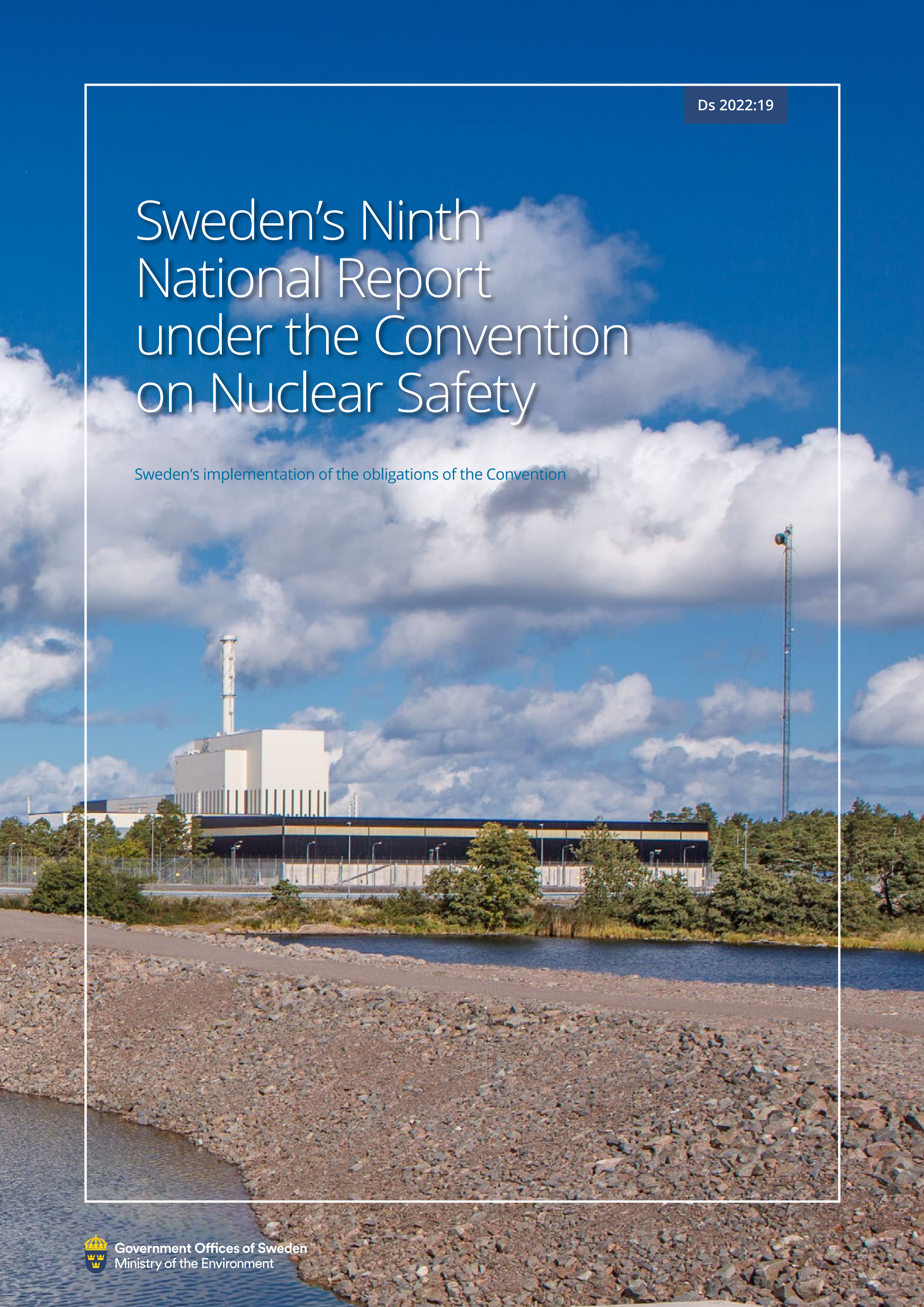
Ds 2022:19

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

Sweden's implementation of the obligations of the Convention



Government Offices of Sweden
Ministry of the Environment

SOU och Ds finns på regeringen.se under Rättsliga dokument.

Svara på remiss – hur och varför
Statsrådsberedningen, SB PM 2003:2 (reviderad 2009-05-02).
Information för dem som ska svara på remiss finns tillgänglig på regeringen.se/remisser.

Omslag: Oskarshamn NPP, Jann Lipka/Strålsäkerhetsmyndigheten
Grafisk formgivning: Granath
Tryck och remisshantering: Elanders Sverige AB, Stockholm 2022

ISBN 978-91-525-0452-9 (tryck)
ISBN 978-91-525-0453-6 (pdf)
ISSN 0284-6012

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Foreword

Foreword

Sweden's ninth national report has been issued in compliance with the provisions of Article 5 of the Convention on Nuclear Safety (CNS). Sweden signed the Convention on 20 September 1994. The Convention was ratified one year later, on 11 September 1995, and entered into force on 24 October 1996.

The first national report on Swedish implementation of the obligations under the Convention was issued in August 1998. Subsequent national reports were issued in August of the years 2001, 2004, 2007, 2010, 2013, 2016 and 2019. All these reports are available from the CNS website as well as from the website of the Swedish Radiation Safety Authority (www.ssm.se). The reports were the subject of discussion at review meetings held in 1999, 2002, 2005, 2008, 2011, 2014 and 2017.

The 8th review conference, originally planned to be held in March 2020, was postponed as a consequence of the Covid-19 pandemic and eventually merged with the 9th conference, planned for March 2023. The present report is an update of the 8th CNS report issued in 2019, and it reflects developments since the 7th report issued in 2016.

The Swedish Radiation Safety Authority has been assigned by the Government of Sweden to coordinate preparation of this national report. The report was produced by a working group comprising representatives of the regulatory body, i.e. the Swedish Radiation Safety Authority, together with representatives of the licensed operators of nuclear power plants in Sweden.

The present report is structured in accordance with Convention guidelines and other recommendations. To provide the reader with a frame of reference and an introduction, Chapter 1 includes basic facts and information about the Swedish nuclear power programme. Chapter 2 includes a summary of the report and additional comprehensive information. It also includes a summary of highlights and issues raised in relation to Sweden during the seventh review meeting, held during the period 24 March–4 April 2017. Additionally, this chapter provides an overview of the issues Sweden was requested to account for in its eighth national report. Chapter 3 provides facts and information, Article by Article, to substantiate compliance with the obligations of the Convention. The reporting on Articles 6, 14, 18, 19 and the summary contain specific paragraphs regarding implementation of Vienna Declaration on Nuclear Safety (VDNS) principles, in consideration of a special letter and advice issued by the president of the eighth review meeting. Altogether, this information provides evidence demonstrating compliance with the obligations of the Convention on Nuclear Safety.

The seventh review meeting of the contracting parties to the Convention on Nuclear Safety resulted in a number of topics to be considered while preparing national reports for the eighth review meeting. The topics are to be reflected upon and the results presented in the report.

The general conclusions regarding Sweden's compliance with the obligations of the Convention are provided in the Summary and in Chapter 3, Article 5.

The present national report covers the period March 2016–February 2022.

The report is designed for good screen readability. This increases its accessibility, while also reducing the need to make a printout. This is beneficial from an environmental aspect.

Executive Summary

The national reports for the review meetings are developed in response to Article 5 of the Convention, which call for a self-assessment of 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 nuclear power reactors were designed in the 1970th and 1980th and have since the original design and constructions been periodically modernised and reassessed to ensure compliance with the current design basis and to further improve safety as well as to prepare for long term operation. In 2015, decisions were taken by the plant owners to phase out the four oldest operating nuclear power reactors during the period 2017–2020. Two of these reactors were shut down permanently during the period 2017 – april 2019, and the remaining two during the current reporting period. The plant owners decisions were based on the overall business and energy market situation and other circumstances over the past few years.

There are currently six nuclear power reactors in operation in Sweden. The four permanently shut down reactors will not be included in this reporting.

From the perspective of political developments, the Government prepared an invitation following the 2014 election to parties across the Parliament to participate in a special energy commission to agree on long-term energy policy. The multiparty Energy Commission, whose members in June 2016 announced an overall agreement on Swedish energy policy, published its final report on 9 January 2017. The agreement included the aim of 100 % renewable electricity production by 2040 which does, however, not preclude the operation of nuclear reactors after 2040. The agreement also confirmed the existing legislation allowing new nuclear power reactors to be built at existing reactor sites to replace existing and closed reactors, and that there is no end date for nuclear energy in Sweden. Furthemore, a special tax on electrical power produced in nuclear reactors was eliminated.

An investigation into a revision of Swedish nuclear legislation has been performed following the Government's authorisation in June 2017. An appointed investigator assisted by an expert committee with representatives from the Government Offices, regulatory authorities, the industry, and non-governmental organisations were involved in the investigation. In early April 2019, a report was delivered to the Swedish Government in which a proposal is made to have the Act on Nuclear Activities (1984:3) repealed and replaced by a new act with a new structure.

A overhaul of SSM's regulations promulgated in the SSM Code of Statutes, SSMFS, began in late 2013. The first of the new regulations are finalised and entered into force in June 2018. By 1 March 2022, key regulations governing nuclear power reactors entered into force.

A full scope IAEA IRRS mission to Sweden was performed in February 2012. The Government subsequently requested a follow-up IRRS mission, which was performed in April 2016. The outcome of the follow-up mission was that two out of 22 recommendations given to Sweden in 2012 remained open, signifying that work remained to be done. A general conclusion of the IRRS team was that they were satisfied with the approach of Sweden to address the findings and work on closing the remaining recommendations. The next IRRS mission scheduled for Sweden is in the fall of 2022.

No major events implying serious consequences for safety at Swedish NPPs have occurred during the review period. However, a few events have occurred which have importance in relation to fuel cladding or containment integrity. For example, reactor containment liner leakage and an internal leakage between drywell and wetwells have been detected and identified during a regular integrated containment air tests during annual outages.

Important measures identified by the EU stress test National Action Plan (NAcP) include measures for meeting new requirements for robust and functionally independent core cooling. The purpose of these measures is to increase the reliability of core cooling in a NPP by introducing a new and alternate independent function. Thus, SSM decided in 2014 that any nuclear power reactor in operation at 2020 must have functionally independent core cooling system (ICCS) capabilities in place. At the time of the eights report, temporary safety measures to increaseing the independence of existing core cooling systems were in place at all plants. By the end of 2020, permanent independent core cooling systems were installed at all reactors in continued operation in Sweden.

Following decisions taken by the plant owners to permanently shut down four reactors, licensees in Sweden were facing new challanges in the area of human resources as well as the overall safety strategies. Decommissioning is now ongoing, in different stages, at three sites. Various approaches are applied by the licensees to preserve, develop and strengthen the safety culture, and to ensure that safety, including measures for radiation protection, is properly maintained.

The closure of the four oldest reactors, less maintenance and fewer large projects involving reactor systems, and concerted efforts to improve radiation protection conditions in the work environment resulted in substantially lower average collective dose per year and reactor. The work to lower individual radiation doses has also been successful. During the reporting period only very few NPP staff received radiation doses exceeding 10 mSv. Special projects have inter alia focused on education and training and measures to adhere the new dose limit for the lens of the eye.

In the area of emergency preparedness, the regulations contain new rules for logistics centres and provisions concerning the ability to receive aid and support from external organisations. Changes have also been made to the structure of the regulations and some requirements were moved to new over-arching general safety regulations in SSMFS 2018:1. A number of new monitoring stations have been installed around the nuclear power plants in Sweden. The new stations will provide information on dose rates at 90 locations around the Swedish nuclear power plants. The licensees have also devoted efforts to the area of severe accident management guidelines (SAMG) and improvements to existing procedures, and new procedures for extraordinary situations at Swedish NPPs are in place, including procedures and guides on managing accidents affecting more than one unit at a site.

At the seventh review meeting, Contracting Parties decided that the fulfilment of the principles and practical implementation of the VDNS should be specifically considered while preparing national reports for the eighth review meeting. For this reason, practical measures regarding implementation of principles of the Declaration are briefly discussed in Chapter 2, and are presented in detail in Chapter 3, Articles 6, 14, 18 and 19 of this report.

1. Introduction

1.1. National policy

1.1.1. Current role of nuclear power in Swedish electricity production

Total electricity production decreased during 2020. Net production amounted to 160.9 TWh, a decrease of 2.9 percent compared to 2019.

Electric power generated in Sweden surpassed domestic consumption. This meant Sweden had a net surplus of 25.0 TWh on its international electricity exchanges. Sweden has had a surplus of electricity since 2014 on an annual basis.

In 2020, windpower production increased by 38.7 percent to 27.5 TWh. Hydro-power, including pumping, increased by 10.7 percent to 71.9 TWh. Conventional thermal power decreased by 16.9 percent to 13.1 TWh. Nuclear power decreased by 26.5 percent to 47.3 TWh. Solar power contributed with 1.0 TWh, an increase of 56.1 percent compared with 2019.

The net electricity generation from the various production resources was in 2020 distributed as presented in the figure 1.

