the effect of climate change at the site must be considered. Also a comprehensive review of identified events and conditions is expected in conjunction with the PSR (see 14.1.1.3).

Annex 2 of SSMFS 2021:4 establishes design criteria for the fulfilment of the main safety (and nuclear security) functions of an NPP that have to be met for all events and conditions. Chapter 3, Section 6 of SSMFS 2021:5 also establishes clarified requirements on analysis of expected radiological consequences for workers and members of the public during operation of the NPP. Acceptance criteria for these analyses are presented in Annex 1 and 2 of SSMFS 2021:5.

In Chapter 5, Section 2, together with Annex 2.2 of SSMFS 2021:5, it is stated that the SAR shall include an overall assessment of the site of the NPP, regarding natural, demographic and other conditions important to safety (or nuclear security). According to Annex 2.5, the SAR shall also include an account of the events and conditions important to safety (and nuclear security) that are adopted as the design basis, which includes the site specific events and conditions mentioned above. From Chapter 5, Section 2 of SSMFS 2021:5, it is also clear that the SAR shall be maintained up to date.

17.2. Implementation by licence holders

17.2.1. Evaluation of site-related factors

As part of the licensing process for the plants, assessments have been performed to evaluate site-related factors affecting the safety of the nuclear installations. Based on experience feedback, certain supplements and improvements to the assessments have been made since then. Basic information about modernisation and key safety upgrades that have been implemented at the operating NPPs is provided in Appendix 1. Further details on specific measures may be found in Sweden's previous national report under the CNS.

The safety analyses of the nuclear installations are based on identifying a number of initiating events, which are then analysed using deterministic methods and, if appropriate, probabilistic methods. The basis for the original design comprised safety features for ensuring the robustness of the facilities during external events with a probability of $>10^{-4}$ per year. Today, events with a probability of $>10^{-5}$ per year are analysed, while the analyses performed as a result of the NAcP as well as the analyses undertaken in support of the design of the ICCS include external events with a probability of $>10^{-6}$ per year.

The licensees have, for all facilities at their sites, identified external events that may lead to a radiological accident. The basic principle is that initiating events are divided into categories based on the estimated frequency of occurrence. A distinction is made between events that are not considered for further evaluation (screening) and events that are considered, with the latter being classified into categories based on frequency. The events that are not considered for further evaluation are those that are either considered extremely unlikely to occur ($<10^{-6}$ per year) with a high level of confidence, or that are deemed physically impossible to occur, such as sandstorms.

The events being considered are assessed in terms of:

- Probability of occurrence with respect to the conditions at the site,
- Whether the event sequences are covered by other events, and
- Whether there is a need for further analysis or other measures.

Deterministic analyses are used to verify that there are no initiating events that can jeopardise the safety of the surroundings and the environment. This is accomplished by verifying that fuel damage is avoided, that the reactor coolant pressure boundary is not overpressurised, that the containment is not overpressurised, and demonstrating that the plant can be brought to safe state after any initiating event.

Calculations are performed to verify that the plant structures can withstand certain loads. Calculations are also used to estimate the fatigue loads of the structures. Estimations and assumptions regarding material properties such as radiation-induced embrittlement are verified through inspection programmes, including monitoring of irradiation and NDT. Safety margin assessments considering all external hazards have been performed. Weaknesses and potential improvements have been identified.

In addition to the DSA, a PSA is performed in relation to external events (excluding a seismic PSA¹⁴) on the part of each reactor. The purpose of the PSA is to evaluate plant resilience against various events. The probability of core damage and the probability of releases to the environment are evaluated in the PSA study.

Assessments performed in relation to siting are reported below. Information on actions taken in the area of on-site emergency preparedness is presented in section 16.

17.2.1.1. Seismic plant analyses

Evaluations of structures, systems and components against ground motions exceeding the values specified for the design basis accidents have been performed. These evaluations place special emphasis on safety margin assessments.

Following the EU stress test, the EU Member States agreed that a return frequency of 10^{-5} per year (with a minimum peak ground acceleration of 0.1 g) should be used as a basis for plant reviews/backfitting.

To ensure compliance with this, Swedish licensees have performed the following actions:

- Further studies regarding the structural integrity of the reactor containments, scrubber buildings and fuel storage pools, and
- A specific pipe, located between the reactor containment and the MVSS, which allows for controlled pressure relief of the containment, has been evaluated further. The function of the pipe is essential for fulfilling the requirements regarding a release of radioactive nuclides affecting society and the environment in the event of a core meltdown.

Ringhals has performed a robustness check for the severe accident mitigation systems on a 10^{-6} per year earthquake, in addition to the estimated ability to withstand the 10^{-7} per year probability earthquake.

14 No seismic PSAs have been performed for Swedish NPPs. However, the Swedish seismic ground response spectra were developed by using probabilistic methods. The plants that were not originally seismically designed have afterwards been verified to the Swedish DBE (10^{-5} /year).

17.2.1.2. Investigations regarding secondary effects of an earthquake

Investigations have been performed on possible secondary effects of an earthquake. Fire analyses at Swedish NPPs are generally performed according to the SAR, however, an analysis of fire starting as a result of an earthquake had not previously been carried out for any Swedish NPP. Detailed analysis of earthquake-induced flooding, such as an analysis taking into account leakage from broken water storage tanks and cracks in cooling water channels, has been performed.

17.2.1.3. Seismic monitoring

Seismic monitoring systems are installed at all Swedish sites. The utilities have updated the procedures and training programme for seismic monitoring, and implemented them.

17.2.1.4. Investigation of extreme weather conditions

Investigations have been performed of plant characteristics in extreme weather conditions. In particular, the investigations assessed plant robustness against combined extreme weather conditions, such as ice storms and simultaneous heavy snow load on structures. Systematic analyses of other possible combinations of naturally occurring hazards have also been performed.

Possible improvements have been identified (e.g. improving the resistance of certain buildings against tornado-induced missiles and heavy snow load). Further analyses have resulted in the identification of additional measures that have been taken to protect the plant against negative impacts of extreme weather.

17.2.1.5. Investigation of extreme water levels

An investigation of the frequency of extreme water levels has been performed. This analysis considered the combined effects of waves and high seawater levels (including potential dynamic effects of such events). Historically, extreme seawater levels in Scandinavia are mainly caused by very high wind speeds. Thus, it is important to expand the analyses to take into account these combined effects.

In 2024, SSM published a research report (2024:6) on long tail flood risk for NPPs. Estimations were made for sea levels with very low probability in today's and possible future climates at Ringhals NPP. The report shows that for short planning horizons (a few decades) it is primarily short-term sea level extremes that drive the flood risk, while mean water level changes drive the risk on longer planning horizons (toward the end of the century and beyond). According to SMHI, this has previously been shown to be the case at other Swedish NPP locations as well.

17.2.1.6. Flooding margin assessments

Oskarshamn NPP

An analysis of incrementally increased flood levels beyond the design basis and identification of potential improvements has been performed. This analysis assessed and verified the capability of the plant to mitigate internal and external flooding events. The analysis also included an evaluation of potential distribution of water volumes inside the plants following external flooding.

Forsmark NPP and Ringhals NPP

Forsmark NPP has performed analyses of extreme external flooding showing that the plants can withstand the 10^{-6} per year flooding. Ringhals NPP has analysed extreme flooding levels, based on statistics, including the consequences of waves. Based on the results of these analyses, the conclusion has been drawn that flood levels having a frequency of $>10^{-5}$ per year cannot flood the ground level, thus ruling out the risk of posing a real threat to reactor safety.

17.2.1.7. Evaluation of the protected volume approach

At all sites, studies have been performed to identify critical areas and rooms inside the plants following a flooding event. In particular, this study considered the need for further improvement of the volumetric protection of buildings containing safety-related equipment located in rooms at or below ground level.

17.2.1.8. Investigation of improved early warning notification

At all sites, the need for improved early warning systems for deteriorating weather conditions has been investigated, as well as the provision of appropriate procedures to be followed by operators when warnings are issued.

17.2.1.9. Development of standards to address qualified plant walk-downs

The licensees have developed standards to address qualified plant walk-downs with regard to earthquakes, flooding, on-site fires and extreme weather conditions. The aim is to enable more systematic identification of non-conformities and their correction (e.g. appropriate storage of equipment, particularly for temporary and mobile equipment and tools used to mitigate beyond design basis external events). The potential creation of debris that might affect essential safety systems of the plant has been recognised and evaluated. The walk-downs also included mapping of potential on-site fire initiators.

17.2.1.10. Practices to collect data for characterizing the sites

Meteorological and hydrological data are acquired from SMHI, the Swedish Meteorological and Hydrological Institute. Since 1966, SMHI has performed oceanographic investigations at sea outside the relevant sites. SMHI has also performed local meteorological surveys and studied fog conditions in the areas.

Reference snow and wind loads are established in Swedish building regulations. Normal wind load ($>10^{-2}$ per year) is defined by Eurocode (EN 1991-4) using the national values from regulations issued by the National Board of Housing, Building and Planning, which specify reference winds for various parts of the country. Estimation of a wind having a probability in the range 10^{-3} to 10^{-6} per year is based on values measured by SMHI over the course of 24 years.

Information is also gathered through observation of ocean levels and precipitation data. Information regarding bedrock is available through drilling protocols and photos taken prior to and during construction of the NPPs. Local meteorological investigations are performed on site using an observation mast, where temperature, wind speed and wind direction are recorded. The temperature of the cooling water intake is measured. Equipment is also available for measurement of ground acceleration and the response of civilian structures.

Potential impacts of climate change are addressed and evaluated. Since all Swedish NPPs are located on the coast, sea-level rise has specifically been considered. In general, the NPPs are found to be well prepared against impacts of a climate change, at least under what reasonably may be regarded as a very long but nevertheless foreseeable time to come.

17.2.1.11. Nearby installations containing materials that might jeopardise the safety of the nuclear installation

Forsmark NPP

The Forsmark NPP is located in a relatively isolated area. There are no other installations near the power plant that contain dangerous materials. Oil spills from ships operating on the Baltic Sea are taken into account in the external event analysis. Possible forest fires near the Forsmark NPP are also considered.

Ringhals NPP

There are two sea lanes close to the Ringhals site along the coast. A risk of external influence at the site may therefore be posed in the form of potential releases from ships, either by means of an accident or in the form of illicit dumping. Releases having a potential to harm or endanger the safe and stable operation of the NPP are taken into account in the external event analysis. Since the distance is sufficiently far, chemical releases do not merit consideration of urgent actions; however, actions will be taken in connection with this kind of event. Main public roads and railroads with transports of large quantities of goods are located at a distance ensuring that potential accident on these routes would not harm or endanger the safe and stable operation of the NPP. An explosion or transport accident occurring just outside the plant site might potentially lead to a loss of external power. The study "Loss of external power" covers this case.

Oskarshamn NPP

The site of the Oskarshamn NPP is located in a relatively isolated area, on the coastline of the Baltic Sea.

Hydrogen gas explosions at the hydrogen gas plant on the site, or at the turbine building are considered to pose a risk. The analysis of existing buildings was performed in 2007. The safety distance is maintained between the NPP and hydrogen gas plant with respect to a possible blast, heat radiation and tremors in connection with a hydrogen explosion. The safety distance between the NPP and hydrogen gas plant is not maintained with respect to objects expelled by a blast (missiles). A missile might potentially reach the NPP, though the buildings are dimensioned to withstand tornadoes, and thus generated missiles.

The Swedish Central Interim Storage Facility for Spent Nuclear Fuel (Clab) is located near the Oskarshamn NPP (see section 19.7.2.1).

There are no other installations near the power plant containing dangerous materials. Oil spills from ships operating on the Baltic Sea are considered in the external event analysis. Potential forest fires occurring near the Oskarshamn NPP are also considered.

17.2.2. Impact of the installation on individuals, society and the environment

At all sites, there are environmental control programmes in place at and around the power plants with the objective of verifying that no unknown sources for releases of radionuclides to water and air exist, and that there is no unpermitted accumulation of radioactive substances taking place in the vicinity of the power plant.

17.2.2.1. Implementation of criteria in the licensing process

A general description regarding the licensing process is presented in section 7.3 and the EIA is further described in section 7.3.1. Protection of the environment is further described in section 15.1.2.