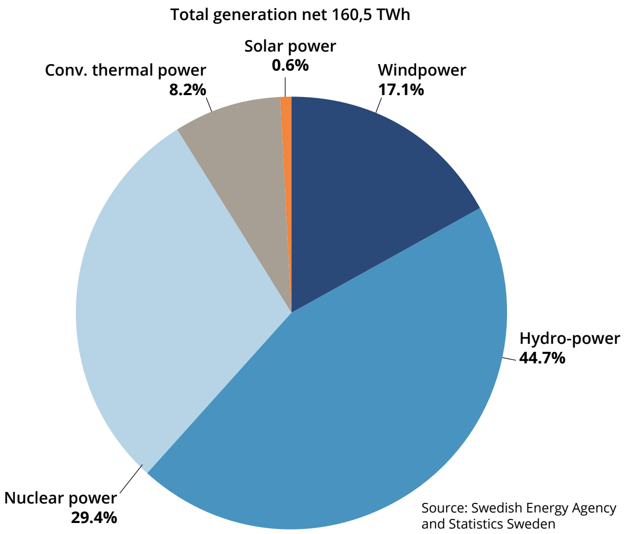

Figure 1. Power generation 2020 by type of power, percent.

The Swedish electric power market has been deregulated since 1996. Trading of electricity is managed on the Nordic marketplace, Nord Pool, which offers trading, clearing, settlement and associated services in both day-ahead and intraday markets across nine European countries. The national high voltage grid is managed by a state authority, Svenska Kraftnät. Regional and local grids are operated as regulated monopolies by various grid companies.

1.1.2. Political developments regarding use nuclear Energy

After the 2014 election, the Government invited parties across the political aisles in Parliament to participate in a special energy commission to agree on long-term energy policy. The multiparty Energy Commission announced an overall agreement on Swedish energy policy in June 2016, and published its final report on 9 January 2017 (SOU 2017:2 in the Government Official Reports series). The main points relating to nuclear energy in the report were:

- The target by 2040 is 100 per cent renewable electricity production. This is a target, not a deadline for banning nuclear power, nor does it mean closing of nuclear power plants through political decisions.
- New nuclear power reactors may be built at existing reactor sites to replace existing and closed reactors. The total number of Swedish nuclear power reactors at any time is limited to 10. Nuclear power reactors may operate beyond 2040; consequently, there is no end date for nuclear energy in Sweden. Central government support for nuclear power, in the form of direct or indirect subsidies, cannot however be assumed.
- The tax on installed reactor capacity was decided to be entirely removed over a period of two years. The Government has thereafter abolished the tax on nuclear reactor capacity with the intent of introducing a compensatory increase in the tax on electricity, though with an exemption for electricity-intensive industry.

The report also stated that Nuclear operators should have full liability for a radiological accidents and that the insurance coverage should triple, from about 4 billion SEK to about 12 billion SEK (1,2 billion Euro), in accordance with the Paris Convention on Third Party Liability in the Field of Nuclear

Energy. In December 2021, Sweden ratified the 2004 Protocols to amend the Paris Convention on Third Party Liability in the Field of Nuclear Energy and the Brussels Supplementary Convention. This was later implemented in the national legal framework through the Act on Liability and Compensation for Radiological Accidents (2010:950), that entered into force on 1 January 2022.

In december 2019 several political parties that initially supported the above mentioned agreement on Swedish energy policy announced that they would withdraw their support and seek support for a new agreement on Swedish energy policy.

In June 2017, the government appointed an inquiry chair to review theAct on Nuclear Activities. The aim of the inquiry was to carry out a review of the nuclear safety law to ensure that the legal framework will provide an effective and sound base ensuring high level of nuclear safety to protect workers and the general public against the dangers arising from ionizing radiations from nuclear installations. The report has been delivered to the government and is, at the time of reporting, being handled by the Government Offices.

In recent years, major changes have also been made to the regulations on financing of the residual products of nuclear power. The main purpose of the changes is to create more clarity in the legislation and improve the financial security of the state.

1.2. National nuclear power programme

1.2.1. 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 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 nuclear power plant (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 nuclear power plant, Oskarshamn unit 1, was commissioned in 1972. Between 1974 and 1985 another eleven nuclear power reactor units were taken in to operation, at the sites in Barsebäck, Oskarshamn, Ringhals and Forsmark. The twelve commercial reactors built in Sweden comprise nine BWRs (ASEA-Atom design) and three PWRs (Westinghouse design). As a result of political decisions, the BWR units Barsebäck 1 and 2 were shut down permanently in 1999 and 2005, respectively. In 2004, Studsvik Nuclear AB decided to shut down the two remaining research reactors at the Studsvik site. The Studsvik research reactors were closed in June 2005 and the decommissioning will be completed in 2019.

An application for a licence to construct, own and operate a nuclear facility consisting of one or two nuclear power reactors with adjacent facilities was presented to SSM in July 2012. At that time the applicant, Vattenfall, considered replacing the two oldest units at Ringhals by one or two new units. However, in late 2014, Vattenfall informed SSM that all ongoing work relating to plans for new builds of nuclear reactors had been put on hold.

During the autumn of 2015, at extraordinary shareholders' meetings of RAB and OKG, decisions in principal were taken to phase out the reactors Ringhals units 1 and 2 and Oskarshamn units 1 and 2. The decisions were taken based on to the overall business and energy market situation, existing taxes, and SSM's requirements for operation beyond 2020. The owners of RAB decided at the time that operation of Ringhals unit 2 would end in 2019 and that operation of Ringhals unit 1 would end in 2020. As a consequence, all major investments in these two units were cancelled, though all necessary measures for maintaining safety were implemented until the reactors were taken out of operation. Subsequently, a new and important mission for the concerned utilities OKG and RAB, has been to ensure safe and effective decommissioning of the permanently shut down units.

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.

The Swedish licensee have implemented safety measures through relevant modifications and, in some cases, by means of comprehensive modernization projects. For example, after the accident in Three Mile Island in 1979, severe accident management systems (including Filtered Containment Venting System, FCVS) were introduced at the Swedish NPPs. Also, extensive modernization programmes were introduced in 2005 and completed in 2015 for all Swedish NPPs in order to meet new requirements issued by the regulator in 2004. In summary, the safety measures implemented as a result of the new regulations in 2004 mainly 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 and or upgraded instrumentation and control equipment.

Furthermore, safety improvements have also been identified through international reviews such as the now completed EU stress test National Action Plan (NacP).

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 installations of the systems are at the time of this report completed. The new systems were taken into operation during the second half of 2020.

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	1800	615	BWR	Barsebäck	1970	1975–1999
Barsebäck 2	1800	615	BWR	Kraft AB	1972	1977–2005
Forsmark 1	2928	984	BWR	Forsmarks	1971	1980
Forsmark 2	3253	1120	BWR	Kraftgrupp AB	1975	1981
Forsmark 3	3300	1167	BWR		1978	1985
Oskarshamn 1	1375	492	BWR	OKG Aktiebolag	1966	1972–2017
Oskarshamn 2	1800	661	BWR		1969	1975–2015
Oskarshamn 3	3900	1450	BWR		1980	1985
Ringhals 1	2540	910	BWR	Ringhals AB	1968	1976–2020
Ringhals 2	2660	966	PWR		1969	1975–2020
Ringhals 3	3144	1117	PWR		1972	1981
Ringhals 4	3300	1171	PWR		1973	1983

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.

1.2.2. Nuclear power installations in Sweden

As of February 2022, Sweden has six nuclear power reactors with an operational licence, as specified in Table 1 above. Seven nuclear power reactors have been permanently shut down, namely Ågesta, Barsebäck unit 1, Barsebäck unit 2, Oskarshamn unit 1, Oskarshamn unit 2, Ringhals unit 1, and Ringhals unit 2.

All Swedish BWRs including Ågesta PHWR were designed by domestic vendor ASEA-Atom (later merged into ABB Atom, further Westinghouse Electric Sweden AB), and all Swedish PWRs were designed by Westinghouse Electric Company (USA). The maximum power level of the operated reactors has been uprated between 6 % and 38 % from the original licensed power levels (see section 6.3). An overview of the current situation and the main data for nuclear power installations in Sweden are shown in Table 1. Figure 2 shows the geographical locations of Swedish nuclear facilities, all of which are situated in the southern half of Sweden.

Considering the ageing of the Swedish nuclear reactor fleet, work on implementation and development of comprehensive ageing management programmes at the nuclear power plants has been ongoing since specific requirements regarding ageing management and long term operation were originally introduced in the national regulations in 2005. In recent years, activities regarding ageing management have been intensified, and the preparations for long term operation for reactors facing the end of their original design lifetime in the near future, typically 40 years, have been intensified.

1.2.3. Ownership and staffing

Ownership of Swedish nuclear power plants is characterized by a large extent cross-ownership, as shown in figure 3. The key players in the nuclear power sector in Sweden are mainly large power companies such as Vattenfall AB, Sydkraft Nuclear Power AB, and Fortum Generation AB.

The respective workforces at the different sites vary in number of employees depending on the plant situation in terms of the operational status for the units. The number of employees is declining at the Oskarshamn and Ringhals sites. This was also previously the case at Barsebäck NPP. Workforces present at Swedish nuclear power plants in 2021, together with trends compared with the years since 2015, are presented in Table 4 of section 11.2.2.

1.2.4. Support organisations of owner and licensees

Swedish nuclear power plant operators jointly own the following support organisations:

– KSU AB (Nuclear Safety and Training): provides operational training, including simulator training, on a contractual basis to all Swedish nuclear power plants. 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 nuclear power plants.
– Norderf (formerly ERFATOM): formed by Swedish and Finnish NPP operators, KSU and SKB with the aim to proactively monitor predetermined trends and deviating results, and carry out experience feedback

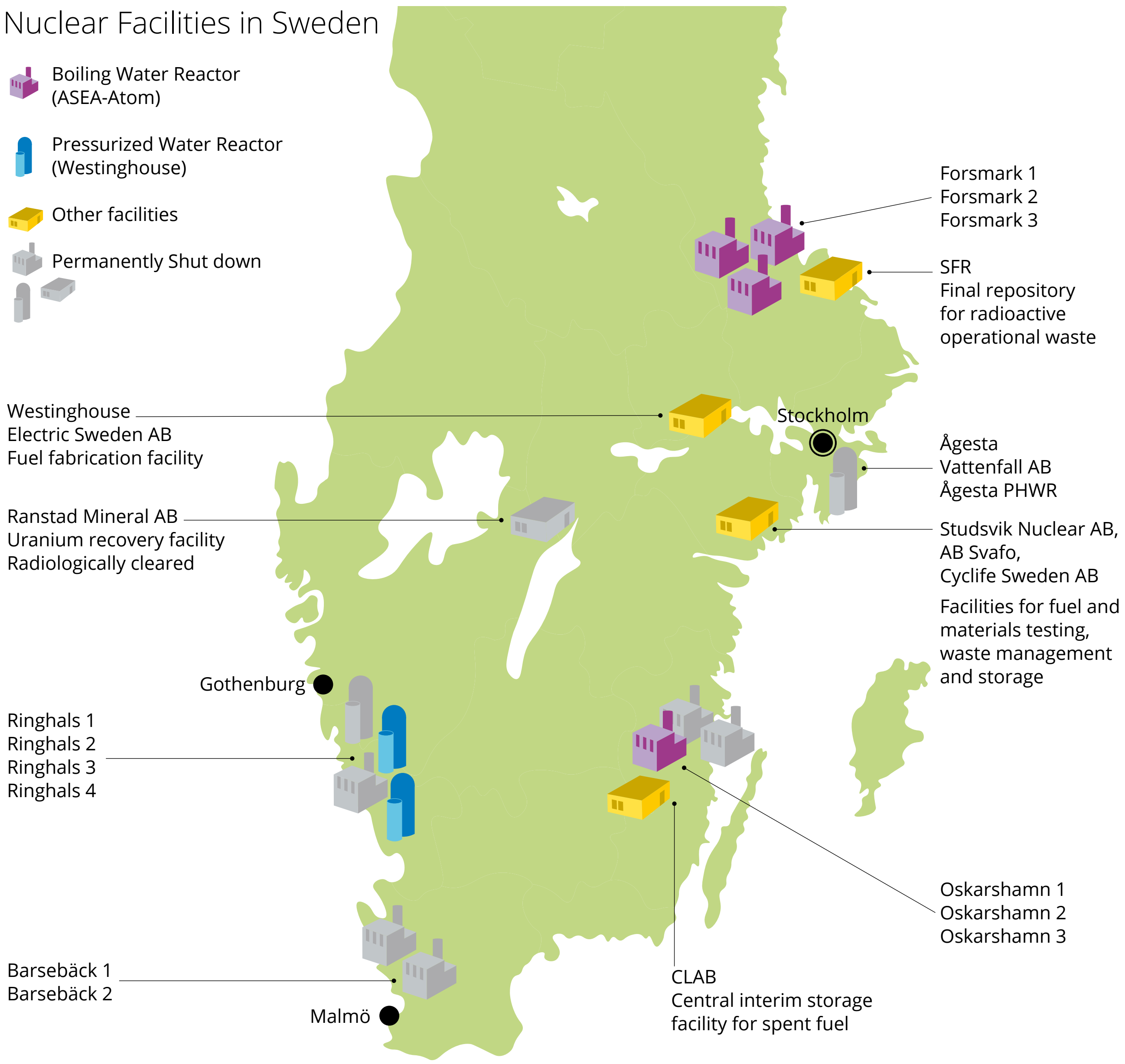

Figure 2. Locations of nuclear facilities in Sweden.

analysis of 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 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 R&D work in connection with the technical concept and location of the final repository for spent fuel, including the Äspö Hard Rock Laboratory and canister laboratory at Oskarshamn. SKB has applied for the construction and operation of a final repository for spent nuclear fuel, which the Government decided to approve on 27 January 2022.

– Svafo is a non-profit company, originaly established to be responsible for coordinating and managing legacy waste - primarily from government research activities. Currently Svafo is tasked to decommission nuclear facilities from previous research and development activities in Studsvik, among other places, and to temporarily store decommissioned waste and waste from the research period until final disposal can be carried out. Its operations are financed by the Nuclear Waste Fund to which owners of the four nuclear utilities pay fees.

1.2.5. 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 Buisness Partners L.P. under the name Westinghouse

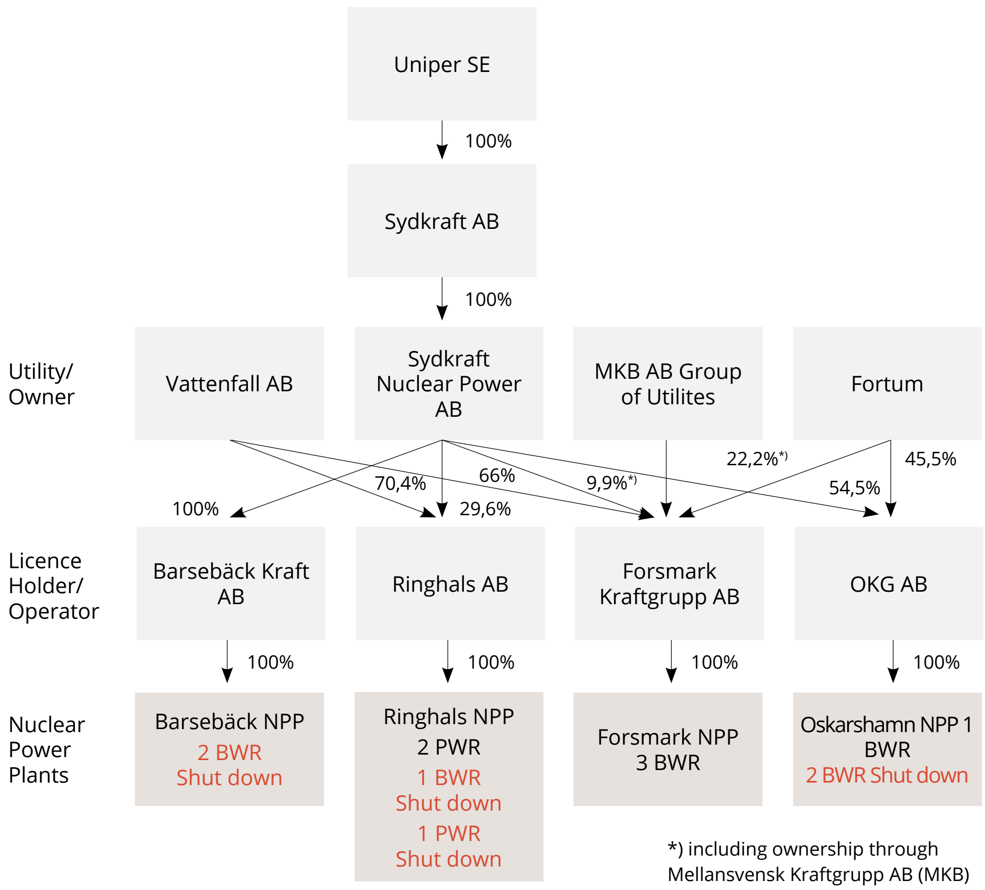

Figure 3. Utility and ownership structure 2021.

Electric Sweden AB. Other active vendors on the Swedish market are Framatome, Westinghouse, GE Hitachi Nuclear Energy, GE, Siemens, and Alstom.

Studsvik AB is a contractor for materials testing and nuclear fuel investigations. Studsvik AB operates a hot-cell laboratory for fuel investigations. The company also provides decommissioning and waste treatment services.

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

1.2.6. Nuclear waste

Operational radioactive waste is generated by nuclear reactors and fuel cycle facilities, such as Studsvik AB's facilities at Studsvik and Westinghouse Electric Sweden AB's fuel fabrication plant located in Västerås. Radioactive waste also originates from medical and research institutions, industry and consumer products. The radioactive waste produced during infancy of the Swedish civil nuclear industry's development, is safely stored at the Studsvik site or has already been disposed of in the Final Repository for Short-lived Radiactive Waste.

In total, the Swedish nuclear power programme is expected to generate approximately 20.000 m^3 (12.600 tonnes) of spent fuel, 155.000 m^3 of short-lived low and intermediate level waste (LILW) from operations and decommissioning, and 15.000 m^3 of long-lived LILW. The assumption is based on 60 years of reactor operation, with the exceptions of Ringhals units 1 and 2 which were expected to be operated for 50 years and the actual years for the permanently shut down reactor units. Total annual production of LILW at the nuclear facilities is usually around 1.000–1.500 m^3.

The national waste programme includes the waste treatment facilities at Studsvik, the Final Repository for Short-lived Radioactive Waste at the Forsmark site (SFR), shallow land burials at the nuclear power plant sites in Forsmark, Oskarshamn and Ringhals and at Studsvik, the Central Interim Storage Facility for Spent Nuclear Fuel at Oskarshamn (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. 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, a disposal facility for long-lived low and intermediate level waste. SKB in addition plans foran extension of the SFR facility to accommodate also waste. Additional land burials may also be constructed.

Transport of spent nuclear fuel and nuclear waste is done largely by sea, since all Swedish nuclear power reactors and most nuclear facilities are situated along coastlines. The transport system has been in operation since 1982 and consists of a transport ship, transport casks and containers, and terminal vehicles for loading and unloading. In 2013, the new transport ship M/S Sigrid was taken into operation, a custom built vessel for transports of spent fuel and radioactive waste from nuclear power plants to Clab and SFR.

1.2.7. Nuclear education, research and development

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

To ensures the availability of qualified staff and necessary competences in the future, all actors in the nuclear industry in Sweden are working systematically with competency 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 society's competence needs; and the attractiveness of the Radiation Safety Sector.

The three Swedish nuclear power plant licensees, the Swedish Radiation Safety Authority (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 ends in 2023, negotiations regarding terms and conditions for the next operating period will be initiated by the end of 2022. In 2020, SSM resumed its cooperation with SKC as well as its SKB board membership.

When SKC was set up in 1992, there was a decision pending on closure of nuclear power plants, and student enrolment in nuclear studies was very low. At that time, the industry and the regulatory authority faced similar challenges in competence development in general and staff renewal in particular. Thirty years later, similar challenges will face Sweden in terms of maintaining sufficient competence for safely operating 6 remaining reactors. Unlike 1992, enrolement in nuclear studies is currently relatively high.

There is currently only one Master programme on Nuclear Engineering in Sweden and this is the TNEEM programme which was established in 2007 at KTH Royal Institute of Technology. It is at the same time a regular Master programme and an international educational collaboration. Students enrolled in courses given in the programme can be either enrolled in the TNEEM programme, or join the programme through the European Master in Nuclear Engineering (EMINE), or though several double degree bilateral agreements that have been established with e.g. Politechnico di Milano, INP Grenoble, Tsinghua University and KAIST. From all these enrollement paths, the programme graduates around 25 students per year.

In addition to efforts within the SKC to maintain and secure necessary competence, SSM also provides financial support for basic and applied research as well as the development of methods and processes to a number of Swedish universities as well as relevant reaserch intsitutes. SSM have also recurrently received Government assignment to investigate staffing and competence needs over the long term among all stakeholders in the Swedish nuclear sector. The last assignment was reported to the Government in 2018.

A large research programme on development of lead-cooled SMR technology has been launched in 2021. The first step in this programme was the establishment of the SUNRISE centre, hosted by KTH Royal Institute of Technology and joining Uppsala University and Luleå University of Technology, as well as a large number of industrial and societal partners, including SSM in an advisory role. The major industrial partners in SUNRISE are Westinghouse, Leadcold and Sandvik, while most companies in the nuclear and nuclear materials sector in Sweden are in the advisory committee of the centre. SUNRISE aims to design and prepare for licensing of a lead-cooled research and demonstration reactor, and includes work on materials development, fuel development, process development, code development and safety studies. The second step in the larger research programme is the Solstice project, which is funded by the Swedish Energy Agency, and in which Uniper, Leadcold, their joint venture company SMR AB and KTH Royal Institute of Technology are designing, building and working with an electrically heated advanced test facility which in many aspects is a mock-up of the proposed research and demonstration reactor, as well as of the Leadcold commercial concept SEALER-55.

The industry and University partners have also formed a centre of excellence, called ANITA, for research on SMR technologies, with focus on light water SMR technology. The participants are Vattenfall, Fortum, Uniper, and the nuclear power specialists Westinghouse and Studsvik, 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 one-third of the total funding for the centre.

Vattenfall

Vattenfall has provided joint funding for a new bachelor's degree programme on nuclear power at UU which started in 2019. Moreover, long-term cooperation is established between the nuclear industry and UU for training staff in nuclear technology and radiation protection within NANSS (Nordic Academy for Nuclear Safety and Security). This effort has also resulted in improved education and closer exchange between students and the industry, because places not used by industry are filled by university students.

Moreover, Vattenfall has been a major partner in KIC InnoEnergy (Knowledge & Innovation Community) during the development of the master's programme EMINE (European Master in Nuclear Energy), where students attend one year in Barcelona or at KTH, and one year in France. Around 20 students graduate annually from the EMINE programme. Discussions are in progress with Chalmers on launching a similar programme.

1.2.8. National industry cooperation

A joint industry initiative was taken in 2013 by forming a coordination group, KSKG (Kärnkraftssäkerhetskoordineringsgrupp), to coordinate critical nuclear safety and security issues (primarily following the Fukushima Dai-ichi accident), EU stress tests on nuclear safety, EU topical peer reviews 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 these licence holders: Forsmarks Kraftgrupp AB (FKA), RAB, OKG, SKB and the owners of the nuclear facilities, i.e. Vattenfall, Sydkraft NP and Fortum.

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

1.3.1. The regulatory body

Through SSM, Sweden is involved in about 150 international working groups. The majority of these groups deal with nuclear safety, and radiation protection issues. 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 and in non-governmental 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 thirteen regulatory bodies in various 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, Germany, Japan, South Korea, Lithuania, Russia, Ukraine, the United Kingdom, and the United States. In addition, Sweden has special agreements with the Nordic countries (Denmark, Finland, Iceland and Norway) regarding emergency preparedness and information exchange.

SSM provided technical expertise to the Swedish government during the development of the new and amended EU directives in the areas of nuclear safety and radiation protection. SSM participates in ENSREG (European Nuclear Safety Regulators Group), an expert advisory group for the European Commission. ENSREG is composed of senior officials from national nuclear safety, radioactive waste safety or 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.

Following the severe accident at the Fukushima Dai-ichi NPP in March 2011, the European Council requested that comprehensive safety and risk assessments should be performed for all EU nuclear power plants. The so called EU stress tests were performed at national level, and supplemented by a European peer review. On behalf of the Swedish government, and with input from the Swedish licensees, SSM developed and published a national assessment report. Furthemore, SSM contributed to this process as a member of ENSREG's stress test peer review board and as a team leader for one of the three topical areas included in the peer review.

In 2017 the first EU topical peer review under the amended EU Nuclear Safety Directive, took place. Ageing management was the topic for this 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.

SSM contributes to the work performed within international conventions in the areas of nuclear safety and radiation protection, such as the Convention on Nuclear Safety and 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, 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 participate actively in the development of the IAEA safety standards, through the membership of the Commission on Safety Standards (CSS) as well as the 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, 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.

ICRP har started a review of its general recommendations on radiological protection in Publication 103, and SSM will take an active part in this work.

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 makes a systematic comparison of national reactor safety requirements and their implementation against jointly agreed reference levels.

1.3.2. 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 aim is to enhance safety at nuclear power plants in the region and improve radiation protection of people and the environment. SSM also works towards increasing awareness about nuclear non-proliferation and strengthening control regimes in the region. The cooperation projects are mainly run together with Russia and Ukraine, though certain projects are also run together with Georgia, Moldova and Belarus. In 2020 SSM received a government assignment to analyse possibilities for a cooperation programme with Armenia, but due to the Covid pandemic, the bilateral cooperation has been delayed. The situation after the Russian invasion of Ukraine in 24 February 2022 will have a major impact on cooperation in the region.

The programmes are based on Government decisions, with financing provided by the Ministry of the Environment, the Ministry for Foreign Affairs, and Sweden's International Development Cooperation Agency. The total budget is approximately 35 million Swedish krona per year.

1.3.3. 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 WANO,in owner's group associations of major European and US vendors, through EPRI and by participation in the Foratom initiative European Nuclear Installations Safety Standards, the European Utilities Requirements project as well as through cooperation with IAEA and and OECD/NEA and participation in IAEA activities. Both Vattenfall and Sydkraft Nuclear Power have direct membership in WANO.

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

Swedish nuclear licensees participated in the 2011 EU stress test and in the 2017 EU Topical Peer Review on Ageing Management. They supported the development and updates of National Report and National Action Plans, through these peer review processes.