17.2.3. Re-evaluation of site-related factors

The most common reason for initiating a change in the design basis is experience feedback from both internal and external sources. With the methods used to collect and evaluate information from the licensee's own facility and other facilities of the same type, and through the systems for international feedback and reporting, the safety design basis is kept up-to-date and relevant. Experience feedback from both internal and external sources is further described in section 19.6.2.

In an attempt to keep the design basis up-to-date and complete, records are kept about new events that need to be addressed in the safety assessment. In this additional work, initiating events are studied that have previously been identified on the basis of their estimated event frequency. If it can be shown that an event is more probable than previously assessed, it may be moved to another category of events that matches the assumed frequency.

Since the systematics of the original design-basis event identification process involved identifying the worst case events that might occur within each event category, only a few events have been added over time to the event list. It is nevertheless possible to identify new potential initiating events identified. All new events are categorised in accordance with their estimated occurrence frequency and their safety impact on the facility, as was carried out during the original event identification. Identification of new initiating events is performed partly through the systematic work on PSAs, which are periodically conducted, and partly by means of the internal and external systems for feedback exchange and reporting.

17.3. Regulatory review and control

Site re-evaluations are conducted as part of PSRs, see section 14.3.2. A review of the NAcP's implementation has been performed and SSM has ensured that all measures identified in the NAcP have been appropriately considered for each reactor.

Most measures in the NAcP have been followed by a phase two, which includes implementation of reasonably practicable/achievable technical and administrative safety improvements. The main improvement is the installation of ICCS, which adds another safety barrier for many of the external events dealt with in the NAcP, see section 18.2.1.6.

Article 18. Design and Construction

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

- (i) the design and construction of a nuclear installation provides for several reliable levels and methods of protection (defence in depth) against the release of radioactive materials, with a view to preventing the occurrence of accidents and to mitigating their radiological consequences should they occur;
- (ii) the technologies incorporated in the design and construction of a nuclear installation are proven by experience or qualified by testing or analysis;
- (iii) the design of a nuclear installation allows for reliable, stable and easily manageable operation, with specific consideration of human factors and the man-machine interface.

Summary statement for the article

Sweden complies with the obligations of Article 18.

Summary of significant changes and developments since the previous report

As mentioned in the previous national report, all major measures identified by the NAcP have been completed in accordance with the original given time schedule, meaning that identified primary measures were implemented by the end of 2020, following the ICCS installations. During the current reporting period only less significant changes and developments have been made. However, during the current reporting period new regulations for construction, as was mentioned in the previous report, entered into force. These regulations establish new requirements on continuous improvements within this area (see section 18.3).

18.1. Regulatory requirements

18.1.1. Defence in depth

The SSM regulations, Chapter 2, Section 2 of SSMFS 2018:1, and Chapter 2, Section 2–3 of SSMFS 2021:4, outline licensees' obligations with regard to barriers and defence in depth. The regulations require the application of a site-, design- and operation-specific defence in depth, defined in five levels. Chapter 2, Section 2–3 of SSMFS 2021:4 further outlines the basic requirements for the principle of defence in depth in design and operation of NPPs as follows.

“Defence in depth shall be divided into levels that aim to:

- counter deviations from normal operation, prevent errors and antagonistic attacks (defence in depth level 1),
- detect and manage anomalies so that they do not lead to elevated radiation levels, detect antagonistic threats, limit the release of radioactive substances in the nuclear reactor, and that normal operation can be resumed (defence in depth level 2),
- limit exposure at elevated radiation levels, limit the release of radioactive materials, prevent large-scale release of radioactive materials, and to hamper, delay and implement actions to address antagonistic threats (defence-in-depth level 3),
- mitigate the consequences of large-scale release of radioactive substances, limit the release of radioactive materials, as well as hamper, delay and implement actions to address antagonistic threats, recover stolen radiation sources, nuclear materials and other radioactive materials (defence in depth level 4), and
- mitigate the consequences of large-scale radioactive release, mitigate the consequences of stolen radiation sources, nuclear materials and other radioactive substances (defence in depth level 5).”

18.1.2. Design and construction

Basic requirements on design and construction are established in Chapter 4, Section 1–2 of SSMFS 2021:4. These can be summarised as follows.

“A nuclear power plant shall be designed to prevent and manage those events and conditions relevant to safety that are likely to have direct or indirect effect on the exposure of workers, the public or the environment, or that are likely to lead to theft and other unauthorised handling of radiation sources, nuclear material and other radioactive substances.”

“A nuclear power plant shall be designed with areas, structures, systems and components as well as conditions for manual tasks and organisational conditions that, in the case of events and conditions of event class H1–H5 fulfil the main safety (and nuclear security) functions

- control of chain reactions of nuclear fission in nuclear material (reactivity control)
- removal of heat from radioactive material (heat removal)
- containment of radioactive substances, shielding of radiation from radioactive substances and control and limitation of releases of radioactive substances (containment, shielding and control); and
- protection against theft and other unauthorised handling of radiation sources, nuclear material and other radioactive substances.”

Furthermore, Chapter 4, Section 3 of SSMFS 2021:4 also sets basic requirements on areas, structures, systems and components as well as conditions for manual tasks and organisational conditions needed for implementing measures at the plant for emergency preparedness and response.

Chapter 4, Section 12 of SSMFS 2021:4 requires that the design and construction of an NPP, must enable the main safety functions to be fulfilled with as high level of dependability as reasonably achievable. To fulfil this general requirement during operation, the design must consider both the reliability of plant equipment and prerequisites for human tasks, and factors affecting these such as maintainability, testability, maintenance support performance, human factors and the man-machine interface. Chapter 4 of SSMFS 2021:4 also includes separate, more detailed requirements on reliability of structures, systems and components important to safety (or nuclear security), resistance to loads and environmental conditions, fail-safe design, maintainability and prerequisites for human tasks.

In order to achieve sufficient reliability for structures, systems and components important to safety, Chapter 4, Section 13 of SSMFS 2021:4 requires that the principles of simplicity, redundancy, diversity, and physical and functional separation are used as needed. Requirements on proven and verified technology are found in Chapter 2 of the Environmental Code and further detailed by the provisions of Chapter 4, Section 13 of SSMFS 2021:4. If the use of proven design and construction is not reasonably achievable, a separate process of verification and validation of sufficient reliability is required. An important addition to the regulations is Chapter 3 of SSMFS 2021:4, containing specific requirements on management and quality assurance of design and construction work.

Sufficient maintenance support performance is achieved through the requirements on competences established in Chapter 3 of SSMFS 2021:6, and on several implemented programmes with the aim to maintain and confirm equipment availability in Chapter 2, Section 5 and Chapter 6 of SSMFS 2021:6 (i.e. maintenance, surveillance, in-service inspection, ageing management).

The regulation SSMFS 2021:4 requires a safety classification based on function. Chapter 4, Section 10, states that structures, systems, components of the NPP shall be divided into safety classes based on their importance to fulfil the basic functions (presented above) in events and conditions of event classes H1–H5 and in scenarios of radiological emergencies. According to the general advice for SSMFS 2021:4, a safety classification may be carried out as per the principles contained in the IAEA Safety Standard SSG-30. Provisions concerning quality classification of mechanical components in certain nuclear facilities are stipulated in the regulation SSMFS 2008:13.

In addition to the regulations SSMFS 2018:1 and SSMFS 2021:4, there are also specific regulations concerning the design and construction of pressure vessels and other mechanical components, competence and training for operators, security and radiation protection, see for example SSMFS 2008:13. There are also requirements on release mitigation in the event of severe accidents given in a governmental decision from February 1986.

In December 2014, SSM issued an injunction with requirements for an ICCS. The injunction required the implementation of safety measures to considerably improve the independence of existing emergency core cooling. The purpose of the measures was to increase the reliability of the core cooling and strengthen the capabilities to prevent core damage during a number of extreme events that were previously not covered by the safety analyses. The extreme events were defined as the extended loss of all AC voltage, as well as common cause failures in emergency core cooling functions. The two events were to be combined with extreme external events and conditions that may arise. The design work for the ICCS has been finalised, and the construction work was completed for all reactors that are in operation after December 2020.

18.2. Implementation by licence holders

18.2.1. Implementation of defence in depth

All Swedish facilities basically follow the INSAG-10 approach to defence in depth, which is referred to in the EU nuclear safety directive and SSM regulations. In practice this also means taking into consideration the WENRA approach of Design Extension Conditions. Swedish NPPs were designed at a time when the focus was on three levels of defence in depth, but have followed the advancements to more specifically address beyond design basis accidents and design extension conditions.

The earliest reactor designs in Sweden incorporated a lower degree of redundancy and separation, but enhanced diversification of safety functions through the use of isolation condensers and steam-driven pumps. Later designs are characterised by significantly increased redundancy and separation, but with a lower degree of diversification of safety functions. Backfitting and modernisations have led to major improvements to the older designs, especially concerning increased redundancy and separation, and have implemented increased diversification and protection against common-cause failures, see Appendix 1.

The risk for single failures is taken into consideration in the design. The same applies to common-cause failures, although it is always possible to postulate even more challenging failures to identify critical areas for improvements. It is an ongoing process to identify reasonably achievable safety enhancements through deterministic and probabilistic methods, complemented by engineering judgements and operational experience.

Safety functions should be able to withstand a single failure in active components during all events within the design basis envelope. Reasonable diversification in order to withstand common-cause failures should be applied to the design of the safety functions for events up to and including unanticipated events (except LOAs (Loss of Cool Accident)).

Safety systems are generally designed to be fail-safe, which means that the loss of active functions leads to a favourable state of the plant. The level of active functions required varies for different designs of different generations. However, for all reactor designs, the severe accident mitigation systems have passive actuation parts that would mitigate the consequences of a sequence where there is a risk of containment overpressurisation.

Separation of systems, both physically and functionally, is an important area in which a number of backfitting measures have been implemented over many years (further details on specific measures may be found in previous national reports to the CNS). In many cases, the need for improved separation was identified through PSA. Swedish reactors have been retrofitted to comply with regulatory requirements on functional diversification. Measures have been taken to ensure that functions of reactivity control, overpressure protection, cooling and residual heat removal, and the containment function, all have diversified backup capabilities.

The objective of implemented or planned design measures or changes (plant modifications and backfitting) is to prevent beyond design basis accidents and to mitigate their radiological consequences, should they occur. Some examples are:

- Structural integrity assessed for containment and containment filtered venting systems for beyond design seismic events.
- Battery capacity extended to 8 hours.
- Mobile and fixed equipment and connection points for recharging of batteries.
- Upgraded reactor cooling pump seals (PWR) reducing reactor coolant system leakage during beyond design conditions.
- Spent fuel pool level measurement, and independent injection.
- Independent Core Cooling designed to cope with loss of ultimate heat sink and extended loss of AC power, as described below.

Measures to increase the level of safety and strengthening the defence in depth at all the Swedish NPPs have been implemented gradually, taking account of new knowledge and experience. New knowledge and experience have emerged from lessons learned in connection with incidents and accidents, and from research, safety analyses and new reactor designs. International accidents/incidents such as the Three Mile Island (TMI) nuclear accident in 1979, as well as domestic incidents such as the “strainer event” in Barsebäck 2 in 1992 and the electric power system event at Forsmark 1 in 2006, have had a major influence on these measures. Furthermore, the Swedish regulations on the design and construction of NPPs issued in 2005 resulted in extensive backfitting and modernisation programmes for all Swedish NPPs. Also, insights gained from the EU stress tests after the accident in Fukushima Daiichi have led to the identification of further areas of improvement, all of which have been addressed by the end of 2020.

In summary, since the time when the original reactor designs were taken into operation, extensive measures have been taken to improve:

- Physical and functional separation within and between safety functions.
- Diversification of safety functions.
- Severe accident management measures.
- Protection against local dynamic effects from pipe breaks and other internal hazards.
- Protection against external events.
- Control room capabilities.
- Environmental qualification and surveillance.

18.2.1.1. Seismic

Sweden uses a design envelope when defining the realistic seismic events on the Scandinavian peninsula. This is done with a safety margin. Reactors built earlier were not originally designed to withstand a design basis earthquake, but earthquake requirements have been taken into account as part of maintenance and modernisation measures. Reasonably practicable approaches to strengthen the reactors’ capabilities to withstand earthquakes have been taken to ensure that no undue risk is foreseen despite seismic criteria being excluded from the initial design basis. Also, when installing new equipment and implementing measures, seismic events are required to be taken into account. For the ICCSs that were installed in 2020, seismic events with a frequency exceeding 10^{-6} per annum have been considered for the design.