Swedish nuclear licensees participate in European Nuclear Installations Safety Standards Initiative, ENISS. ENISS has representation from 19 European nuclear power companies and licensees from 16 countries. The primary objective of ENISS was to create a forum for the European nuclear operators to prepare common positions for WENRA consultation processes. For example, ENISS participated actively in the consultation process for the WENRA study, "Safety Objectives for New Power Reactors", and the review of the 2014 update of the WENRA Safety Reference Levels, as well as the Guidance Documents related to that update, i.e., WENRA Guidance Documents on Design Extension Conditions (Issue F) and Natural Hazards (Issue T). Another task of ENISS is to review new or revised IAEA Requirements and Guidelines, TECDOCs and the Safety Glossary. From this aspect, ENISS has adopted a coordinating role in the European industry's contacts with the IAEA. This means that European nuclear utilities can join the IAEA revision process at an earlier stage than was previously the case.

In February 2019, Vattenfall nuclear sector received full membership of the Electric Power Research Institute, EPRI. This organisation offers support, often based on best practices, in many important nuclear areas. EPRI conducts research on materials management, fuel and chemistry, plant performance and strategic initiatives to support safe, reliable, cost-effective and environmentally friendly use of nuclear power. This is done by means of global collaboration conducted together with nuclear power plant operators, regulatory authorities, and other research organizations. The membership gives Vattenfall the potential to maintain existing and develop new competences as well as the possibility to follow the latest development in important areas of interests.

2. Summary of the development since last national report

2.1. Highlights and issues in the discussion about Sweden at the seventh review meeting held in 2017

Observations and aspects which were highlighted and documented by the rapporteur during the discussions of the CNS Review Meeting regarding the seventh Swedish national report, led to the following challenges presented in country report. A short summary on progress done since seventh review meeting is also presented below.

Challenge SE-2014-05: Ensuring safe long-term operation of Swedish NPPs requires additional safety improvements and licensee applying an effective ageing management (remained open).

In the latest years, the preparations for long term operation (LTO i.e. more than 40 years of operation) has been intensified. SSM requires an integrated programme for management of degradation due to ageing. Long term operation (LTO) is not formally defined in Swedish legislation or associated regulations, instead the term "continued operation" has been suggested. The requirement on establishment of an ageing management programme is applicable to all reactors in operation, regardless of age. SSM recognizes the fact that the reactors were originally designed for an operating time of 40 years, with LTO used as a term to designate operation in excess of 40 years. Since the last CNS report, SSM has defined a position regarding LTO which states that that the main process for supervision in regards of LTO will be within the framework of the PSR reviews.

The licensees have developed overall ageing management programmes (AMP), by compiling information from already existing programmes, such as maintenance, component qualification, in service inspection and chemistry programmes. These programmes compile a lot of experience gained from the operation of the plants as well as external ageing related experience.

To have international experience and aspects included in the overall ageing management programmes, all licensees have made use of the IAEA SALTO or pre-SALTO reviews, which were important steps in both the technical details of managing ageing issues, as well as a in creating a companywide awareness of the necessities and requirements related to operating the plants beyond its original design life. Furthermore, Sweden participated in the first EU Topical Peer Review process on managing the ageing of nuclear installations.

Through supervision, SSM has found deviations in some of the plants aging management processes, and has requested improvements and relevant measures to be implemented by the licensees. Follow-up reviews and inspection have been conducted to control that the measures taken by the licensees have the intended effect. Results from these inspections are described in Sweden's EU Topical Peer Review on ageing management.
More details are available and described in section 14.3.5.

Challenge SE-2017-01: Implementing an approach, consistent with the government assignment, to sustain and develop capability in both the regulatory body and licensee (including sustaining support such as R&D and suppliers) given the plan to shut down some NPPs and the need to develop additional capability in technical and radiological aspects of the decommissioning area.

As presented in section 11.4., in September 2018 SSM submitted a government assignment on the national long-term competence supply in the field of radiation safety to the government. The report to the Government shows that there are challenges and shortcomings in the supply of skills in the radiation safety area in Sweden. It includes several suggestions covering the areas of knowledge management, funding provided to the critical core of research environments, and identification of education programmes critical importance to society in the field of nuclear safety and radiation protection.

In addition, recommendations were given to employers and to the industry within the field to attract students so that they enrol in nuclear safety and radiation protection programmes, and to manage research funding to guarantee that the relevant research environments will be sustained.

Since September 2018, some progress has been made and the industry have carried out recruitment campaigns to attract young employees. Additionally, SSM is reforming its work to strengthen the national strategic perspective on long-term knowledge management.

Challenge SE-2017-02: Maintaining and overseeing safety culture during the transition from operation to decommissioning.

Following the decisions on permanent shutdown of four reactors, the licensees concerned are facing new tasks to take measures and set up strategies in order to ensure that safety is maintained throughout the decommissioning process. In this respect preservation of safety culture is an important aspect, which needs to remain in focus of both the licensees and the regulatory body, and numerous activities were started and are currently ongoing.

In order to maintain continuity in the work with, and implementation of safety culture throughout the decommissioning process, the licensees developed action plans or special projects. These plans and projects address safety-related activities that the management prioritises in order to maintain, develop and strengthen the safety culture, and to ensure that safety and radiation protection standards are maintained throughout the decommissioning process.

Various approaches have been used by the licensees concerned, including new safety promoting work methods, experiences exchanges (benchmarks) with other organisations, and projects for preparing for decommissioning.

Safety culture workshops and surveys were also performed in order to identify and discuss safety culture challenges related to transition to decommissioning.

SSM focus areas has been the licensees' competence provision and staffing, considering the challenges the licensees have in retaining personnel and hiring new staff now and in the near future. SSM has formed a cross-organisational team to carry out the strengthened supervision, and to ensure that the licensees are continuously followed.

One further area that has come into focus is the issue of the relationship between national culture and nuclear safety culture. A Country-specific Safety Culture Forum (CSSCF) was 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 national attributes can influence nuclear safety culture. SSM was involved in the development of this forum and hosted the very first CSSCF in January 2018. Representatives from both the regulator and the industry participated in the workshop on national safety culture.

Section 12.2.1 and 12.4.1 contains more details and description of the activities performed.

Challenge SE-2017-03: Completion of the remaining work to update the set of regulations, including consideration of the requirements from EU Directives and WENRA reference levels.

On 15 June 2017, the Swedish Parliament (Riksdagen) 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. At the same time, several regulations of the Swedish Radiation Safety Authority were amended to transpose other provisions of the directive.

As presented in section 7.2.2 of the report, a major review of SSM's Code of Statues, SSMFS, is under progress. In May 2018, the first part of the new Code of Statutes, concerning nuclear activities, was decided. This part (SSMFS 2018:1) includes regulations on basic rules for all licensed activities involving ionising radiation. The regulations also transpose provisions of Council Directive 2013/59/Euratom, which have not been included in the new Radiation Protection Act. The regulation SSMFS 2018:1 came into force on 1 June 2018 and regulations on nuclear power reactors in operation entered into force 1 March 2022.

In preparing SSM's new Code of Statutes, consideration is also given to all relevant IAEA standards as well as to the WENRA Safety Reference Levels.

2.2. Significant changes to the National Nuclear Programme

2.2.1. Licensee

During the review period two nuclear reactors units at Ringhals site were permanently shut down. The owners of RAB decided in 2015 that operation of Ringhals unit 2 would end in 2019 and of Ringhals unit 1 in 2020. In consequence, all major investments for these units were cancelled, but all necessary measures to maintain safety were taken until they are decommissioned. Ringhals units 3 and 4 will remain in operation, with a planned lifespan of 60 years, i.e., into the 2040's.

2.2.2. Regulatory programme

Pursuant to Government's authorisation in June 2017, the Ministry of the Environment and Energy appointed an inquiry chair to conduct a review of the national nuclear legislation. Additionally an appointed expert committee with representatives from the Government offices, regulatory authorities, the industry and non-governmental organisations was established to assist the inquiry chair. In April 2019 the inquiry chair delivered a report (SOU 2019:16) to the Swedish Government where it is proposed that the current Act on Nuclear Activities will be repealed and replaced by a new act with a new structure.

Most of the substance of the present provisions is transferred to the new act, but sometimes with revised language. Some provisions are suggested to be modified and others deleted. A few completely new provisions are also suggested to be added.

A summary of the most important proposals from the inquiry is presented in section 7.1.2.

2.2.3. Regulatory body

SSM is currently revising its Code of Statutes related to nuclear activities and radiation protection. Experience has demonstrated the need to clarify and broaden the regulations in order to create more predictability for the licensees and to improve the regulatory support.

The major review of Codes and Statutes, SSMFS, began in late 2013. In the early stages of the work, a decision in principle was taken stating that the aspects of radiation protection, nuclear safety and security to a greater extent than previously should be regulated in an integrated manner. The new structure that was decided signifies regulation of radiation safety (i.e. radiation protection, nuclear safety and security) at nuclear facilities for different phases of a facility's lifetime and for different main types of substantive issues (see section 7.2.2). Considering the relatively large change to structure and content as well as to the regulatory approach, SSM decided to apply a multi-step process during the development process. Thus, the first parts of the new Code of Statutes entered into force in in June 2018, and regulations on nuclear power reactors in operation entered into force 1 March 2022.

An additional challenge for the regulator was the Government's decision in August 2017 to relocate SSM's headquarters from Stockholm to Katrineholm by the end of 2018. Starting from October 2018, SSM has located parts of its operations in the new offices. In addition, SSM also opened a branch office in Gothenburg.

SSM was reorganised during 2021 to increase transparency and separation of licencing, supervision and regulation.

2.3. IAEA IRRS mission and other IAEA peer-reviews

A full-scope IAEA IRRS mission to Sweden was performed February 2012 and the resulting recommendations have been addressed, on behalf of the Swedish Government, by SSM in an action plan. A follow-up mission took place in April 2016.

The general conclusion from the 2016 IRRS follow-up team was that they were satisfied with the approach of Sweden to address the findings of the 2012 IRRS mission and to improve on the regulatory system for nuclear safety. However, two of 22 recommendations originally given by the IRRS team were judged still to be open. The two recommendations refer to:

- Provisions to maintain competence for nuclear safety and radiation protection on a national level, and
- The systematic evaluation of operational experience from non-nuclear facilities and radiation protection events and activities, including dissemination of all significant experience.

The work with these recommendations are still ongoing. Also, the 2016 IRRS follow-up mission resulted in four additional suggestions for Sweden (for more information see section 8.12).

The Government has officially requested IAEA to carry out the next IRRS mission in Sweden, which is scheduled for 2022.

Furthermore, several IAEA SALTO review missions were performed in Sweden during the current and previous reporting periods. In December 2017, IAEA performed a pre-SALTO peer review at Oskarshamn NPP for OKG unit 3. In November 2016 and in June 2019 IAEA performed pre-SALTO reviews at the Forsmark NPP and a full scope SALTO peer review mission at Forsmark NPP in October 2021. In March 2018, an IAEA SALTO peer review mission was performed at Ringhals NPP for unit 3, and a follow-up mission in September 2020.

OKG performed an expert mission(limited SALTO) in December 2019 and will perform a pre SALTO mission in September 2022. OKG is also planning for both a SALTO and follow up mission in the coming years.

The sections 9.2.3.1 and 9.2.3.2 contain more details and description of the activities performed.

2.4. Implementation of Vienna Declaration on Nuclear Safety

Since the previous national report a number of safety related activities in line with the VDNS principles have been ongoing. The most relevant activities are as follows:

- 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 installations of the systems are at the time of this reportcompleted. The new systems were taken into operation during the second half of 2020.
- During this review period, the focus from both the regulatory body and the licensees on the assurance of long-term safety functions and safety barriers through the introduction of extensive work related to ageing issues, has been maintained since the last report. The licensees have subsequently updated ageing management programmes to address the impact of degradations and other ageing related processes on specific safety related components and systems. These activities also relate to the preparation of LTO at the units that will be facing end of their design lifetime, to assure safe continued operation. For this purpose, ageing issues are given considerably increased attention in relation to PSR reporting and review, including reporting on matters related to long-term plant safety status and proof of continued safe operation until the time for the next PSR (see section 14.1.1).
- Operational procedures and improved guides to handle accidents affecting more than one reactor unit at a site have been developed and are in place at all sites. The updates also included improved severe accident management procedures in line with international standards for such procedures. The work was finished at the end of 2020 in the Swedish NPPs.

2.5. Future activities until the next National Report

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 vital importance for further work to ensure that safety and radiation protection are properly maintained.

The Act on Nuclear Activities have been updated regarding the responsibility for the final repository for spent fuel and put in force by January 1, 2022.

A major review of SSM's Code of Statutes, SSMFS, has been completed (see section 7.2.2).

The challenges related to transition from operation to decommissioning will continue to be in focus for all organisations involved and particularly in the area of human resources. The changed work load in total with lower number of employees and with operation and decommissioning in parallel, is a challenge for years to come for both the licensees and the regulatory body.

In order to keep focus on the area of ageing management and LTO, several IAEA SALTO missions has been performed and are scheduled to be performed at Swedish NPPs.

Ringhals performed a follow up SALTO mission for Ringhals 3, also valid for Ringhals 4, in September 2020 and are not planning any further reviews.

Forsmark has done a full scope SALTO mission in October 2021 for Forsmark 1 and 2 and are planning for a SALTO mission in 2023.

OKG performed an expert mission(limited SALTO) in December 2019 and will perform a pre SALTO mission in September 2022. OKG are also planning for both a SALTO and follow up mission in the coming years.

Preparation for the next IRRS mission to Sweden, scheduled for 2022, will be a vital part of SSM's activities during the period, requiring extensive efforts and resources prior to the mission.

Part I General Provisions

3. Compliance with Articles 4 –19 of the Convention

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 the ninth Swedish 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 nuclear power plants during the past six years, 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, safety upgrading already decided, and measures already implemented, is provided in section 18.2. and Appendix 1.

Summary of developments since the last report

During the current review period, the following developments are of relevance with regard to the obligations of Article 6:

– Permanent safety enhancements measures has been undertaken with the installation of an independent core cooling function, designed to fulfill the cooling of the reactor core in case of extreme events, such as a complete loss of electrical power (for 72 hours) or a loss of the normal acess to the ultimate heat sink under extreme (beyond design basis external events) which were previously not covered by the safety analyses.
– The licensees have finalised implementation of major power uprating as the remaining part of the uprate programme for nuclear power capacity in Sweden and all the reactors concerned have resumed commercial operations.

6.1. Significant events since the previous national report

During the current review period, no events occurred indicating a serious degradation of safety and radiation protection at Swedish nuclear power plants. An overview of the most relevant events occurring during the period 2016–2021 is provided below.

Ringhals NPP Leakage through the reactor containment liner (R3)

The containment of Ringhals unit 3 is a concrete structure with a gastight steel liner covered with concrete on both sides. Hence the condition of the steel liner cannot effortlessly be inspected.

During a containment air test (CAT) in 2016 an inspection was performed in the auxiliary building to look for leakage from the concrete structure of the containment. This inspection revealed a leakage through the containment but the origin of this leakage could not be determined. Since the CAT showed that the containment leakage was within the specified limits unit 3 was started up.

An effort to analyse, assess and to perform corrective actions in order to ensure the integrity of the containment was initiated after outage 2016. During outages 2017 and 2018 the steel liner in a few selected areas was inspected at by removing the concrete from the inside of the containment wall. These inspections was carried out with no anomalies found. During outage 2020 the steel liner in an area around the purge air system penetration was inspected. In this area a corroded part of the liner was detected. The corrosion had caused a hole in the liner of approximately 50 mm diameter. The steel liner was then repaired and the concrete was restored. After the reparation of the liner a CAT was performed and any leakage to the auxiliary building could no longer be detected.

The cause of the corrosion was a piece of wood located at the outside of the steel liner. This piece of wood had been accidentally forgotten in connection with the concrete casting during the construction of the containment. The area in question is judged to have been difficult to visually inspect why the piece of wood could have been missed despite the inspection programs carried out during the casting. During outage 2021 additional inspections of the steel liner was performed at similar penetration areas with no anomalies found. The forgotten piece of wood is therefore considered to be an isolated case and no further inspection are to be performed.

Shielding fuel assembly damaged during handling in fuel pit (R3)

During transport of a shielding fuel assembly (SFA) in spent fuel pit during yearly outage 2021 at Ringhals unit 3, the top plate separated from the rest of the fuel assembly as welds holding the sockets between top plate and fuel assembly separated. The fuel assembly placed itself on top of the fuel rack and tipped to the side, leaning against the spent fuel pit wall and a spent fuel pit cooling pipe. The fuel building was evacuated and radiation protection personnel measured the activity in the building, finding that the incident had not caused the release of any radioactivity.

The incident did not result in the release of any radioactivity and the integrity of the fuel rods remained intact. Neither the spent fuel pit cooling or integrity of the spent fuel pit itself were affected by the fuel rod placing itself against them and remain operable. Root cause analysis showed that the welds in SFA fuel assemblies were too weak as a result of a design flaw, eventually leading to a break. The yearly outage was halted until the fuel assembly was moved to a secure position and analyses were complete, resulting in a total unplanned outage extension of 49 days.

Forsmark NPP

At Forsmark NPP unit 2 on November 29, 2019 after pool cleaning, the filter in the pool remediation equipment was to be replaced. A total of five people, two reactor hall mechanics, two radiation protection technicians and one cleaning staff participated. Everyone has approved radiation protection training and a PJB was conducted before the work was started. The area was clearly closed off and two radiation protection technicians were present throughout the work so that no unauthorized persons could be in the area. All personnel had electronic dosimeters with preset alarm levels.

When lifting the filter, the electronic dosimeter began to alarm for the individual who handled the filter, the activity alarm in the ceiling of the reactor building began to alarm shortly afterwards. The electronic dosimeter of one of the radiation protection technicians also began to alarm. These alarms safely interrupted the work.

The event resulted in a maximum individual dose of 1.7 mSv, this should be compared to the annual dose limit of 20 mSv and Forsmark's planning value of 10 mSv per year. After the event, the individual's accumulated annual dose is lower than Forsmark's planning value.

When considering the number of independent safety barriers, it is necessary to consider the number of alarms and how the staff reacted to the alarms separately. In this case, there were four independent safety barriers; (1) Personal electronic dosimeters with preset alarm levels. These worked as expected, (2) Installed gamma alarm in Reactor Hall ceiling. These worked and the alarm was functioning as expected, (3) Portable air monitoring. These did not alarm because it was too far away from the filter (4) Radiation protection technician with radiation protection instruments. The instrument malfunctioned and showed an incorrect measurement value.

The two alarms that worked require staff to respond to the alarm. The work was safely interrupted as soon as possible when the alarms were triggered.

Procedural deficiencies: Telescope detector had not been functionally checked with respect to the high dose probe, despite the fact that all other radiation protection instruments are functionally tested before use. This was due to lack of high-dose material available for the functional control of the high dose probe.

Shortcomings in safety culture: It is clear from interviews with staff involved that the working environment has been stressed and error prevention methods have not been applied.

Forsmark have implemented corrective actions based on a Human, Technology, Organisation investigation.

6.2. Safety improvements of nuclear power reactors

Comprehensive overviews of plant modifications performed in the past and implemented during the current reporting period are presented in Appendix 1.

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.

The Swedish licensee implemented safety measures through relevant modifications and, in some cases, by means of comprehensive modernization projects. For example, after the accident in Three Mile Island in 1979, severe accident management systems (including Filtered Containment Venting System, FCVS) were introduced at the Swedish NPPs. Also, extensive modernization programmes were introduced in 2005 and completed in 2015 for all Swedish NPPs in order to meet new requirements issued by the regulator in 2004. In summary, the safety measures implemented as a result of the new regulations in 2004 mainly 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 and or upgraded instrumentation and control equipment.

Furthermore, safety improvements have also been identified through international reviews such as the EU stress test National Action Plan (NacP).

Following the EU stress test, Sweden developed a National Action Plan (NAcP), with the intention to manage all plant weaknesses identified by the EU stress tests as well as by other forums such as the second extraordinary meeting under the Convention on Nuclear Safety. In general, the Swedish NAcP required investigations to be performed with the aim to identify necessary technical and administrative measures, how they should be implemented as well as appropriate time schedules for the implementation of these measures. All actions resulting from these investigations were successfully completed according to schedule, including the Independent Core Cooling System (ICCS) installations.

6.2.1. Independent core cooling system

The ICCS is a major safety enhancing technical measure that was required to be in place by the end of 2020 at all Swedish NPPs in operation. The ICCS provides core cooling that is completely independent from previously existing core cooling systems in terms of power supply and water source. The introduction of the ICCS strengthens reactor capabilities to prevent core damage during a number of extreme events that were previously not covered by the safety analyses. The ICCS is designed to protect the plants during events leading to loss of normal core cooling functions. Such events for example include failure of all AC voltage, as well as common cause failures in emergency core cooling functions, which might occur simultaneously due to extreme external impact. Examples of design solutions for ICCS functions are given in section 18.2.1.6.

Forsmark NPP

A new ICCS (Independent Core Cooling System) was put into operation at each one of the three Forsmark reactors in 2020. The new system is a consequence of the stress tests following the Fukushima accident and the SSM requirements for an ICCS, designed to withstand extreme external hazards. The power supply is galvanically separated from the plant's regular electrical power system via a motor-generator set. Forsmark units 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.

Safety improvements have been conducted on Forsmark unit 1, 2 and 3 in order to increase the resilience to external grid disturbances. The improvements includes introduction of the ICCS, exchange to more resilient components and installation of component protection.

Ringhals NPP

Ringhals has installed an independent core cooling system (ICCS), contained in a separate hardened building, for Ringhals units 3 and 4 in 2020. 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 independent core cooling system are:

- Extended Loss of AC Power, ELAP (for 72 hours
- Loss of Ultimate Heat Sink, LUHS (for 72 hours
- Extreme external events (including terrorism) beyond the ordinary design base

In addition to the independent core cooling system main function, the system also improves the capability to cool the spent fuel pool by establishing a feed and boil-off cooling function if the ordinary means of cooling the spent fuel pool is lost. Measures have also being taken to improve the physical separation between the existing redundant spent fuel cooling pumps and seismic reinforcement of the storage racks for the spent fuel elements.

Oskarshamn NPP

At Oskarshamn unit 3 a permanent independent core cooling function, mainly located inside the existing reactor building, has been installed. The function consists of a one-train system that provides core cooling water via a new penetration through the containment wall, with new isolation valves, and that connects to the existing piping inside the containment. The capacity is around 120 kg/s in order to restore normal water level in the RPV after an ADS. The ADS function is enhanced with new logic and independent battery power to the blow-down valves.

All electrical equipment that is needed for the ICC function and the reactor protection system is protected against all electrical disturbances (including unknown) via motor-generator sets that are installed to feed the bus-bars with power, including the battery packs. The battery packs have a capacity of 24 hours, after that a dedicated diesel generator can be started to feed the bus-bars (the DG is also protected by motor-generator sets).

The primary water source for the ICC is the central handling pool at the reactor service floor. The pools (central handling pool, storage pool of the internal parts and the spent fuel pool) can get make-up water from the fire extinguishing tanks. This make-up water is provided by a two train system.

The fire extinguishing tanks can in turn be fed with a two-train system from a fresh-water pond on-site that normally holds 120 000 m3.

The ICC-pump is a direct diesel-motor driven pump with throttling capablílity, on order to keep normal water level in the RPV once it is restored after the ADS.

The two fire extinguishing pumps are also direct diesel-motor driven.

If the ICC-pump should be (or become) unavailable, the fire extinguishing piping is directly connected (with shut-off valves) to the pressure side of the ICC-pump and can, in that way, feed the RPV with cooling water.

The pumps providing water from the fresh water pond are electrical and have a dedicated diesel generator located close to the pumps.

The fire extinguishing pumps and piping can also be used for feed-and-bleed of the spent fuel pool. The capacity is enough for both the ICC needs and the cooling of the spent fuel. The bleed-water is brought to the plants outlet channel via its own piping.

All equipment and installations described above have the following design events:

- Extended Loss of AC Power, ELAP (for 72 hours)
- Extreme (unknown) electrical disturbances
- Loss of Ultimate Heat Sink, LUHS (for 72 hours)
- Extreme external events beyond the ordinary design bases.

6.2.2. Regulatory control

SSM has continuously performed reviews and follow up on the licensee actions concerning the Swedish NAcP. All measures in the NAcP have been completed in accordance with the original given time schedule, meaning that all identified measures were fully implemented by the end of 2020. Of the various actions, the installation of Independent Core Cooling Systems at all reactors in operation after 31 December 2020 is the most extensive single measure taken. More details on the progress of the Swedish NAcP are given in Appendix 2.

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.

The power uprate programmes in Sweden 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 are illustrated by figure 4 below.

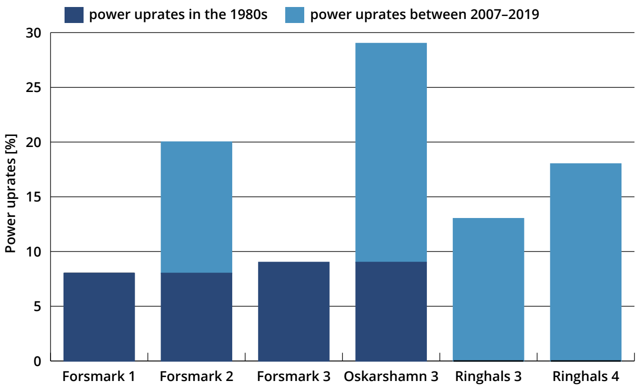

Figure 4. Power uprate levels of Swedish reactors in operation.

Depending on the magnitude of the power uprate, a power increase can affect the facility in a number of different ways and to a varying degree. Therefore, conditions and parameters that might affect safety must be identified and analysed in order to show that the safety requirements are met. A number of components and systems in the nuclear power plant 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, the ongoing power uprate processes have developed as follows:

- Forsmark unit 2 resumed commercial operation at the new power level in 2020 following completion of startup testing in 2012 and with a steady state operation at the new maximum power level since 2013.
- Oskarshamn unit 3 got permission for routine operation at the new power level in 2019.

6.4. Implementation of Vienna Declaration on Nuclear Safety

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 Vienna Declaration on Nuclear Safety.