18.2.1.2. Flooding and tsunami

The general risk of flooding was reassessed after the Fukushima Daiichi accident. The analyses and, in some cases, corresponding administrative and physical improvements, show that the NPPs can handle extreme water levels with an exceedance frequency of 10^{-5} per year. For the ICCSs that were installed in 2020, extreme water levels with an exceedance frequency of 10^{-6} per annum has been considered for the design.

The tsunami risk in Sweden is low given the geographical location of the country. After the Fukushima Daiichi accident, the tsunami risk was reassessed and no additional measures to particularly mitigate a tsunami were identified.

18.2.1.3. Other external hazards

The facilities' characteristics in relation to extreme weather conditions have been reassessed after the Fukushima Daiichi accident. In general, the evaluations indicate that the facilities are robust; however, for some areas, measures have been taken to strengthen the protection against extreme weather conditions. The ICCSs have made the facilities even more robust.

18.2.1.4. Simultaneous accidents at multiple units

Simultaneous accidents at multiple reactors on the same site were not included in the design basis of existing nuclear facilities. Safety systems as well as severe accident management systems at Swedish NPPs are, however, dedicated to one unit only. Shared auxiliary systems principally encompass the off-site grid, station blackout generators, and inlet and outlet channels to the ultimate heat sink. Evaluations and measures for coping with multi-unit accidents were part of the NACP, where the requirement for independent core cooling specifically addresses the loss of ultimate heat sink and extended loss of AC power at all reactors on the site, see sections 18.1.

18.2.1.5. Severe accident mitigation measures

The government decree of February 1986, following the TMI accident in 1979, substantially strengthened the nuclear reactors' capabilities to manage design extension conditions. This government decree required all licensees to take appropriate actions to ensure that all nuclear power reactors are capable of withstanding a core melt accident without any casualties or ground contamination of significance to the population. In the decree, it was stated that these requirements can be considered met if a release is limited to a maximum of 0.1 % of the reactor core content of Cs-134 and Cs-137 in a reactor core of 1,800 MWt (corresponding to approximately 100 TBq Cs-137), provided that other radionuclides of significance are limited to the same extent as caesium. This resulted in an extensive backfitting for all Swedish nuclear power reactors including:

- Filtered containment venting through an inert MVSS with a decontamination factor of at least 500,
- Unfiltered pressure relief in BWRs in the case of a large LOCA and degraded pressure suppression function to protect the containment from early overpressurisation,
- Flooding of lower drywell from wetwell (most BWR:s),
- Passive autocatalytic recombiner (PAR),
- Independent containment spray,
- All mitigating systems designed to withstand an earthquake, and
- A comprehensive set of Severe Accident Management procedures and guidelines.

All of the reactors in operation have chosen the Multi Venturi Scrubber System (MVSS) concept to fulfil the requirements for filtered venting. A venturi scrubber is a gas cleaning device that lets the contaminated gas pass as bubbles through the cleaning liquid. Conceptual illustrations of the overall severe accident mitigation concept for the BWRs and PWRs are presented in figure 17 and figure 18, respectively.

The major component is the scrubber system, which comprise a large number of small venturi scrubbers submerged in a pool of water. The water contains chemicals for adequate retention of iodine.

The design of the venturi is based upon the suppliers' broad experience in this area, gained when designing venturi for cleaning of polluted gases from various industrial plants. The MVSS can be activated automatically, via a rupture disk, or manually. There are two separate venting lines from the containment for these two modes of activation. The venting line with the rupture disk is always open so that no operator actions are needed to vent this way. The design principle of the system is the same for BWRs and PWRs. The system is kept inert to avoid a hydrogen explosion.

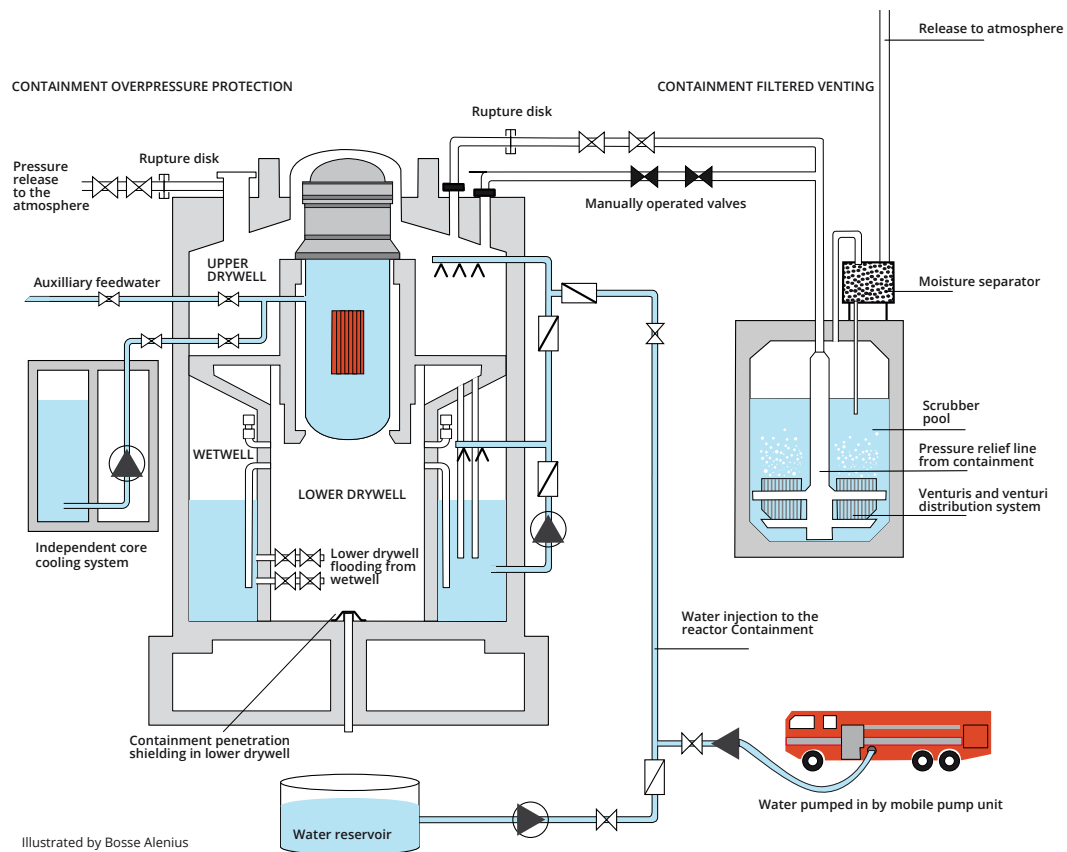


Figure 17. Schematic view of the severe accident mitigation features installed in Swedish BWRs.

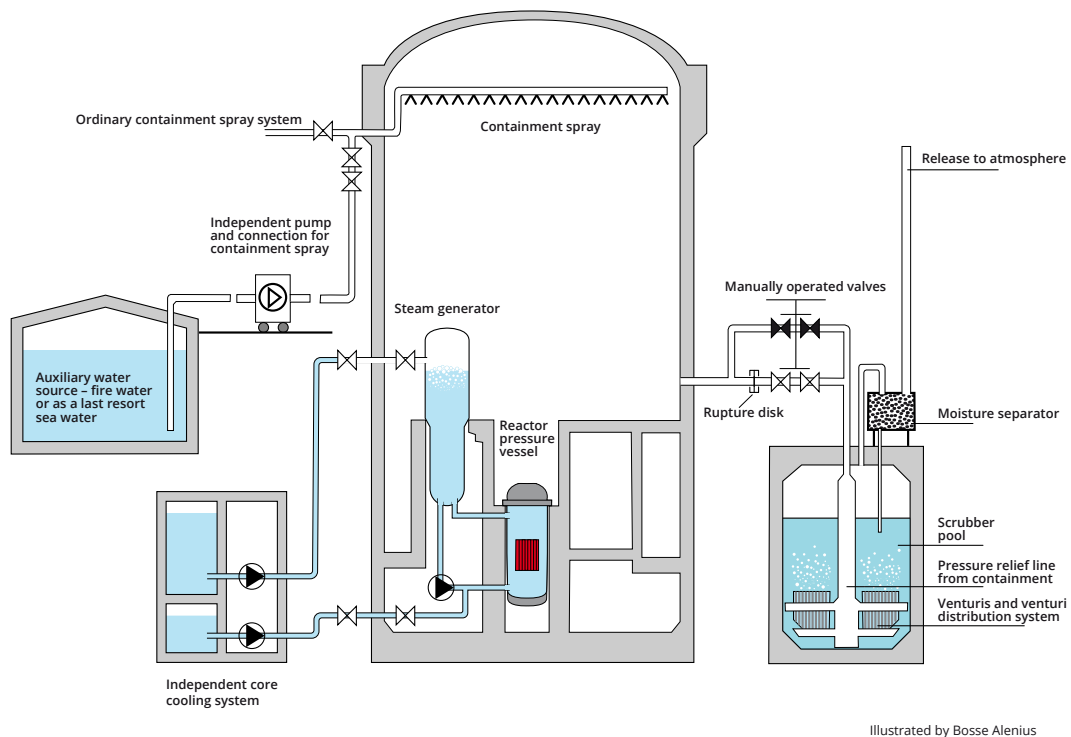


Figure 18. Schematic view of the severe accident mitigation features installed in Swedish PWRs.

The Swedish strategy for dealing with a core melt in BWRs is to allow the core debris to fall into a large volume of water in the lower regions of the containment. This is a quite uncommon approach and only a few reactors in the world apply this strategy. Since the strategy is somewhat unique, the international research related to the special phenomena, mainly steam explosion, associated with this strategy was fairly limited. An extensive national research programme was set up in the 1980s to highlight all important aspects needing to be addressed. The programme (APRI, Accident Phenomena of Risk Importance) is still running in cooperation between the Authority and licensees. The programme is conducted in consecutive three-year periods, with evaluation of the progress and results over the previous three years. The current programme is the 10th cycle. In order to address specific uncertainties relating to the Swedish severe accident mitigation strategy, major efforts are conducted by the Royal Institute of Technology and Chalmers University of Technology within the APRI programme. The severe accident research is currently targeted at confirming that the uncertainties linked to the chosen solution are acceptable. APRI also monitors international research in the area of severe accidents.

Results from the APRI programme indicate, among other things, that a major interaction between concrete and core melt (MCCS) will most likely be avoided. Nevertheless, some issues still need to be further explored, including steam explosions, which might occur when the core melt interacts with water and a huge heat transfer occurs.

18.2.1.6. Installation of Independent Core Cooling Systems (ICCS)

ICCSs are in place at all reactors in operation, as summarised in Appendix 1. The ICCSs are independent, robust and qualified functions introduced to ensure safety in any extreme conditions that could affect the sites and the reactor units. The new systems were introduced following the Fukushima accident and subsequent EU stress tests. The ICCSs are designed to withstand extreme external hazards. The purpose of the ICCS is to provide alternative core cooling if the ordinary safety systems are unavailable in the event of design extension conditions (DEC).

The design events for the ICCSs are:

- Extended Loss of AC Power, ELAP (for 72 hours).
- Loss of Ultimate Heat Sink, LUHS (for 72 hours).

In addition to loss of AC power, it is postulated that DC power is lost and that any existing steam-driven auxiliary feedwater pump that may be part of the reactor design fails. The ELAP/LUHS events are assumed to coincide with, or be the consequence of, severe external events (beyond the ordinary design base), including various electrical disturbances.

Forsmark NPP

A new ICCS was put into operation at the Forsmark plant in 2020. The ICCS mainly consists of the following components:

- Building structure
- Water source
- Pump
- Valves
- Connection pipes

The power supply is galvanically separated from the plant's regular electrical power system via a motor-generator set. Forsmark 1 and 2 share the same ICCS building and water source. There are, however, separate pumps, pipes and valves so that the ICCS function is independent between the units. The water source is sufficient for at least 24 hours of operation for both units, or 72 hours for one unit. In case of operation for both units, additional water sources are available to make operation for 72 hours possible. The pump capacity is sufficient to supply water to the RPV at full pressure.