Since the introduction of nuclear power in Sweden extensive safety modifications and modernizations programs at all operation NPP have been introduced. Measure to improve safety include among others, the introduction of severe accident management systems (including Filtered Containment Venting System, FCVS) in respons to the accident in Three Mile Island in 1979, as well as the most recent completion of the ICCS (see section 6.2).

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 assessement 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 of developments since the previous report

During the review period, the following developments are of relevance with regard to the obligations of Article 7:

- On 15 June 2017, the Swedish Parliament (Riksdag) 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. At the same time, several regulations of the Swedish Radiation Safety Authority were amended to transpose other provisions of the directive.
- A new Radiation Protection Act (2018:396) was decided by the Swedish Parliament (Riksdag) on 26 April 2018 and entered into force on 1 June 2018. The new Radiation Protection Act transposes several key provisions of Council Directive 2013/59/Euratom laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation.
- A major overhaul of SSM's Code of Statutes, SSMFS, is under progress. On 24 May 2018, the first part of the new Code, concerning nuclear activities, was decided. This part (SSMFS 2018:1) includes regulations on basic rules for all licensed activities involving ionising radiation. The regulations also transpose provisions of Council Directive 2013/59/Euratom, which have not been included in the new Radiation Protection Act. The regulation SSMFS 2018:1 came into force on 1 June 2018. Key regulations applying to nuclear power reactors were issued at the end of 2021 and entered into force on 1 March 2022.
- On 1 April 2019, an inquiry chair appointed by the Government presented a proposal regarding a new Act on Nuclear Activities. This proposal has been submitted for a consultation procedure involving authorities, municipalities, licensees and other stakeholders.

7.1. Hierachy of Swedish legislation and the regulatory framework

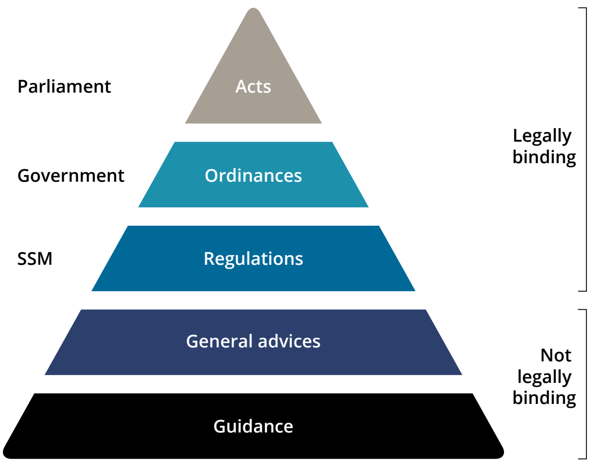

Figure 5. Hierarchy of Swedish legislation and the regulatory framework.

In the Swedish system the parliament decides on acts, the government on ordinaces and SSM on more detailed regulations and guides, see figure 5. 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 for comprehension of the implications of the regulations, with 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 basic 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 code all supplemented by a number of ordinances and other secondary legislation which contain more detailed provisions for particular aspects of the regime.

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 safety and security, while the Environmental Code regulates general aspects of the environment and the possible impacts of "environmentally hazardous activities". Nuclear activities are defined as belonging here.

The objective of the Radiation Protection Act is to protect people, animals and the environment from harmful effects of radiation. The Act applies to radiation protection in general and, in this context, provides provisions regarding workers' protection, 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 reactors, and research in the field of nuclear waste. Financial means for these purposes must be available when needed.

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 acts 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 Ordinance (2003:789).

7.1.2. The Act and Ordinance on Nuclear Activities

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

The Act does not contain provisions concerning radiation protection and general provisions on environmental protection. These areas are regulated by a separate act and a separate code: 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 should be 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.

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. These included the Article 8a, paragraphs (a) and (b) of the directive, which correspond to safety objectives according to the Vienna Declaration on Nuclear Safety. These new provisions in the Act on Nuclear Activities concern not only existing Swedish nuclear power reactors, but also any new reactors that might be built.

The Ordinance on Nuclear Activities (1984:14) contains 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.

Pursuant to the Government's authorisation granted in June 2017, the head of the Ministry of the Environment and Energy appointed an inquiry chair to conduct a review of national nuclear legislation. The Government also appointed an expert committee with representatives from the Government offices, regulatory authorities, the industry and non-governmental organisations, to assist the inquiry chair. On 1 April 2019, the 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, though occasionally using revised wording. Some provisions have been modified and others removed. A small number of entirely new provisions have also been added to the proposed legislation.

A summary of key proposals made by the inquiry is presented below.

The responsibilities of licence holders and operators are clarified:
The inquiry proposes clarification of the operator's long-term responsibility, including the financial responsibility for the decommission of closed facilities and the management and disposal of spent nuclear fuel and nuclear waste, and the licence holder's responsibility for the safety of nuclear facilities and activities, i.e. that a nuclear facility is designed, sited, constructed, commissioned, operated and decommissioned in a safe way, as well as the responsibility for safe management of nuclear material or radioactive waste resting with the licence holder. The proposal also clarifies that delegation of licensee responsibility is not allowed.

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 new act. Up until now, the stepwise licensing process has had its legal basis in the licence conditions stipulated by the licensing authority (the Government). The licence conditions usually state that the licensee is not allowed to begin construction, commence test operation, or commercially operate the nuclear facility or begin decommissioning activities until the regulatory authority has given its approval.

Subsidiary responsibility and ultimate responsibility of the state:
The inquiry proposes that the state's subsidiary responsibility for nuclear activities, which ensues from international commitments and which has been confirmed by the Swedish parliament and government, should be laid down in the act. Moreover, the inquiry proposes introduction of provisions clarifying that the long-term responsibility for a geological repository for spent nuclear fuel or radioactive waste, once it has been sealed, shall rest with the state (ultimate responsibility of the state).

Permanently closed nuclear power reactors:
The inquiry proposes introduction of an obligation requiring the licence holder to notify the authorities when a decision has been made to permanently shut down a nuclear power reactor. A formal notification should also be made when all nuclear fuel (nuclear material under safeguards) has been removed from the permanently shut down nuclear power reactor.

Nuclear waste:
The inquiry proposes harmonisation of the concept of nuclear waste with the definition of radioactive waste contained in the Radiation Protection Act. Thus, nuclear waste becomes a subset of what is defined as radioactive waste. Furthermore, the inquiry proposes a change to the provisions regarding special permits for the disposal of foreign nuclear waste in Sweden and for the final disposal of Swedish nuclear waste abroad. In general, "special reasons" for these permits should be the requirement, and not "exceptional reasons", as is the case today. However, this does not entail any practical change in the basis for the assessment or the grounds for granting such permits, since that which has been termed "exceptional reasons" rather constitutes "special reasons".

Research and development responsibility for waste management:
The inquiry proposes amending the current requirement of the Act on Nuclear Activities to imply that a licence holder of a nuclear power reactor is responsible for setting up a comprehensive research and development programme as needed for the safe management and disposal of spent nuclear fuel and radioactive waste, including building necessary waste management facilities and repositories. Furthermore, the inquiry proposes that the programme should only cover parts of the planned system for waste disposal for which a licence has not been granted. This means that the obligations only covers the parts of the waste system for which a solution is yet to be realised. Dismantling of closed nuclear facilities should be encompassed only to the extent that this relates to existing or planned repositories.

Decommissioning and dismantling of nuclear facilities:
The inquiry proposes amending the Environmental Assessment Ordinance (2013:251) to imply that a renewed licensing process, including an environmental impact assessment, for decommissioning of a nuclear power reactor would apply as of the time when dismantling and demolition activities commence. The assessment should focus on the environmental effects that the new activities, i.e. dismantling and demolition, entail. Activities performed under the existing licence, e.g. management of operational wastes and spent nuclear fuel, do not need to be subject to new review and approval.

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.

The proposal regarding a new Act on Nuclear Activities with the appurtenant ordinance has been submitted for consultation with government agencies, municipal authorities, licensees and other stakeholders.

The proposals regarding subsidiary responsibility and ultimate responsibility of the state were implemented in the autumn of 2020. The rest of the proposals are still handled in the Government Offices.

7.1.3. The Radiation Protection Act and Ordinance

Requirements for radiation protection are set out in the Radiation Protection Act and Radiation Protection Ordinance. The purpose of the legislation is to protect people, animals 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.

A new Radiation Protection Act (2018:396) was decided by the Swedish Parliament on 26 April 2018, entering into force on 1 June 2018. The new Radiation Protection Act transposes several key provisions of Council Directive 2013/59/Euratom laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation.

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 license conditions and conditions for revocation of licenses.
– Provisions on supervision and mandates of the regulatory authority.
– Provisions on responsibilities and sanctions.

The Ordinance on Radiation Protection (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 Ordinance also stipulates that certain provisions in the Act do not apply to very low-level radioactive materials and technical equipment emitting only low-level radiation (exemption). The regulatory authority may also issue regulations concerning the release of very low-level radioactive material.

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 Code is applicable to nuclear activities and activities involving radiation and must be applied in parallel with the Act on Nuclear Activities and the Radiation Protection Act. 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
– ny 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 are several important principles that must be complied with by a licensee, e.g:

– The knowledge principle means that the implementer must possess the knowledge that is necessary regarding the nature and scope of the activity to protect human health and the environment against damage or detriment.
– The precautionary and BAT (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. For the same reason, the best possible technology shall be used in connection with professional activities.

- The most suitable site principle means that as regards activities for which land or water areas are used, a suitable site shall be selected while taking into account the goals of the Environmental Code. Sites for activities must always be chosen in such a way as to make it possible to achieve their purpose with a minimum of damage or detriment to human health and the environment.
- The after-treatment liability principle means that everyone who has pursued an activity that causes damage or is detrimental to the environment shall be responsible for restoring it to the extent deemed reasonable. An individual who is liable for after-treatment shall carry out or pay for any after-treatment measures necessary.

The general rules of consideration function as a preventive tool 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 need a permit. A permit is also needed for the decommissioning of nuclear reactors. The Land and Environmental Court is the court of first instance for the hearing of cases concerning such activities. In addition, the Government must consider the permissibility of nuclear activities, e.g. the disposal of spent fuel and radioactive waste. The 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 him/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, for example, the media about matters that would otherwise be secret without punishment and without the employer discovering who provided the information.

7.2. National safety and radiation protection regulations

7.2.1. SSM's nuclear safety and radiation protection regulations

With reference to its legal mandate SSM issues legally binding safety and radiation protection regulations for nuclear facilities in its Code of Statutes, SSMFS. General advice provides interpretation of the regulations, in addition to guidance on understanding the meaning of the regulations, including explanations and examples of application. See also figure 5 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 (RL) 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, various interested parties is required before new regulations are issued.

SSM's Code of Statutes (SSMFS) currently (February 2022) contains 15 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. Experience has demonstrated the need to clarify and broaden the regulations in order to create more predictability for the 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 have, historically, emerged as the need for regulation arose. The report also notes that the IAEA's safety standards were used as the basis for the Swedish nuclear safety rules, or referenced therein, but not in a systematic way. Therefore, the report recommended that SSM review the existing regulatory framework and make it clearer, more consistent and comprehensive. Moreover, the Swedish Government has, through appropriation directions, ordered SSM in 2012 and 2013 to review the regulations concerning nuclear power reactors, to ensure that appropriate requirements were in place for potential new nuclear power plants, taking into account the experiences of events and accidents that have occurred and new international safety standards.

Against this background, a major and thorough review of the Codesof 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, nuclear

Traditional way of regulating in Sweden

New integrated regulation

	Nuclear safety	Radiation protection	Nuclear security	Non-proliferation control
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 6. Different approaches to regulation of various aspects.

safety and security, to a greater extent than previously, should be regulated in an integrated manner and in the contexts where these aspects are concerned, and not in separate regulations. See also figure 6. The objectives 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. In order to achieve this aim, it was decided to define a collective term that encompasses "nuclear safety", including "security" (in accordance with the Act on Nuclear Activities) and "radiation protection". The term "radiation safety" (strålsäkerhet in Swedish) was therefore defined accordingly.

The new structure that was decided signifies regulation of radiation safety at nuclear facilities for different phases of a facility's lifetime and for different main types of substantive issues. Moreover, this regulation is to encompass three levels, namely:

1. The first level represents requirements that are applicable to all licensed activities involving ionising radiation;
2. The second level is facility/activity-specific requirements; and
3. The third level consists of requirements applying to specific aspects of radiation safety.

This structure is also illustrated schematically in figure 7 below.

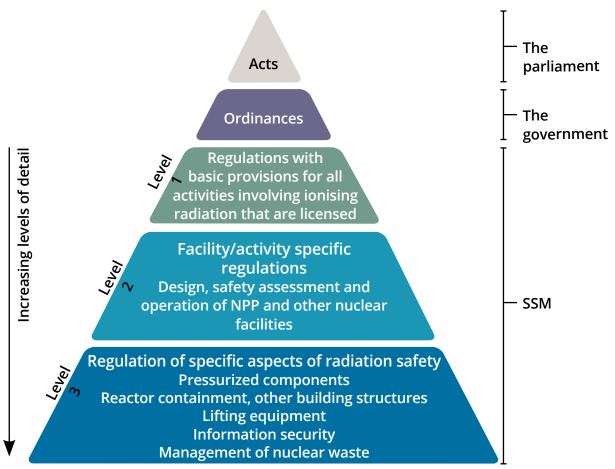

Figure 7. Schematic illustration of the structure of radiation safety regulations.