Decay heat will be removed from the containment after about 8 hours of ICCS operation by transporting steam to the multi venturi scrubber. One important design condition is that the multi venturi scrubber system must be fully available for severe accident management if an event escalates into a severe accident scenario involving core damage. If needed, there is an additional possibility to utilize mobile equipment to supply more water, and thereby use the ICCS for a longer period of time than 72 hours.

Forsmark has also implemented of a new function for independent water supply to the spent fuel pools, using the principle of “feed-and-boil”. The water is allowed to boil while water is added at least at the same pace that the boiling occurs. The technical solution consists of new pipes, mobile pumps and level measurement.

Ringhals NPP

An ICCS was installed in Ringhals 3 and 4 in 2020.

The main features of the ICCS are as follows:

- Providing feedwater to the steam generators (normal operation).
- Providing boron and make-up to a closed reactor coolant system (normal operation).
- Providing borated make-up for feed-and-bleed for an open reactor coolant system (shutdown mode).
- Providing make-up for feed-and-boil of the spent fuel pit.

All features, including supportive functions, are housed in a separate building designed to withstand severe external events, one for each unit. Inside the building, there are two large water tanks that provide the different functions with water for independent core cooling, see figure 17 and 18.

The water provided to the reactor coolant system is borated and demineralised, and the water for the steam generators and spent fuel pit is demineralised and deaerated.

The ICCS building has a separate electrical power supply system that is galvanically, functionally, and physically separated from the regular electrical power system. The galvanic separation is achieved by a motor-generator set between the incoming power supply and ICCS power system. The electro-magnetic design of the building structure and shielding of cables ensure that no electrical disturbances (conductive or radiative) can affect the ICCS.

In addition to the ICCS main function, the system also improves the capability to cool the spent fuel pool by establishing a feed and boil-off cooling function.

Oskarshamn NPP

The ICCS function comprises a new one-train low pressure make-up system with a direct diesel-driven pump and supporting electrical and water source make-up systems. The primary water source for the ICCS is the central handling pool at the reactor service floor. The available amount of water is sufficient for continuation of core cooling for 40 hours. After 40 hours, make-up water for the central service pool is taken from the fire water tanks, which will last for another 32 hours.

As part of the design and installation of the ICCS at Oskarshamn NPP, measures have been taken to establish feed-and-bleed for the spent fuel pools (SFP). The measures comprise feeding water to the SFP from the fire water tanks. If additional make-up water for both the ICCS and the SFP is needed, it can be pumped by diesel-driven pumps from a freshwater pond on the site that holds approximately 120,000 m³. The bleeding is done through new piping leading to the normal cooling water outlet channel. The measures introduced will keep the SFP temperature below 80°C.

The ICCS has its own diesel generator set that can recharge the dedicated batteries for the ICCS and energise the battery-backed busbars after the initial 8 hours in order to retain Reactor Protection System (RPS) functionality. Residual heat is released through the multi-venturi scrubber system.

Implementation of the final design solution has been completed, including the extension of the battery capacity.

18.2.2. Incorporation of proven technologies

The application of particular standards for fulfilment of legal and regulatory requirements is a licensee responsibility. The original design of the Swedish NPPs relied to a large extent on US standards, and these US standards still have a strong influence. As applicable, European standards have been assessed by the licensees, and where appropriate, incorporated into the design. One way for the licensees to perform the work is to use the co-operation of a shared group, mainly for managing technical requirements for plant design found to be applicable. Further information on verification by surveillance, testing and inspection is provided in sections 14.1.2 and 14.2.4.

18.2.3. Design for reliable, stable and manageable operation

The design solutions must be adapted to the ability of the personnel to manage the facility in a safe manner, as well as to manage abnormal events, incidents and accidents. In some areas, specific Swedish requirements on consideration of grace time have been added, e.g. the “30-minute rule”. This rule requires that all measures needing to be taken within 30 minutes after an initiating event involving the risk of radioactive release must be automated. The rule is implemented in the BWRs, and with some exceptions in the PWRs.

Human factors have long been recognised as an important consideration in design matters, and are specifically addressed in SSMFS 2021:4. Both the licensees and the Authority have dedicated functions in place in their respective organisations to specifically ensure that due consideration is given to human factors.

The Swedish licensees also participate in international organisations, such as the Halden Project in Norway, which conducts research of importance for the areas of fuel, materials and human factors.

18.3. Regulatory review and control

The regulatory approach in Sweden is to require retrofitting of facilities to meet modern requirements, and all facilities are expected as far as reasonably achievable to meet modern standards. Major safety upgrades have been completed at Swedish facilities over the last decades to achieve this target, see Appendix 1. SSM conducts and will continue to carry out supervision of licensee implementation of safety improvements and other measures taken to ensure compliance with current standards and regulations.

SSM’s overall assessment is that the measures taken to comply with modern requirements established in SSMFS 2008:17 (superseded by SSMFS 2021:4–6) have significantly improved the level of safety at all NPPs in Sweden. The main capability that has been improved is control over conditions that might possibly arise in the event of design basis accidents. The operation of the NPPs and licensee monitoring of the barriers’ surveillance have also been substantially improved by implementing new or upgraded control equipment.

All major measures were completed in accordance with the original given time schedule, meaning that the identified primary measures were implemented by the end of 2020, following the ICCS installations. A few minor remaining actions, which had been accepted by SSM for later implementation, were subsequently completed in 2024.

According to the regulations, any safety significant events or plant modifications must be reported to SSM. A standing group of experts (see section 10.6) makes the first assessment of all notifications; this consists of experts representing all relevant disciplines, including human factors experts. Information on regulatory review and control activities in relation to human factors and operation is provided in the reporting under the Articles 12 and 19.

18.4. Vienna Declaration on Nuclear Safety (VDNS)

This section, in reference to Article 18, describes how Sweden implements relevant improvements concerning principles of the VDNS regarding the design of power plants.

As reported in previous national reports, all Swedish NPPs have installed filtered venting systems according to the Multi Venturi Scrubber concept to fulfil the requirements for filtered venting in the case of a severe accident mitigation. Simultaneous accidents at multiple unit sites were not included in the design basis of existing nuclear facilities. Safety systems as well as severe accident management systems at Swedish NPPs are, however, dedicated to one unit only.

In 2014, SSM decided that the licensees should be required to implement an ICCS at those reactors intended to be operated after December 31 2020. Design solutions for the ICCS function were developed for all affected reactors and were operative by the end of 2020.

Implementation of particular design measures to maintain the integrity of the physical containment and to basically avoid a severe accident with the potential for long-term off-site contamination are examples of the fulfilment of VDNS principles.

Article 19. Operation

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

- (i) The initial authorization to operate a nuclear installation is based upon an appropriate safety analysis and a commissioning programme demonstrating that the installation, as constructed, is consistent with design and safety requirements;
- (ii) Operational limits and conditions derived from the safety analysis, tests and operational experience are defined and revised as necessary for identifying safe boundaries for operation;
- (iii) Operation, maintenance, inspection and testing of a nuclear installation are conducted in accordance with approved procedures;
- (iv) Procedures are established for responding to anticipated operational occurrences and to accidents;
- (v) Necessary engineering and technical support in all safety-related fields is available throughout the lifetime of a nuclear installation;
- (vi) Incidents significant to safety are reported in a timely manner by the holder of the relevant licence to the regulatory body;
- (vii) Programmes to collect and analyse operating experience are established, the results obtained and the conclusions drawn are acted upon and that existing mechanisms are used to share important experience with international bodies and with other operating organisations and regulatory bodies;
- (viii) The generation of radioactive waste resulting from the operation of a nuclear installation is kept to the minimum practicable for the process concerned, both in activity and in volume, and any necessary treatment and storage of spent fuel and waste directly related to the operation and on the same site as that of the nuclear installation take into consideration conditioning and disposal.

Summary statement for the article

Sweden complies with the obligations of Article 19.

Summary of significant changes and developments since previous report

- Forsmark's application to take Forsmark 1 into trial operation at higher reactor power with a maximum thermal output of 3,253 MW has been approved (see section 19.1.3).
- During the period since the previous national report, SSM has reviewed the work of the operators of Forsmark and Oskarshamn on developing and implementing new SMAG and has found that this has been completed satisfactorily and achieved a good quality (see section 19.3.3).
- Over the past three years, the number of LERs has been approximately 20 per year and operating reactor, which is the same level as for the previous reporting period (see section 19.5.3).

19.1. Initial authorisation

19.1.1. Regulatory requirements

The Act on Nuclear Activities (1984:3) requires that a nuclear facility shall be designed, sited, constructed, commissioned, operated and decommissioned so that radiological emergencies are avoided and, if a radiological emergency nevertheless occurs, so that the consequences of the emergency can be managed.

Chapter 2, Section 1 of SSMFS 2018:1 requires that events and conditions important to safety (or nuclear security) shall be identified and assessed by the licensee, before any activity or operation begins. The assessment of these events and conditions shall form the basis for the measures needed to meet all safety (and nuclear security) requirements.

For NPPs, Chapter 4 of SSMFS 2021:4 more clearly specifies the events and conditions important to safety (or nuclear security) that shall be considered in design of an NPP, and also specifies the main safety/security functions that have to be fulfilled at all events and conditions used as design basis and criteria for their fulfillment. Requirements on deterministic and probabilistic safety analysis (level 1 and 2) are found in Chapters 3 and 4 of SSMFS 2021:5. Requirements on PSAR are included in Chapter 7 of SSMFS 2021:5, as a part of the safety demonstration required for modifications (or new built) significant to safety (or nuclear security).

Chapter 3 of SSMFS 2021:4 establishes requirements on the management of design and construction work, including requirements on plans for commissioning, to demonstrate that the installation, as constructed, is consistent with design and safety (and nuclear security) requirements.

19.1.2. Implementation by licence holders

No nuclear units have been commissioned in Sweden since 1985, when Forsmark 3 and Oskarshamn 3 went into commercial operation. No additional units are currently undergoing planning or construction.

As described in section 14.2, all Swedish units in operation have been analysed and have followed commissioning programmes in order to demonstrate their compliance with design and safety requirements, as specified in the legislation, regulations and standards that were in effect at the time of startup. The objective was to develop a PSAR before commencing design, construction and erection of the unit, and subsequently an FSAR. Extensive operational testing was conducted to verify both the function of the different individual systems and their collective performance. Permission to start up the units was given in steps by the regulatory authority, following completion of the different operational tests, and reporting of results from the startup stages. Permission for commercial operation was granted when the operational tests had been completed satisfactorily and reported, and the FSAR including technical specifications had been accepted.

The main changes and modifications in the SAR over time have been related to plant modifications due to power uprates. In addition, plant modifications and related analyses are to be reflected in SAR updates. The state of the art safety requirements are regularly assessed for their implementation in the current SARs, and the licensees have specific procedures in place for evaluation of new or revised codes and standards, to ensure that they are reflected in a regular update.

19.1.3. Regulatory review and control

SSM reviews SARs updated in support of authorisation applications for power uprates, and notifications of updates related to plant modifications or safety analysis updates. Reviews by SSM have the aim of verifying that the SAR reflects the facility as it is built, analysed and verified, and that it shows how current requirements for design, function, organisation and activities are met.

SARs are subject to recurring supervision according to the baseline supervision program. During the reporting period, baseline inspections were carried out at all sites.

SSM has reviewed remaining issues related to the introduction of the ICCS in 2020.

SSM has since the previous report reviewed and approved Forsmark's application in 2022 to take Forsmark 1 into trial operation at higher reactor power with a maximum thermal output of 3,253 MW, which corresponds to 120 % of the original output.

19.2. Operational limits and conditions

19.2.1. Regulatory requirements

For NPPs, Chapter 5, Sections 3 and 4 of SSMFS 2021:5 require a set of OLCs to be specified (known in Sweden as STF), based on limits and conditions for safe operation as proven by safety analysis or experience. Chapter 4, Section 11 of SSMFS 2021:4 also requires that limits and conditions for normal operation shall be specified for all areas, spaces, structures, systems and components contributing to the fulfilment of the main safety (and nuclear security) functions. While some of these limits and conditions for normal operation shall be included in the OLCs, other limits and conditions for normal operation may be important for maintenance, inspection and testing, as defined references or required functions.