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 today's 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 have to go through 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 parallell with a second preliminary consultation procedure with relevant licensees. At this stage SSM also requests input to the 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 NGOs. In addition, the proposals will be published as draft documents on SSM's website to enable interested parties in the public to submit their comments. This last consultation procedure will also have an attached report on the impact of the new regulations on the facilities and activities in question.

The first parts of the new Code of Statutes were finalised, issued and entered into force in June 2018. Key regulations applying to nuclear power reactors were issued at the end of 2021 and will enter into force on 1 March 2022. The remaining parts of the new Code of Statutes are expected to be completed and enter into force in 2024.

7.3. System of licensing

Licensing of nuclear activities is governed by several acts having different purposes. This also involves a number of 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

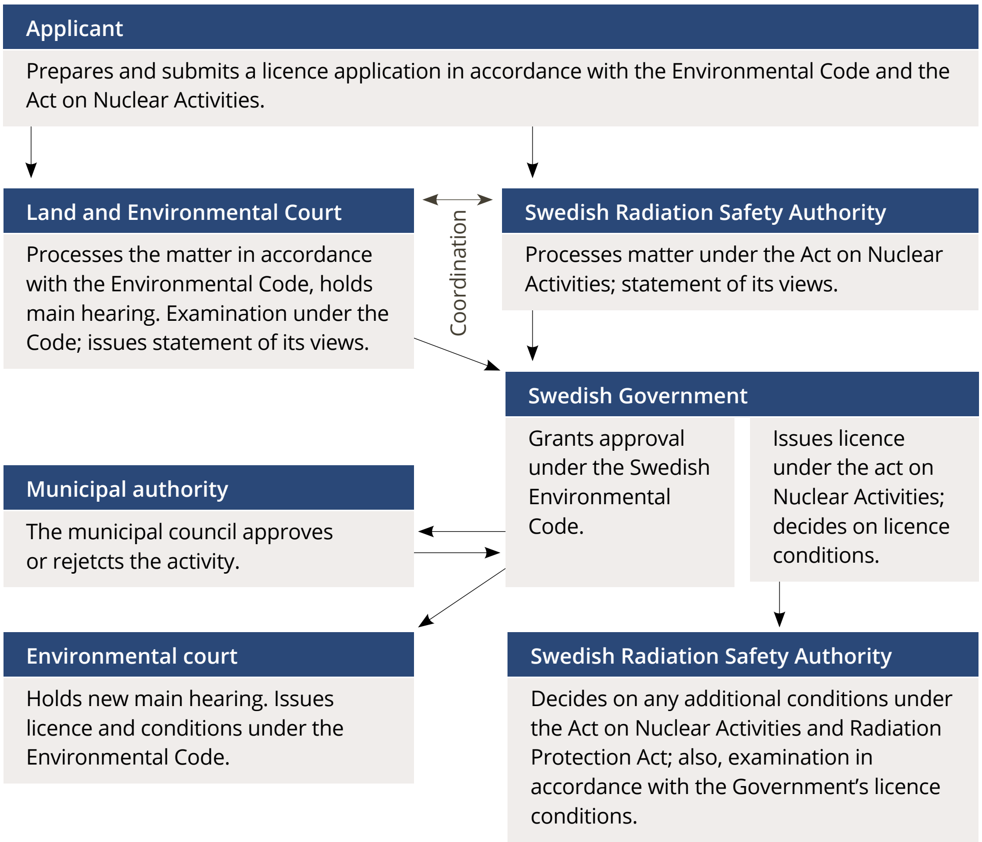

Figure 8. Schematic illustration of the licensing process for a new nuclear facility.

conditions are issued under the various acts by the authorities responsible.

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 the Swedish Radiation Safety Authority, 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 under Chapter 6 of the Environmental Code. Figure 8 below is a schematic illustration of the licensing process for construction of a new nuclear facility. The figure depicts how related review and licensing tasks are assigned.

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

During the licensing process, an important instrument is the Environmental Impact Assessment (EIA). Swedish EIA legislation is in accordance with Directive2011/92/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 connection with the future 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).

If the Government grants permissibility as per the Environmental Code, licensing approval needs to be issued for the nuclear activity according to the Act on Nuclear Activities, and for the environmentally hazardous activity according to the Environmental Code. The Government ultimately grants a possible licence in accordance with the Act on Nuclear Activities.

The application is reviewed by the regulatory authority assigned by the Government (i.e. SSM) and forwarded thereafter for a Government decision. A 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.

It should be noted that the preparation and review of an application, as well as the issuing of a licence and 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 the licence under the Act on Nuclear Activities, SSM must in these matters also propose that the Government take a decision on licence conditions enabling a continued step-wise review process until such date that the planned facility may begin regular operation.

As regards nuclear facilities, depending on the type of matter, one or more of the following licence conditions are to be proposed:

- The facility may not commence construction prior to approval by SSM.
- The facility may not commence test 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. As mentioned in section 7.1.2, this process involving step-wise reviews is now 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 licence are granted with an indefinite term. This means that the operation of a nuclear power reactor is allowed as long as the licensee meets the requirements set by the applicable laws, government ordinances, regulation of the nuclear regulatory authority, and conditions imposed to the initial 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 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.

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 nuclear power plant 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, for compliance with the Act, or regulations issued or conditions granted 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 be imposed 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 nuclear power plants), including on-site emergency preparedness and response.

The amended directive further strengthens the role and the independence in regulatory decision-making of the 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 the Article 8a, paragraphs (a) and (b) of the directive, which correspond to safety objectives as per the Vienna Declaration on Nuclear Safety. These new 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 changes to the Act also clarified licensee responsibility as well as the requirements for continuous analysis and assessment of safety at facilities.

Changes to existing SSM regulations have also been made for transposition of the 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 encompassed sufficiently by the regulations. These amendments were decided on 15 June 2017 and concerned SSM's regulations (SSMFS 2008:1) on safety in nuclear facilities, and the regulations (SSMFS 2014:2) on preparedness at nuclear facilities. The amended regulations entered into force on 1 August 2017.

7.4.2. European basic safety standards 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 new 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 recommendations from 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 International Atomic Energy Agency (IAEA).

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

The main transposition in Sweden of Directive 2013/59/Euratom has been implemented 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 have been 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 certain conditions are necessary to ensure safety. SSM may also decide that additional measures are necessary, and issue orders and 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 the legislation. If there is an ongoing licensed activity that does not comply with regulations or the terms of the licence, the supervisory authorities may issue any injunctions and prohibitions required 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 taken at this person's own expense.

The Act on Nuclear Activities also contains provisions regulating areas such as safeguards and sanctions. Anyone who conducts 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 as per 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 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. SSM's management system provides guidance on how different measures should be used (see further description in 8.8).

7.6. Regulatory supervision

SSM's regulatory activities relating to inspection and assessment are reported under "Article 8, Regulatory Body". An overview of SSM's supervision with regard to the safety of nuclear installations and supervisory programme is contained in section 8.10.

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 (which have existed for at least three years and have a minimum of 100 members).

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 appealed. Under certain conditions, the Supreme Administrative Court might examine whether a decision by the Government 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 have been taken according to the correct procedures.

To ensure that necessary information in relation to the nuclear safety of nuclear installations and its regulation is made available to workers and the general public, all reports issued by SSM are 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, a licensee is 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 safety reference levels for existing nuclear power reactors (SRLs). The SRLs reports were issued in 2006 and updated in January 2008, September 2014 and March 2020 (issued February 2021). The 2020 SRLs include new issues such as internal hazards and external hazards. WENRA reports are available on the WENRA website (www.wenra.org).

The 2020 SRLs are based on latest available knowledge and experience and takes into account the lessons learned from the accident at the Fukushima Dai-ichi Nuclear Power Plant, including the insight from the EU stress tests, the reviews of the 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 makes the reference levels available for stakeholder consultation.

WENRA members are currently working on a pilot study regarding member countries' implementation of SRLat their nuclear power plants. Technical specifications for the coming ENSREG Topical Peer Reviiew regarding Fire Safety, as well as the preparation for the 2024 SRLs revision programme. Furthermore, during this review period WENRA has published a number of reports, guidance, position papers and recommendations, including guidance documents on different initiating events connected to issue TU (Externa Hazards) , reports regarding applicability of the Safety Objectives to SMRs and Practical Elimination Applied to New NPP Designs, which provide a common understanding of the approach to demonstrate the avoidance of early releases and large releases by using the notion of practical elimination.

In preparing SSM's new Code of Statutes, consideration has been given to the WENRA Safety Reference Levels as well as other WENRA reports.

7.9. Vienna Declaration on Nuclear Safety

Article 8a, paragraphs (a) and (b) of Directive 2009/71/Euratom, are corresponding to the first and second principles under the Vienna Declaration on Nuclear Safety. These provisions of the Directive have been transposed into the Swedish Act on Nuclear Activities, which means that the first and second principles in the Vienna Declaration on Nuclear Safety are considered in the act. These new 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 Vienna Declaration on Nuclear Safety in the form of SSM's ongoing comprehensive review of its Code of Statutes, and which shall ensure that IAEA Safety Standards are more 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 of developments since the last report

During the current review period, the following developments are of relevance with regard to the obligations of Article 8:

- SSM has been reorganised and its headquarters partly relocated.
- Development of the integrated management system has resulted in a new overarching process map.
- Development of the supervisory programme for nuclear power plants.
- New regulations for nuclear reactors have been developed.

8.1. The regulatory body and its mandate

8.1.1. General information about the Swedish Radiation Safety Authority

The Government decided on 31 August 2017 to relocate SSM's headquarters to the city of Katrineholm by 30 November 2018. Katrineholm is situated about 120 kilometres southwest of Stockholm. In addition, SSM has opened a small branch office in Gothenburg.

In February 2019, SSM had approximately 50 employees with positions at the Katrineholm office. In the long term, SSM's ambition is to increase its staffing to approximately 70 employees.

In connection with the decision to relocate parts of the Authority to Katrineholm, the Government also decided that the Authority's tasks concerning the Nuclear Waste Fund and control function in nuclear waste financing would be transferred to the National Debt Office by 1 December 2018 at the latest. The transfer of these tasks was completed by 1 September 2018. Nevertheless, SSM has the task of providing assistance on the information and analyses within its area of responsibility which are needed by the Debt Office for performance of its tasks.

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

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 contains detailed objectives and reporting obligations. Other authorities that have a supervisory mandate relating to nuclear power plants are the Swedish Civil Contingencies Agency, the Swedish Work Environment Authority, the Nuclear Waste Fund, and the National Electrical Safety Board.

SSM is a central administrative authority, independent in its decisionmaking (see section 8.2), that reports to the Ministry of the Environment.

The director general of the Swedish Radiation Safety Authority 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 has an 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) in the Authority's activities, but it has no decision-making powers.

The level of requirements imposed on SSM and other Swedish authorities for openness and provision of information services to the public, politicians and media is very high. Swedish official documents are public unless a decision is made to classify them according to 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 to have access to a document.

As all other Swedish authorities, SSM issues an annual report and financial statement, which are submitted to the Government. They summarize major results, effects, revenues and costs. The Government carries out follow-up work and evaluates an agency'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.

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 press contacts and IT support outside office hours.

8.2. Independence of the regulatory body

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

According to the Swedish constitution, administrative authorities are independent in its 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 Cabinet as a whole is responsible for all governmental decisions. Although in practice, a large number of routine matters are decided upon by individual ministers, and only formally confirmed by the Government, the principle of collective responsibility is reflected in all forms of governmental work.

The laws governing SSM concentrate solely on nuclear safety and radiation protection (also security, physical protection, and non-proliferation, but these tasks of SSM are outside of the scope addressed in this convention). SSM reports to the Ministry of the Environment, which is not involved in the promotion or utilization of nuclear energy.

8.3. Missions, tasks and fundamental values

SSM's missions and tasks are defined in the Ordinance (2008:452) with instructions for the Swedish Radiation Safety Authority and in annual appropriation directions. In the latter, the Government issues directives for authorities, which include the use of 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 safety including physical protection in nuclear technology activities, as well as in other activities involving radiation, and for issues regarding non-proliferation.

SSM is to work actively and preventively to promote high levels of nuclear safety and radiation protection 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 safety and radiation protection internationally.

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

SSM shall furthermore:

1. Take measures to fulfil Swedish obligations according to conventions, EU ordinances/directives, and other binding agreements;
2. Supervise 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, rescue 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 focus more on short-term issues and funding of authorities' activities.

SSM's work can be divided into supervision of safety and radiation protection work relating to non-ionising and ionising radiation. As far as concerns ionising radiation, 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 also runs the 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 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.

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. We have a systematic and structured approach to continual improvements to our processes in order to develop our operations, render them more efficient and achieve our objectives.

Key values:
Credibility, Integrity and Openness

Credibility means pursuing our 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 us to be unduly influenced when it comes to our 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 we clearly and proactively provide information about our work, standpoints, advice, recommendations and decisions. Openness also involves our 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 scrutinize its own safety culture and its wider role in the national safety infrastructure. A regulatory body must have public safety as the primary focus, and in order to achieve, this it is essential for the regulatory body to have a healthy safety culture. SSM has for several years worked on its own safety culture. This work has encompassed involvement in international activities to enhance the safety culture as well as internal activities.