19.2.2. Implementation by licence holders

The OLCs for a reactor are included in the STFs required by SSM's regulations. This document is considered as one of the cornerstones in the governance and regulation of the operations of Swedish NPPs. As required by SSM, all control room operators and operations managers, as well as engineers on duty at the plants, are given training and annual retraining on the intent and content of this document. Each STF is unit-specific and is in its basic version approved by SSM. For the oldest BWRs, STFs were produced in close cooperation between nuclear utilities. Consequently, the structure of the STF documents is similar for all BWRs in the country. For PWRs, the STFs follow the Westinghouse Owners Group (WOG) approach. The scope and content of Swedish STF documents are similar to the OLCs used in other European countries.

The original STF for each unit is derived from the safety analyses contained in the SAR, where the behaviour of the unit, when different transients and abnormal events are assumed to occur, is described. However, several revisions have been made in the STFs for all reactor units since the first versions were issued. Corrections and updates take place when new and better knowledge is available, either from research and testing, or from operational experience or plant modifications. Suggestions for changes in the STF are subjected to a two-fold safety review and notified to SSM. Today, STFs are integrated in plant management systems in order to ensure adequate use and updates of the document.

Parts of STFs developed after commissioning the plants comprise specific chapters concerning conditions during refuelling outages and the background to the document (STF BASIS). SSM has imposed further requirements for the scope of STFs, for instance their also covering non-safety system equipment of importance for defence in depth, such as fire protection systems and certain electrical systems. For these, requirements for operability have been included to a varying extent in STFs.

The STF of the Westinghouse PWRs at Ringhals has been updated as part of a particular project using the MERITS concept (Methodically Engineered Restructured and Improved Technical Specifications) documented in NUREG-1431 rev. 1, and following experience gained by the Westinghouse Owners Group, documented in NUREG-1431 rev. 2.

Before equipment with importance for defence in depth is accepted for continuous operation following maintenance, in-service inspection or after a plant modification, the equipment must pass an operability test to verify that the equipment fulfils specified operational requirements. Integrated tests for verification of complete system function are used as far as possible. If they are not feasible, overlapping tests are conducted. After this, an initial integrated test is performed.

19.2.3. Regulatory review and control

A licensee regularly notifies SSM when changes are made in the STF or when temporary exemptions are needed. These notifications on changes in STFs and requested exemptions from STFs are reviewed as described in section 14.3. In total, SSM receives 10 to 20 such notifications from the licensees each year.

The baseline supervision program that describes supervision groups also includes STF, see section 8.8. Since the previous report, one baseline inspection of STF has been carried out, identifying no significant deviations.

One finding from reviews undertaken in the reporting period concerned deficiency in handling the updating of both SAR and STF in connection with the facility change that led to the notification. SSM assessed that no administrative sanctions were necessary.

In another case, after reviewing the notification of a change in methodology in the SAR, regarding principles for determining the maximum permitted period to recover from deviations from STF, SSM prohibited implementation before supplementary analyses had been performed and reported to SSM.

In 2023, SSM carried out a compliance inspection of STF that identified deviations from the requirement for necessary operator information. This resulted in SSM issuing orders for corrective actions.

19.3. Procedures for operation, maintenance, inspection and testing

19.3.1. Regulatory requirements

While Chapter 3, Sections 4 and 5 of SSMFS 2018:1 require that all activities important to safety (or nuclear security) follow written procedures, requirements in Chapter 2, Section 4 of SSMFS 2021:6 specify that all procedures at an NPP shall be adapted to the tasks to be performed and to the conditions in which the tasks are expected to be fulfilled. Chapter 5 of SSMFS 2021:6 further specifies more detailed requirements on principles for, and quality assurance of, operational procedures and guidelines to be used during normal operation, under anticipated operational occurrences or during accident conditions.

Provisions in SSMFS 2021:6 regulate actions to be taken by licensees in cases of identified deficiencies in design, assessment or operation. These actions include a first assessment and categorisation of the deficiency, adjustment of the operational state, implementation of necessary measures, performance of safety reviews, and reporting to SSM (see 19.5.1). A graded approach is applied depending on event categorisation. The three categories defined in SSMFS 2021:6 are:

Category 1

A severe deficiency observed in one or more barriers or in the plant's defence in depth, or 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

A deficiency observed in one barrier or in the plant's defence in depth that is less severe than that which is referred to in category 1, or a well-founded suspicion that safety is threatened. (In these cases, the facility is allowed to continue operation under certain limitations and controls).

Category 3

A temporary deficiency in the plant's defence in depth that arises while corrective actions are performed and which, without any corrective actions, could lead to a more severe condition. Such deficiencies are pre-analysed in the OLCs. (In these cases, the facility is allowed to continue operation under certain limitations during implementation of the corrective measures).

In all three cases, corrective actions are to be subjected to a twofold safety review by the licensee. The results of these reviews must be submitted to SSM. After a category 1 event, SSM must approve the measures taken before the licensee is allowed to restart the plant. Category 3 events are not subject to specific written reporting to SSM except for a compilation of these events that is included in the annual report. The regulations also include an important general clause stipulating that the plant is to be brought to a safe state without delay if there is a disturbance in its operations or in cases where it is difficult to determine the significance of an identified deficiency.

In addition to the requirements in SSMFS 2021:6, Chapter 3 of SSMFS 2021:4 requires that associated procedures, as far as reasonably achievable, are verified and validated during commissioning of a new power plant or of new equipment.

Chapter 2, Section 5 and Chapter 6, Section 2 of SSMFS 2021:6 require a systematic coordination of plans and procedures in the implementation of programmes for maintenance, surveillance and in-service inspection. Since Chapter 6 of SSMFS 2021:6 include all requirements related to maintaining plant dependability, the chapter also specifies requirements on programmes for chemistry, verification of equipment qualification and ageing management, housekeeping and foreign material management.

The regulations of SSMFS 2008:13 further state that inspection and testing of mechanical components with required functions for maintaining pressure or carrying load, protecting such components, or holding or steering other components, shall be carried out in accordance with qualified methods and verified procedures.

19.3.2. Implementation by licence holders

All activities that directly affect the operation of the plants are governed by pre-established procedures. Operating procedures cover all operational states including normal operation, abnormal operation, accident conditions, design extension conditions and functional tests. For more severe situations, specific symptom-based emergency procedures are in place which are comparable to the commonly used severe accident management guidelines, SAMG. The specific symptom based emergency procedures cover all severe situations including situations resulting from extreme external hazards. Maintenance activities according to an approved maintenance programme are also to a great extent accomplished according to procedures that are not always as detailed as operating procedures, where activities are described systematically, in sequences.

Periodic maintenance consists of activities performed on a routine basis, and may include any combination of external/internal inspection, alignment or calibration, overhaul, and component or equipment replacement. Any deficiencies found by predictive or periodic maintenance are addressed by corrective or planned maintenance.

Planned maintenance includes activities performed prior to equipment failure, and is typically carried out during outages, or on spare or redundant equipment that is available during plant operation. The safety regulation allows preventive maintenance to be performed during operation, if specific conditions are met. This is specified in the OLCs and lies within the conditions analysed and described in the SAR.

Modification activities are also carried out as part of maintenance and the Plant Life Management (PLiM) programme, which deals with the design life of components, to fulfil their function throughout the plant's expected lifetime. Such activities are part of the long-term plans and strategies included in the safety programmes. Optimisation is also carried out in order to achieve an appropriate balance between maintenance and equipment modification.

Signing off steps' fulfilment, carried out in the procedures, is mandatory in most cases in order to confirm their completion and to facilitate verification. Temporary operation procedures (TOP) and special conditions are controlled in the form of operation notices with limited validity. These notices are reviewed and issued by the operations department according to a special procedure.

Operations personnel are deeply involved in production and revision of operating procedures. Normally, the different process systems are allocated among shift teams, and one part of team responsibility is the task of developing, reviewing and revising related operating procedures.

Development of procedures follows specified directives, which include reviewing the documents, normally by more than one person other than the author, before their approval by the operations manager or someone else with the corresponding level of authority. The same applies when revising procedures. Revision of procedures is to be carried out continuously, particularly in the case of maintenance procedures, when new experience is obtained.

Procedures used for abnormal operation and emergency should undergo specific safety review. The same review applies when it comes to procedures for checking operability according to technical specifications. As far as possible, or when needed, full-scale simulators of the units are used when verifying a new or revised operating procedure.

Emergency procedures have been developed in order to deal with anticipated operational occurrences and accident conditions. Emergency procedures are supplemented by symptom-based emergency operating procedures for all units. They are used by the shift supervisors and represent a link to the safety panel display system (SPDS) in place using different layouts at all Swedish units as part of the accident management system. The emergency management procedures are also the link to the emergency planning and its criteria for activating an alarm. Following the EU stress tests, experience from the Fukushima event has been incorporated into relevant procedures resulting in improvement of procedures to better facilitate the organisation during extraordinary situations. The structure of procedures is illustrated by figure 19.

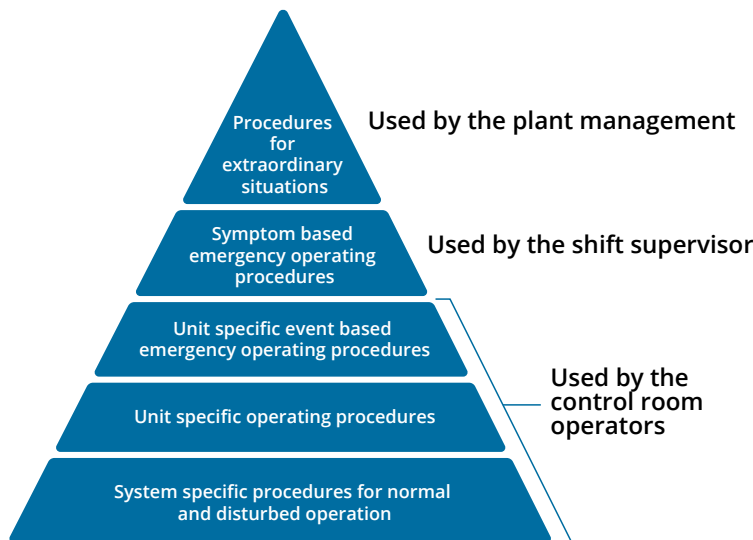


Figure 19. Overview of the main procedures applied during emergency situations.

Other documents are available that reference to the main procedures. The level of detail and number of procedures decrease with the increasing height of the pyramid.

At the top of the pyramid, procedures for extraordinary situations include procedures for the engineer on duty, the operative emergency response plan, and technical handbooks for dealing with beyond design basis accidents, including severe accidents as well as cases when more than one unit per site is affected.

The Swedish PWRs follow EOPs (Emergency Operating Procedures) and SAMG (Severe Accident Management Guidelines) from the Westinghouse Owners Group, whereas the BWRs have own specifically developed instructions and guidelines from the 1980s for accident management. At that time, these procedures (both PWR and BWR) covered situations including loss of all AC power and depressurisation by means of the system for filtered ventilation of the containment.

19.3.3. Regulatory review and control

Procedures are usually reviewed during supervision. When conducting an event investigation, SSM requests procedures to be submitted relating to the event in question. In these cases, SSM conducts a review to determine whether the procedure provides a sufficient basis for the personnel to properly accomplish their tasks.

Ordinarily, operational, emergency and maintenance procedures are not reviewed by SSM when they have been published or updated. However, SSM's review of the procedures that was carried out in 2016 highlighted the need for a reassessment of the instructions and guidelines for severe accident management at the BWRs. In July 2017, SSM issued orders to the licensees to evaluate and reassess their procedures for BWRs, with reference to recommendations from the IAEA and WENRA.

The licensees' work at Forsmark and Oskarshamn NPPs has resulted in the implementation of new SAMG inspired by IAEA Safety Guide NS-G-2.15 and Specific Safety Guide SSG-54. During the period since the previous report, SSM has reviewed the work of the operators of Forsmark and Oskarshamn on developing and implementing new SAMG and has found that this has been completed satisfactorily and achieved a good quality. In addition, SSM issued new orders in March 2021 to Ringhals NPP to update the SAMGs for their PWR units 3 and 4. The licensee has submitted a plan to follow the current work of PWROG (PWR Owners Group) in developing a new generic SAMG and subsequent plant specific customisation and implementation of the new guidelines.

19.4. Engineering and technical support

19.4.1. Regulatory requirements

Chapter 3, Sections 4 and 5 of SSMFS 2018:1 require that all activities important to safety (or nuclear security) follow written procedures. Chapter 3, Sections 11 and 12 of the Radiation Protection Act (2018:396), and Section 13 of the Act on Nuclear Activities, together require that anyone conducting nuclear activities involving ionising radiation shall have the economic, administrative and personnel resources necessary to fulfil the requirements set by these acts. Chapter 3, Section 10 of SSMFS 2018:1 also specifies in more detail requirements that plant personnel have the necessary competence and suitability required for tasks that are important for safety, while also ensuring that these aspects are documented. A long-term staffing plan is required. The requirement also covers contractors. Requirements for using contractors as opposed to own personnel should be carefully considered in order to have a capability to develop and sustain adequate in-house expertise, as stated in Chapter 3, Section 11 of SSMFS 2018:1. The requirements also state that necessary expertise should always be available in-house for procuring, managing and evaluating work important for safety that is carried out by contractors.

In addition to the requirements on resources and competences in SSMFS 2018:1, Chapter 3 of SSMFS 2021:6 requires a systematic identification of competences needed for safety (or nuclear security) related activities at an NPP, for several years ahead. It is also required that this include a documented plan of how to achieve this, both in short- and long-term perspectives.

Chapter 8, Section 2 of SSMFS 2021:6 also specifically requires that engineering and technical support is available within the emergency response organisation.

19.4.2. Implementation by licence holders

The NPPs have personnel whose role is specifically to account for the responsibilities of the licensees. All the licensees have these competencies available in their organisation. This means that even if some external support must be used to undertake certain tasks, the plants have in-house expertise and the capability to evaluate the results of analyses, calculations, etc. that have been performed. Additionally, the Vattenfall nuclear licensees are supported by a centralised engineering organisation that also is responsible for ensuring the Vattenfall's nuclear fuel supplies.

19.4.3. Regulatory review and control

With the exception of the independent safety review functions and involvement in the national competence situation, as reported in section 11, SSM has thus far not specifically reviewed the engineering and technical support available at the NPPs. In connection with other inspections and reviews, the specialist staffing situation has occasionally been commented upon.

19.5. Reporting of incidents to SSM

19.5.1. Regulatory requirements

The requirements of SSMFS 2021:6 include a provision on reporting of deficiencies and incidents related to design, assessment or operation of the nuclear installation, together with an appendix specifying requirements for various types of events related to barriers and defence in depth, protection of workers, abnormal discharges of radioactive substances, detection of abnormal radioactivity levels in the surrounding environment and events involving a lost radioactive source. Reporting procedures for different types of incidents are described in the regulations.

Safety-related events related to deficiencies of barriers and defence in depth are reported according to the following:

- Reporting within one hour: events triggering a General Emergency or Site Area Emergency at the plant, scram with complications, and events and conditions belonging to category 1 (see 19.3.1).
- Reporting within 16 hours: events rated at Level 2 or above on the INES scale.
- Reporting within 7 days:
 - » a comprehensive investigation report after a General Emergency or Site Area Emergency at the plant, following events and conditions belonging to category 1 or for events rated at Level 2 or higher on the INES scale
 - » an initial evaluation of events and conditions belonging to category 2, INES events of Level 1, and scram reports
- Reporting within 60 days: a comprehensive investigation report on events and conditions belonging to category 2 (see 19.3.1), events rated at Level 1 on the INES scale, and scram reports.

In addition to this any work at the plant where the collective dose to workers has exceeded 0.1 manSv shall be reported to SSM within three months. Deficiencies in procedures for radiation protection or internal transport of radioactive material, faults in equipment measuring or monitoring radiation dose, dose rate or radioactive substances, suspected exceeded dose limits or internal contamination of workers, unintentional exposure or dispersion of contamination, significant contamination or radioactive material outside controlled area, levels of radioactive substances in the environment that deviate from normal, and lost sources of radiation shall also be reported. These deficiencies shall be reported immediately or within seven days, depending on severity.

Additional requirements include daily reporting of operational state, power level and occurrence of any abnormal events or disturbances, such as scrams, and the requirement for a comprehensive annual report summarising all experiences that are important for plant safety.

19.5.2. Implementation by licence holders

Incidents of safety significance, including unintended reactor shutdowns, are reported in accordance with SSM regulations and as specified in the STFs. There are two types of licensee event report (LER), the more severe of which is called category 1. Only a very limited number of events of this category have occurred at Swedish plants over the years and none during the current reporting period (March 2022–February 2025). During the period, no reported events were rated as Level 2 or higher on the INES scale.

Events that have resulted in reactor shutdown are analysed by the operations department and reviewed independently by the safety department as well as, at some sites, by the safety committee before restarting the unit. The reports are reviewed at different levels within the operating organisation and approved by the operations or production manager before submittal. These reports are distributed within the organisation, to the regulatory body, and to other Swedish NPPs. This description is also valid for handling of LER category 2.

The front page of the standardised report form describes the event in general: identification number, title, reference to the relevant STF paragraph, date of discovery and length of time for corrective actions, conditions at the time of occurrence, system consequences, a contact person at the plant, and activities affected by the event. On the reverse side of the document, the event is described under the following headings:

- Sequence of events and operational consequence(s)
- Safety significance
- Direct and root causes
- Corrective actions
- Lessons learned from the event
- Other information

If the description of the event is extensive, additional pages are added to the form.

Reports are also required e.g. if the permitted levels of activity release from the plant, accordance to the STF, are exceeded or in the event of unusually high radiation exposure to individuals at the plant.

19.5.3. Regulatory review and control

Over the past three years, the number of LERs has been approximately 20 per year and operating reactor. Licensee reporting provides in most cases the necessary information, together with SSM verifications on-site, for making regulatory decisions. SSM performs every year, and for each licensee, an analysis in order to identify trends and patterns emerging from events related to barriers and defence in depth.

For more serious incidents, SSM has a procedure in place for conducting on-site rapid investigations in the form of surveillance inspection (see section 8.8). This procedure has been used in a few cases over the past few years.

The majority of events that occurred in the period 2022–2025 are rated below scale or Level 0 on the INES scale (no safety significance). A very small number has been rated Level 1 (anomaly). No event has been rated Level 2 and above.

19.6. Operating experience

19.6.1. Regulatory requirements

While Chapter 3, Section 16 of SSMFS 2018:1, requires that experiences from own activities or from similar activities shall be collected and assessed to improve safety (and nuclear security), Chapter 3, Sections 18 and 19 of SSMFS 2018:1 also require that events of importance to safety (or nuclear security) shall be evaluated in a systematic manner, resulting in a plan for actions needed to prevent reoccurrence of events with a negative impact on safety (or nuclear security). Chapter 3, Section 18 of SSMFS 2018:1 requires the fostering of a reporting culture, so that errors and abnormal conditions are identified and recorded. SSM ensures that significant events are reported to international organisations as appropriate (the IAEA/NEA IRS) and to other regulatory bodies, as well as to other suitable organisations.

Chapter 2, Section 5 and 20 of SSMFS 2021:6, now require implementation of an operating experience programme, to compile experiences significant to safety (or nuclear security), follow scientific and technological development, assess and prioritise experiences and to convey these to relevant personnel and parties, such as international bodies, other operating organisations and SSM.

19.6.2. Implementation by licence holders

The objective of the operating experience analysis and feedback programme is to learn from experience, from one's own plant and from others, and to prevent recurrences of events, particularly events that might affect plant safety. The operating experience process consists of a wide variety of activities within the plant organisation as well as externally. Some activities are described briefly below.

Around half of operating experience feedback is from plant personnel and around half of overall analysis efforts focus on events at the licensees' own reactors. Event reports constitute essential input for this analysis task, together with specific operating experience reports written about events. The reports include events that do not meet the event criteria for LERs, in addition to minor events and near-misses.

SSM imposes strict requirements for systematic investigations and analyses of events. The event sequence must be fully clarified, including circumstances that might have prevented or stopped the sequence, identification of direct and root causes, analysis of the consequences and description of the measures taken to prevent recurrence. HTO analysis is used when root cause and in-depth analyses are deemed relevant. HTO analysis is an established methodology (see section 12.2) executed by a team of trained investigators available at all plants.

Analyses of reactor shutdowns and other event reports from Swedish NPPs, as well as from Finnish BWRs in addition to other information from abroad, are performed by Norderf, which provides Nordic NPPs with external operational experience from the nuclear industry worldwide. Norderf consists of representatives from TVO (Finland), Swedish nuclear power companies, SKB (Swedish Nuclear Fuel and Waste Management Company), as well as KSU (nuclear safety and training). Analysis work is performed by representatives of the above organisations and the results are reported to the plants every other week, supplemented by topical and annual reports. Event reports are classified. Severe events also lead to recommendations (REK) directed towards Swedish and Finnish operators.

The procedure for operating experience feedback (OEF) describes the requirements, organisation and working principles for experience feedback in the Nordic system. A shared organisation reviews experience feedback from the areas of reactor safety, environmental protection and occupational safety. Other experience feedback initiated by Norderf, or any other internal organisation, is also reviewed and entered into a shared database.

The working principles of the Nordic system include screening by different organisations:

- KSU is responsible for collecting and assessing events abroad for the Norderf process. These sources are mainly WANO, IAEA, OECD/NEA, USNRC, EU Clearing House etc., and the information is collected, reviewed, screened and sorted as well as categorised by KSU. The events are graded on a scale of four.
- Norderf assesses all events, including scram reports, from Nordic BWR and PWR reactors. International events are assessed by Norderf and categorised into one of the below:
 - » Category A: Significant importance for reactor safety
 - » Category B: Moderate importance for reactor safety
 - » Category C: Minor importance for reactor safety
 - » Category N: Not applicable to Nordic plants
- The task of OEF is to collect, evaluate, document and follow up experience from the Nordic system.
- The OEF database is used for registration and management of issues and the measures taken.
- All Norderf Category A, B and C events, WANO Significant Operating Experience Reports (SOERs) and Norderf recommendations are managed in the respective plant's OEF system.

All Swedish event reports are registered in the Norderf event database. The database is intended for use by plant personnel who have direct access and can use it for specific purposes.

The NPPs also report events to the WANO Event Reporting Program. Event reports are selected in accordance with WANO criteria and sent for worldwide distribution. As mentioned above, Swedish utilities also participate in various owners' groups. Some plants also carry out cooperation directly with other plants (i.e. Forsmark NPP with the Finnish plant, TVO, and Oskarshamn NPP with other Uniper SE plants). Participation in owners' groups is considered valuable, although it is a more demanding task given the need to separate operating experience relevant to a specific plant design.

Operating experience at KSU

OEF is included in KSU's training programmes for plant personnel. A special section at KSU is responsible for screening and selecting OEF suitable for the training programmes. OEF information is forwarded to training departments in the form of OEF modules sorted by training category. International OE information suitable for training purposes is selected from WANO, IAEA and NRC reports. Trainers can also consult with OE engineers for additional operating experience suitable for training of operations personnel.

Ringhals NPP

The internal operating experience feedback function at Ringhals NPP follows the principles of the industrial practice commonly referred to as the Corrective Action Programme (CAP). The external operating experience feedback function (OPEX) is managed in a similar systematic process.

CAP has the purpose of identifying deviations, near-misses and lessons learned in daily operations, implementing corrective actions, and performing follow-ups. In addition, CAP provides input for the internal experience feedback loop.

Each department is responsible for reporting of deviations from expected conditions and ensuring that the process of screening, analyses, corrective action and follow-ups is effective.

Each department is responsible for managing OPEX within their organisation, including screening and corrective actions. A central OPEX group manages screening and addressing. Input for the central OPEX group consists of screened observations that might be of interests to share and act upon across the organisation, along with OPEX information from Norderf.

Forsmark NPP

The OEF function at Forsmark NPP is organised in the Engineering Department. It is composed of two groups: Internal/External Operating Experience and HTO Investigation. The HTO investigation group's main task is to provide and assist the entire organisation with adequate knowledge for performing root cause analysis for events affecting the interplay between Man, Technology and Organisation. The main task of the Internal OE is to manage all OEF in a systematic and structured way. This includes implementation of a process for CAP. In order to assist in handling and processing of OE reports, all main departments at Forsmark NPP have OE coordinators who are responsible for ensuring that matters are dealt with as specified by the CAP process.

The main task for external OE is to enhance reactor safety by making use of experience from external events and lessons learned. A group made up of members designated based upon their technical skills and position in the organisation meets every other week to evaluate incoming external reports. The WANO SOER coordinator assists in and follows up ongoing work with recommendations and actions for the SOER.

Oskarshamn NPP

All departments and sections at Oskarshamn NPP are responsible for applying experience feedback in daily work within their own operations. This means that departments and sections at Oskarshamn NPP:

- Identify and share experiences.
- Identify root causes to prevent recurrence.
- Allow experience feedback to be a natural part of daily self-assessments and development and improvement work.
- Report on experiences and conduct trend analyses.

Departments and sections at Oskarshamn NPP also obtain experience feedback from the quality department and from the OE group, which consists of key members from various parts of the organisation. Production managers deal with deviations and events with regard to reactor safety at daily operational review meetings. These are held every weekday. Specific key issues are dealt with at operation assessment meetings, where the production managers require a broad illustration and cause analysis of the issues being dealt with. Depending on the nature and complexity of the event, HTO analyses on different levels are conducted in order to as far as possible have capability to focus resources and evaluation time on events that require special scrutiny. External issues are assessed with regard to any possibility that a similar event might occur at Oskarshamn NPP. It is vital in this assessment to avoid exclusion of any issues based on dissimilarities found, and instead to seek identification of associated similarities and details.

Oskarshamn NPP works with a CAP for management of events, nonconformities and suggested improvements. These are referred to collectively as 'observations'. The main objective of observations is not only to identify appropriate measures for reducing the risk of recurrence, but also to eliminate the risk of more serious events taking place.

All employees at Oskarshamn NPP undergo training on reporting of observations. Managers and other key personnel undergo training on actively managing observations, performing analyses, and executing proposed actions. Experiences from the plant are shared through the CAP process by the managers responsible in accordance with the management system. It is expected that all nonconformities and improvement proposals are dealt with in the process, which visualises the drive for continuous improvements and defines setting of priorities.

19.6.3. Regulatory review and control

SSM's event evaluation process, which deals with analysis of disturbances on electricity-generating NPPs, is in place and used by SSM. The procedure describes the management and evaluation of shortcomings reported by the licensees. This activity is divided into two parts: a national part which deals with reporting from the respective power plant, as regulated by SSMFS 2021:6, and an international part which is reporting activity through the IAEA/NEA reporting system, IRS.

All reports from licensees are periodically screened by a SSM team of four to five persons. These persons have different expert knowledge and make a first assessment as to whether these reports need further regulatory attention. Licensees are asked for clarifications if necessary. If there are any regulatory concerns, the issue is brought up at the management meeting of the supervision division and further measures to be taken by SSM are decided. The event analysis group can also issue information notices in order to raise concerns in a broader sense. Once per year, a seminar is held at which licensees and the regulator discuss lessons learned from recent reports and the quality of the reports and root cause analysis.

Since the 1970s, all LERs and reactor shutdown reports from Swedish nuclear power reactors have been registered in a database at the regulator. All events are indexed and searchable and can easily be trended across many parameters. The events are also evaluated against IRS reporting guidelines and, if necessary, suggested for reporting to the IAEA/NEA international reporting system, IRS.

In addition the internal and external experience feedback arrangements of each licensee are supervised periodically according to the baseline supervision program described in section 8.8.

19.7. Radioactive waste

19.7.1. Regulatory requirements

The Radiation Protection Act (2018:396) provides general requirements on handling of radioactive waste such as that the licensee must take measures to limit the generation of radioactive waste and that radioactive waste shall be taken care of as soon as reasonable achievable, and sent for final disposal if needed.

Requirements for clearance of materials and release of sites are stipulated in the regulations SSMFS 2018:3, which address exemptions from the Radiation Protection Act and the clearance of materials, building structures, and sites. The licence holder can perform clearance of materials in accordance with a control programme. The clearance of building structures and areas must be approved by SSM. Contamination must be removed as far as reasonably achievable before clearance.

Chapter 5, Section 9 of SSMFS 2018:1 requires a documented plan for radioactive waste management. Section 10 in the same chapter also requires that management of radioactive waste is adapted to the characteristics of the waste and that radioactive waste streams with different characteristics are separated from each other. Chapter 5 of SSMFS 2018:1 also includes further general requirements on documentation of radioactive waste and annual reports to SSM, describing, among other things, amount, contents, placement of and responsibilities related to the radioactive waste.

Regulations on radioactive waste management from nuclear facilities (SSMFS 2021:7) have been in force since 2022 and are mainly used in parallel with SSMFS 2018:1, but also with SSMFS 2021:4–6. These regulations specifically cover requirements for documented plans based on an evaluation of alternative management options; the derivation of acceptance criteria stating the properties of spent fuel and radioactive waste that can be received for storage, disposal or any other treatment; control measures of waste items to ensure that they meet the acceptance criteria; waste type descriptions and verification of waste items; and an up-to-date inventory of all spent fuel and radioactive waste at the facility.

SSMFS 2021:7 superseded waste handling requirements in SSM's general regulations on nuclear facility safety, SSMFS 2008:1. Whilst SSMFS 2008:1 currently still applies to waste storage at other facilities, waste storage at NPPs is regulated in SSMFS 2021:4 and SSMFS 2021:6. The regulations SSMFS 2021:4 and SSMFS 2021:6 stipulate for instance how waste handling shall be addressed in the design of the NPP, in order to minimise the generation of radioactive waste and to ensure that appropriate space is provided for storage and handling of the waste. They also require that core management during operation of the reactor ensures that used nuclear fuel has appropriate characteristics to be managed according to the plan for radioactive waste.

19.7.2. Implementation by licence holders

19.7.2.1. Spent fuel

Spent fuel is stored in fuel pools at Swedish NPPs, usually for an average of two years while awaiting transport from the site. In the cases of the Forsmark and Ringhals NPPs, transports are undertaken by the m/s Sigrid, which ships the spent fuel in special transport casks to Clab. Clab is a central interim storage facility located near the Oskarshamn NPP. At the Oskarshamn site, handling and operation of the casks are performed using purpose-built vehicles. All transportation of the spent fuel is a routine operation.

19.7.2.2. General objectives of waste management

The general objectives of waste management at the locations of the NPPs are:

- Minimising the amount of waste,
- Ensuring that all nuclear waste is handled and conditioned for disposal according to existing regulatory requirements, and
- Accomplishing safe and cost-efficient waste management with the least possible impact on human health and the environment.

Waste minimisation is in certain cases substituted by optimisation of waste generation, in which consideration is given to radiation doses and costs. Minimisation of the amount of waste is, for example, achieved by reducing the amounts and kinds of materials brought into radiologically controlled areas, and separating waste at source. Clearance of radioactive waste is also used to minimise the amount of waste for disposal. Treatment practices such as incineration and melting can reduce the volume of the waste needing to be disposed of. Radioactive wastes generated at Swedish NPPs belong to different categories; consequently, they are treated, stored and disposed of in various ways as described briefly below.

19.7.2.3. Clearance of radioactive waste

The licence holder can perform clearance themselves of their own waste and must have written procedures and a control programme to do this. The licence holder may under certain circumstances apply to SSM for conditional clearance of waste with higher activities.

Metal waste can be treated in a melting facility where much of the metal can be cleared for unrestricted use. Most of the activity ends up in the slag and dust and needs to be disposed of.

19.7.2.4. Low and very low-level waste

After segregation with respect to activity content and combustibility, low-level waste is compacted into bales or packaged in drums or cases, which are placed in standard freight containers. Some waste with very low activity level is disposed of in licensed shallow land burial sites at the NPPs. To minimise infiltration, the waste is covered with bentonite liners and/or compacted clays. The sealing layers are protected by an approximately 1 metre thick layer of moraine. Some combustible low-level waste is shipped to Cyclife Sweden AB, where it is incinerated in a special facility. The ash is collected in steel drums, returned to the waste owner and handled according to the corresponding waste description.

19.7.2.5. Intermediate-level waste

This type of waste is dominated by filters and spent ion exchange resins, which are commonly solidified with cement or bitumen in steel drums, or in moulds of reinforced concrete or carbon steel. The cement or bitumen immobilises waste, while moulds contain different materials and in case of use concrete moulds also provide for radiation shielding. Some intermediate-level resins with relatively low activity content are packaged in concrete tanks and dehydrated without solidification.

Metal scrap and other kinds of solid wastes above a certain level of activity also belong to this category. They are packaged in concrete or steel moulds, compacted if possible and grouted with concrete for disposal to the final repository for short-lived radioactive waste (SFR), or awaiting future treatment to comply with future waste acceptance criteria for the not yet built final repository for long lived radioactive waste (SFL).

19.7.2.6. Registration, storage and disposal of waste

Registration and documentation are required for all waste management at the sites including spent fuel. Examples of data relating to the waste that is documented and registered in a database include:

- Identity
- Category of waste and type of package
- Amount of waste or spent fuel
- Activity content and nuclide composition of the waste
- Initial enrichment and burnup of the spent fuel
- Position at the facility
- Information of waste description and certificate of compliance

Production and storage of radioactive waste and spent fuel at the NPPs are reported annually to SSM.

Intermediate and low-level waste at the NPPs is stored temporarily in containers, rock caverns or storage buildings while awaiting transport to a treatment facility, to the SFR repository or to the not yet built SFL repository.

19.7.3. Regulatory review and control

Inspection of on-site management of radioactive waste is carried out by SSM's inspectors. SSM also inspects radiation protection aspects of waste handling. The licence holder notifies SSM of any new or revised waste plans, waste acceptance criteria and waste descriptions. Many of them are reviewed by the authority. SSM must approve the waste description for the waste and package prior to their use for disposal in a final repository.

19.8. Vienna Declaration on Nuclear Safety (VDNS)

This section, in reference to Article 19, accounts for Sweden's implementation of relevant improvements concerning principles of the VDNS regarding safe operation of NPPs.

Swedish PWRs use EOPs (Emergency Operating Procedures) and SAMG (Severe Accident Management Guidelines) from the Westinghouse Owners Group, whereas the BWRs are subject to their own developed instructions and guidelines for accident management. These procedures (both PWR and BWR) originally covered management of situations including loss of all AC power and dealt with depressurisation through the system for filtered ventilation of the containment, etc.

Procedures for extraordinary situations at Swedish NPPs are in place at all sites. Based on experience from the Fukushima event, the procedures and guidelines were enhanced to be applicable for accidents affecting more than one unit at a site. They were also adapted to accommodate international guidelines in the area of SAMG.

Abbreviations

ALARA	As Low As Reasonably Achievable (a principle applied in radiation protection)
ANS	American Nuclear Society
ANSI	American National Standards Institute
APRI	Accident Phenomena of Risk Importance
BAT	Best Available Technique
BDBA	Beyond Design Basis Accident
BSS	The Basic Safety Standards Directive of Euratom
BWR	Boiling Water Reactor
CAP	Corrective Action Programme
CAT	Containment Air Test
CCF	Common Cause Failure
Clab	Central Interim Storage Facility for Spent Nuclear Fuel
CNS	Convention on Nuclear Safety
DBA	Design Basis Accident
DEC	Design Extension Conditions
DSA	Deterministic Safety Assessment
EDG	Emergency Diesel Generator
EIA	Environmental Impact Assessment
ELAP	Extended Loss of AC Power
ENISS	European Nuclear Installations Safety Standards
ENSREG	European Nuclear Safety Regulators Group
EPD	Extended Planning Distance
ePM	Enhanced Performance Monitoring
EPRI	Electric Power Research Institute
EU	European Union
EU BSS	European Basic Safety Standards
EUR	European Utility Requirements
FCVS	Filtered Containment Venting System
FME	Foreign Material Exclusion
FSAR	Final Safety Analysis Report
HTO	Human-Technology-Organisation,
I&C	Instrumentation and Control
IAEA	International Atomic Energy Agency
ICCS	Independent Core Cooling System
ICRP	International Commission on Radiological Protection
IEEE	Institute of Electrical and Electronics Engineers
INES	International Nuclear Event Scale
INPO	Institute of Nuclear Power Operations
IRRS	IAEA Integrated Regulatory Review Service
IRS	the IAEA/NEA International Reporting System for Operating Experience
ISI	In-Service Inspection
KPI	Key Performance Indicator
KSKG	Kärnkraftssäkerhetskoordineringsgrupp (Nuclear Safety Coordination Group of the Swedish licensees)
KSU	Kärnkraftssäkerhet och Utbildning AB (the Swedish Nuclear Training and Safety Centre)
KTH	Kungliga Tekniska Högskolan (Royal Institute of Technology)
LER	Licensee Event Report

LILW	Low and Intermediate Level Waste
LOCA	Loss of Coolant Accident
LTO	Long Term Operation
LUHS	Loss of Ultimate Heat Sink
MSB	Myndigheten för samhällsskydd och beredskap (Swedish Civil Contingencies Agency)
MVSS	Multi Venturi Scrubber System
NACp	EU stress test National Action Plan
NCFSI	Nonconforming, Counterfeit, Fraudulent, or Suspect Items
NDT	Non Destructive Testing
NGO	Non-Governmental Organisation
NKS	Nordic Nuclear Safety Research
Norderf	Swedish-Finnish Group for Operating Experience Feedback
NORM	Naturally occurring radioactive material
NPP	Nuclear Power Plant (including all nuclear power units at one site)
NPSAG	Nordic PSA Group
NUREG	Nuclear Regulatory Guide (issued by the USNRC)
OE	Operational Experience
OECD/NEA	Organisation for Economic Co-operation and Development/ Nuclear Energy Agency
OEF	Operating Experience Feedback
OKG	OKG Aktiebolag (licence holder of Oskarshamn NPP)
OLC	Operational Limits and Conditions
OSART	Operational Safety Review Team (a review service of the IAEA)
PAZ	Precautionary Action Zone
PHWR	Pressurised Heavy Water Reactor
PSA	Probabilistic Safety Analysis (or Assessment)
PSAR	Preliminary Safety Analysis Report
PSR	Periodic Safety Review
PWR	Pressurised Water Reactor
R&D	Research and Development
RL	Reference Level
RP	Radiation Protection
RPS	Reactor Protection System
SALTO	Safety Aspects of Long Term Operation (a review service of the IAEA)
SAMG	Severe Accident Management Guideline
SAR	Safety Analysis Report
SFL	Final repository for long-lived waste
SFP	Spent Fuel Pools
SFR	Final repository for short-lived radioactive waste
SKB	Svensk Kärnbränslehantering AB (the Swedish Nuclear Fuel and Waste Management Company)
SKC	Svenskt kärntekniskt centrum (Swedish Centre of Nuclear Technology)
SMHI	Swedish Meteorological and Hydrological Institute
SOER	Significant Operating Experience Report
SQC	Swedish Qualification Centre (NDT qualification)
SRL	Safety Reference Level
SSC	Structures Systems and Components
SSM	Strålsäkerhetsmyndigheten (Swedish Radiation Safety Authority)
SSMFS	Strålsäkerhetsmyndighetens författningssamling (the SSM Code of Statutes)
STF	Säkerhetstekniska driftförutsättningar (Technical Specifications, Operational Limits and Conditions)
SVAFO	Swedish company engaged in management of radioactive waste
SWEDAC	Swedish Board for Accreditation and Conformity Assessment
TLAA	Time Limiting Ageing Analysis
TMI	Three Mile Island NPP
TSO	Technical Support Organisation
UPZ	Urgent Protective action planning Zone
USNRC	US Nuclear Regulatory Commission
VDNS	Vienna Declaration on Nuclear Safety
VTT	Finnish Technical Research Centre
WANO	World Association of Nuclear Operators
WENRA	Western European Nuclear Regulators' Association

Appendix 1:

1. Modernisation and safety upgrades at operating Swedish NPPs

This appendix presents a compilation of the modernisation and safety measures at the operating NPPs Oskarshamn, Forsmark and Ringhals, highlighting key upgrades, safety enhancements, and extended operational strategies.

Please refer to Appendix 1 in Sweden's Ninth National Report under the CNS (Ds 2022:19) for a complete list of major implemented safety measures during 1995–2021. Please refer to Appendix 2 in the same report (Ds 2022:19) for a complete list of the technical and administrative measures implemented at the Swedish NPPs according to the Swedish NAcP following the EU stress tests.

After the accident in Three Mile Island in 1979, severe accident management systems (including Filtered Containment Venting System, FCVS) were introduced at all Swedish NPPs. Through a decision by SSM in 2014, the licensees were required to implement an ICCS at reactors intended to be operated beyond 2020.

1.1. Oskarshamn NPP

Oskarshamn 3

The PULS (Power Uprate with Licensed Safety) project at Oskarshamn 3 included a power uprate, compliance modifications in relation to the requirements of SSMFS 2008:17, and the replacement of critical components to extend the plant's operating life to 60 years (until 2045). The uprate increased thermal power to 3,900 MWth (1,450 MWe gross), 129 % of the original design.

Major safety modifications included:

- **Component Upgrades:** Replacement of reactor pressure vessel (RPV) internals, main steam isolation valves, high-pressure and low-pressure turbines, main circulation pumps, and main cooling water pumps.
- **New Installations:** New generator, scram modules for hydraulic SCRAM, logic chains in the reactor protection system, diversified cooling chains, and upgraded station transformers.
- **Safety Enhancements:** Nuclide-specific on-line measurement in the turbine off-gas system for early fuel failure detection, redesigned auto-switching automatics for diesel bus bars, and diverse RPV level measurement.

Post-PULS modifications (2010–2013) included:

- Turbine bearing replacement
- Enhanced reactor protection instrumentation in the emergency control room
- 400 kV switchgear replacement
- Internal replacements in the RPV (shroud head, steam separators, steam dryers)
- Fire hazard analysis (2010–2013)
- Environmental qualification updates inside containment (2014)

1.2. Forsmark NPP

1.2.1. Forsmark NPP Modernisation Programs

The Program 2000 modernisation (1995–2000) was followed by Program P40+ aimed at long-term operation, which focused on technical maintenance (70 %), safety upgrades (20 %), and dose/environmental improvements (10 %).

Completed major safety measures included:

- Core and Reactor Upgrades: Core spray nozzle removal, RPV level diversification, diversified reactor shutdown system, robustness measures against pipe breaks, and earthquake reinforcements.
- System and Equipment Replacements: Main circulation pump upgrades, new I&C systems in the emergency control room, new high-voltage switchgear (400 kV), and steam/moisture separator replacements.
- Electrical & Fire Safety Enhancements: Fire safety improvements, prevention of oxy-hydrogen in steam systems, ventilation improvements in electrical buildings, and improved physical protection measures.

1.2.2. Forsmark Unit-Specific Upgrades

Forsmark 1 and 2

- Core grids and reactor internals replaced
- 6 kV switchboards replaced

Forsmark 1

- Independent spent fuel pool water supply
- Boron injection system automation for diversified reactivity control
- Separation of operational and safety functions in the power system
- High-pressure drainage forward pumping
- Enhanced reactor protection trip conditions
- Reactor protection system trip condition upgrades
- Improved cooling chain separation and redundancy

Forsmark 2

- New step-up and auxiliary transformers
- Access to independent spent fuel pool water supply at F1
- Boron injection system automation for diversified reactivity control
- Separation of operational and safety functions in the power system
- New inboard isolation valves in the main steam system

Forsmark 3

- New emergency feedwater source for the RPV
- Independent spent fuel pool water supply
- Boron injection system automation for diversified reactivity control
- Separation of operational and safety functions in the power system
- Enhanced reactor shutdown system
- Upgraded residual heat removal diversification

1.3. Ringhals NPP

1.3.1. Ringhals NPP Modernisation Program

The Ringhals renewal program (initiated in 1997) focused on safety enhancements, system upgrades, and operational life extensions across all four units.

Completed modernisation measures included general Safety and Operational Upgrades (Ringhals 1–4):

- Improved emergency preparedness (compliance with SSMFS 2014:2)
- Fire protection system upgrades
- Updated environmental qualification outside containment

1.3.2. Ringhals Unit-Specific Upgrades

Ringhals 3 and 4

- Safety valve improvements, radiation monitoring system modernisation, containment sump blockage mitigation
- Enhanced battery capacity for blackout scenarios
- Upgraded safety injection pump vibration monitoring
- Extended Class 1E battery capacity (≥ 8 hours)
- Mobile diesel generators for backup charging
- GREAT Power Uprate (thermal power increased to 3,144 MW)
- Turbine modernisation
- Pressuriser component replacements

Ringhals 4

- Steam generator and pressuriser replacement
- Earthquake resilience measures

Departementsserien 2025

Kronologisk förteckning

1. Hyra anstaltsplatser utomlands. Ju.
2. Moderna – en ny myndighet för modern konst, arkitektur och design. Ku.
3. Sveriges försvarsmaterieldirektör. En ny inriktning. Fö.
4. En ny lag om unga lagöverträdare. Ju.
5. Genomförande av direktivet om skydd för personer som deltar i den offentliga debatten. Ju.
6. En ändamålsenlig hantering av tillstånd och tillsyn av explosiva varor. Fö.
7. Polisens användning av AI för ansiktsgenkänning i realtid. Ju.
8. Administrativa sanktioner i socialförsäkringen. S.
9. Ett nationellt mobilförbud i de obligatoriska skolformerna och fritidshemmet. U.
10. En ändamålsenlig hantering av tillstånd och tillsyn av explosiva varor – slutredovisning. Fö.
11. En tydlig beslutsordning för deltagande i Natos samlade verksamhet för avskräckning och försvar. Fö.
12. Nordisk verkställighet i brottmål. Ju.
13. Rätt att installera laddpunkt hemma. Ju.
14. Kompletterande bestämmelser till EU:s förordning om överföring av straffrättsliga förfaranden. Ju.
15. Nya regler om aktier på multilaterala handelsplattformar. Ju.
16. Några frågor om ersättning vid gemensamhetsinrättningar. Ju.
17. Förbättrade förutsättningar för IVO – förslag för att motverka oseriösa och kriminella aktörer inom hälso- och sjukvården. S.
18. Nya regler om ansökningsförfarandet för vissa uppehålls- och arbetstillstånd. Ju.
19. Slutredovisning av uppdraget om förstärkningsteam inom socialtjänsten. S.
20. Utökade befogenheter för civilanställda vid Polismyndigheten att utreda brott. Ju.
21. Förbättrade förutsättningar för operativt militärt samarbete. Fö.
22. Sweden's Tenth National Report under the Convention on Nuclear Safety. KN.

Departementsserien 2025

Systematisk förteckning

Försvarsdepartementet

Sveriges försvarsmaterieldirektör. En ny inriktning. [3]

En ändamålsenlig hantering av tillstånd och tillsyn av explosiva varor. [6]

En ändamålsenlig hantering av tillstånd och tillsyn av explosiva varor – slutredovisning. [10]

En tydlig beslutsordning för deltagande i Natos samlade verksamhet för avskräckning och försvar. [11]

Förbättrade förutsättningar för operativt militärt samarbete. [21]

Justitiedepartementet

Hyra anstaltsplatser utomlands. [1]

En ny lag om unga lagöverträdare. [4]

Genomförande av direktivet om skydd för personer som deltar i den offentliga debatten. [5]

Polisens användning av AI för ansiktsgenkänning i realtid. [7]

Nordisk verkställighet i brottmål. [12]

Rätt att installera laddpunkt hemma. [13]

Kompletterande bestämmelser till EU:s förordning om överföring av straffrättsliga förfaranden. [14]

Nya regler om aktier på multilaterala handelsplattformar. [15]

Några frågor om ersättning vid gemensamhetsinrättningar. [16]

Nya regler om ansökningsförfarandet för vissa uppehålls- och arbetstillstånd. [18]

Utökade befogenheter för civilanställda vid Polismyndigheten att utreda brott. [20]

Klimat- och näringslivsdepartementet

Sweden's Tenth National Report under the Convention on Nuclear Safety. [22]

Kulturdepartementet

Moderna – en ny myndighet för modern konst, arkitektur och design. [2]

Socialdepartementet

Administrativa sanktioner i socialförsäkringen. [8]

Förbättrade förutsättningar för IVO – förslag för att motverka oseriösa och kriminella aktörer inom hälso- och sjukvården. [17]

Slutredovisning av uppdraget om förstärkningsteam inom socialtjänsten. [19]

Utbildningsdepartementet

Ett nationellt mobilförbud i de obligatoriska skolformerna och fritidshemmet. [9]