SSM participated 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) and has, as a direct result of this work, incorporated the five principles from these efforts into the management system of the regulator. The five principles in the integrated management system of SSM 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 has also conducted several internal seminars, some with invited speakers, on different themes related to the safety culture of the regulator, such as leadership, the roles of the regulatory body, the content of the OECD-NEA booklet "The Safety Culture of an Effective Nuclear Regulatory Body", and information safety and information classification.

Furthermore, SSM procured an external evaluation of the safety culture, conducted by Lund University. The evaluation involved interviews, focus groups and a questionnaire, and resulted in a valuable baseline evaluation of the status of the safety culture. SSM is still working on some of the findings from the evaluation in its continuous effort to support and promote the safety culture of the regulatory body.

When hiring new employees they have an obligatory digital security training.

8.5. Human and financial resources

8.5.1. Staffing

SSM has (31 Dec. 2021) a workforce totalling 297 employees.

The authority had an average of 297 employees in 2021. This is a decrease of 8 employees compared with the previous year. Staff turnover was 12 percent in 2021, which is an increase compared with the previous year when turnover was 10 percent. A total of 35 people have terminated their employment, of which 13 are women and 22 are men. Of these, 12 people have retired.

Compared with many other authorities, the staff of SSM has a rather high educational level. This is a result of the many specialist areas covered by the Authority, and to some extent the fact that there are no Technical Support Organisations in Sweden to support the regulatory body with specialist knowledge.

Comparing internationally, the number of regulatory staff in Sweden is small for the size of the nuclear programme. When comparing the sizes of staff between different countries, it is however important not only to count the staff members per reactor, but also to consider the types of legal obligations imposed on the licensees and the different supervisory practices.

8.5.2. Recruitment

In total, the authority had 49 recruitment cases in 2021, which is a marginal decrease compared to 2020 when the authority had 50 recruitment cases.

2021 there has been a small decrease in male applicants and a small increase in female applicants to the authority. This is probably due to the fact that the authority has had more recruitment cases within support competence where many applications have been received and where the proportion of applications from women is higher.

A recruitment strategy with prioritized activities has been developed to increase the authority's ability to attract and recruit the right skills in the coming years. Lack of competent applicants is a problem that the authority shares with the state in general.

8.5.3. Staff turnover

Staff turnover was 12% in 2021.

8.5.4. Knowledge management

SSM systematically analyses prospective skills needed by the Authority in the short and long term in order to perform its current and future tasks. Working strategically with staffing and competence, and thereby developing the organisation and its work is a crucial prerequisite for SSM's capability to achieve its goals and effectively conduct its activities.

The purpose of the model is to provide an overview of the methods and other assumptions that SSM applies in order to optimally meet its needs for staffing and competence (see figure 9).

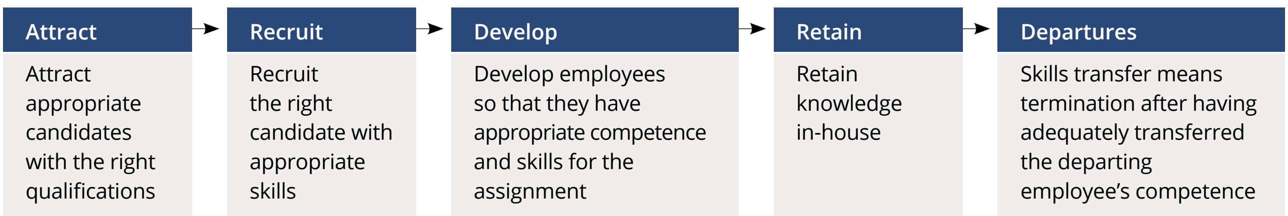

Figure 9. Knowledge management process.

The overall objective of the model is to create the preconditions for performing effective knowledge management in order to develop the operations of SSM.

SSM's model includes the following steps:

- To attract the right candidates with appropriate qualifications, we use our employee value proposition and market it, for example at job fairs.
- In order to recruit the right candidates, we apply competence-based recruitment, and ensure that the employees that we recruit are committed to SSM's induction programme that also includes a mentor for the first six months.
- In order to retain our employees, we have several programmes in the areas of supervision and leadership. Employee departures are subject to a tailored skills transfer programme for the purpose of retaining knowledge in-house at SSM.

8.5.5. Employee value proposition

An important prerequisite for the Authority's staffing and competence is that the Authority succeeds in attracting and recruiting staff who have the education, experience and skills needed, together with the qualities that make the employees contribute optimally to the organisation. What the Authority offers as an employer and workplace should be attractive to those who we wish to recruit.

8.5.6. Skills transfer programme

SSM has developed a skills transfer concept (KÖK) in order to manage transfer of skills possessed by only one or a few employees. It is important to have a structured and systematic approach to maintaining competence and skills in the organisation. The programme should also be seen as a professional development opportunity for both mentors and mentees. The mentorship pairs are identified in connection with professional development interviews.

SSM has continued working on a structured programme for transfer of competence. A leadership Competence programme has been run to enable backup functions among the Authority's employees possessing critical competence, as well as to carry out professional development. The KÖK programme defines different roles: A mentee sees to it that objectives and goals are met. A mentor transfers his or her skills and helps the mentee achieve the defined objectives and goals. A supervisor performs follow-ups and sees to it that the competency transfer takes place.

8.5.7. Competence and employee policy

A basic competence profile and performance expectations for all staff at SSM, including managers, are given in the Employee policy. The policy has a clear starting point in the public administration values and has a clear link to the Authority´s model for training of leaders, "Developing Leadership.

8.5.8. Introduction programme

8.5.8.1.

A new induction programme for employees has been developed with the aim of providing basic knowledge about the Authority and the Authority's role and mandates. The induction programme is mandatory for new employees, and covers the Authority's role, occupational health and safety work, in addition to SSM's core operations. The aim is to foster a deeper understanding of the Authority's activities and to give new employees an important network.

8.5.8.2. Safety training

Training efforts are conducted continuously to increase safety awareness among employees. An introduction to the safety work is provided and given to all new employees. The majority of SSM's employees in safety-classified positions have undergone a basic safety education programme over the past years.

8.5.8.3. Leadership training

In recent years, ongoing development efforts have been undertaken on the part of the entire senior management team. The content of this work was based on the skills profiles of identified managers at SSM.

The Authority has continued to develop managerial skills and carried out basic training programmes for new supervisors, and continuing education in developmental leadership. A specific internal training program for future leaders has been set up in order to foster good leadership and secure a consistent management of the Authority´s regulatory functions.

SSM has worked on developing the Authority's employer branding in order to attract candidates and retain in-house knowledge at three locations. Consequently, the Authority has developed more flexible terms of employment including teleworking, together with the opportunity to use travel time as working hours.

Internal training program

At the end of 2019, the admission process to the management supply program was carried out in the form of an application, nomination, interviews, tests and selection of 10 participants. The program started in February 2020 with all participants being assigned a mentor, which is an important support throughout the program. All planned training has subsequently been carried out according to plan, such as physical meetings, with certain adjustments required during the current pandemic in accordance with the Swedish Public Health Agency's recommendations and SSM's guidance. In parallel with the training, the participants work with their respective group tasks, which are: Leading at a distance, Leadership of the Future and From one in the group to being a manager.

8.5.9. 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 2019, 2020 and 2021, including the funding of the separately financed international cooperation and development work, are shown in Table 2. Additional resources are in the form of fees for processing of special applications and licensing work, which are directly payable to the Authority.

8.6. Integrated management system

SSM has an integrated and process-based management system. The management system describes how activities are controlled, implemented, followed up and improved. The management system can be viewed as a structure of processes that together create an overall picture of the activities. The management system supports a systematic and effective approach and good administration.

The management system has been designed to ensure that radiation safety requirements are fulfilled in coordination with other operational requirements. The management system has also been designed to support and promote a culture whereby issues with an impact on radiation safety are given the attention and priority that their importance requires.

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. Process-oriented management is based on the management process, the main processes and the supporting processes.

Table 2. Budget of SSM in million SEK.

Budget item	2019	2020	2021	Source of funding
Nuclear safety, emergency preparedness, supervision, crisis management, nuclear non-proliferation (including administration)	397.0	395.7	409.9	Mainly fees
Supervision of nuclear facilities (proportion of above)	152.0	157.6	155.5	Fees
Crisis management (proportion of above)	26.0	26.0	30.5	Fees
Nuclear non-proliferation (proportion of above)	14.0	14.0	12.0	Fees
Scientific research and development work (proportion of above)	76.0	76.0	77.0	Mainly fees
Final disposal of radioactive waste	60.0	60.0	60.0	Fees
Licensing of new facilities	21.5	21.5	19.1	Fees
Historical wastes, etc.	3.0	3.0	3.0	Tax funded
International cooperation and development	31.5	26.0	28.0	Tax funded
Total (million SEK)	**513.0**	**506.2**	**520.0**	

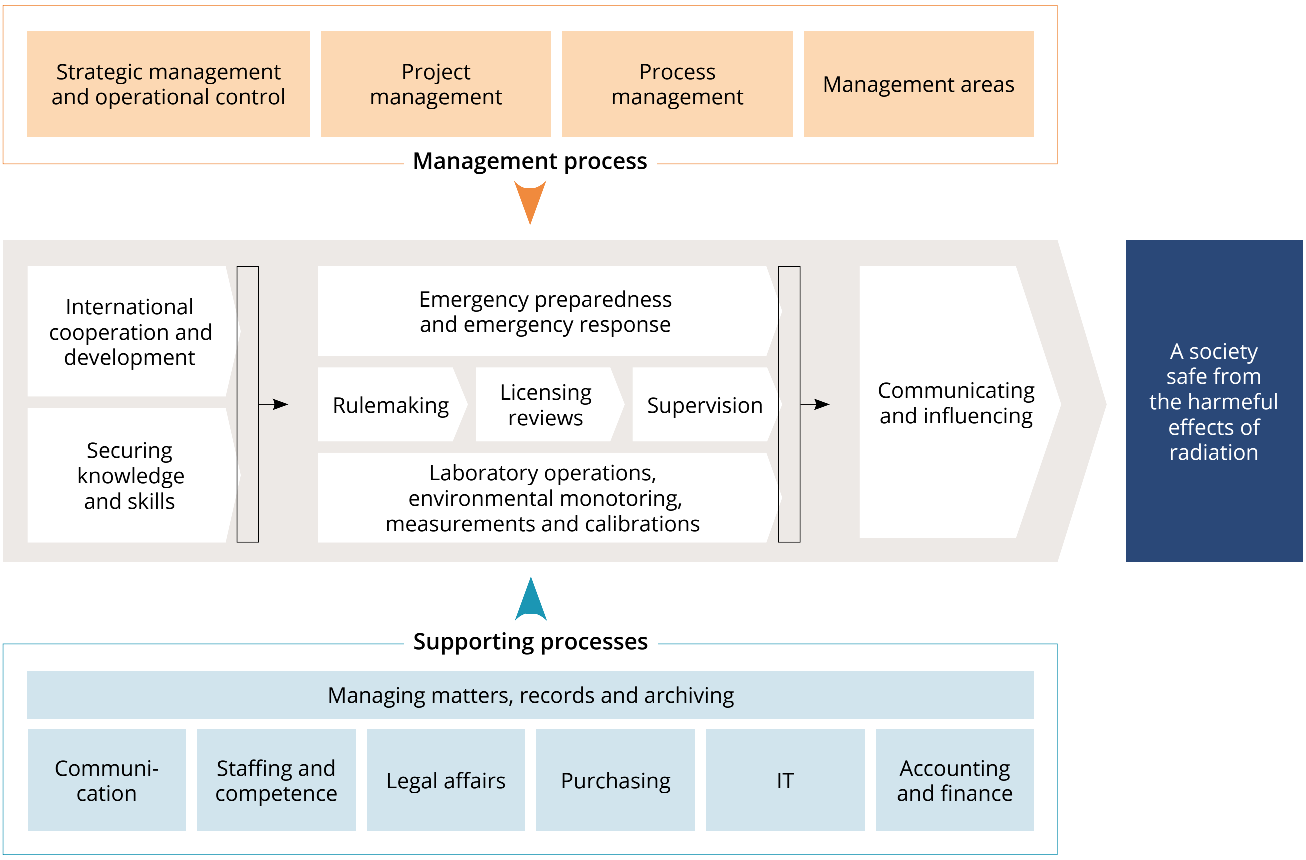

Figure 10. SSM's overarching process map.

The management process is based on the authority's overall remit to be proactive in good radiation safety in society and is divided into a strategic element with the strategic vision and an operational element with planning and follow-up of the activities. An internal management and control system is integrated with the authority's financial planning and management of objectives and results within the scope of the management process.

Figure 10 illustrates SSM's present overarching process map.

8.7. Internal and external audits

SSM ensures that annual internal and external audits of the Authority's activities are carried out. The SSM management system accounts for internal and external requirements; the latter including ISO standards, statutes and legal provisions.

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

External audits are carried out every year. Audits on the annual report, finances and effectiveness are conducted by the Swedish National Audit Office. The requirements of ISO 9001, ISO 14001, OHSAS 18001 and other relevant requirements are audited by contracted external auditors accredited by the government authority SWEDAC. In 2018, SSM was re-certified in accordance with ISO 9001 and ISO 14001. These certificates are valid until 5 December 2021. The certificate in OHSAS 18001 is valid until 26 October 2019. The plan is to be certified in ISO 45001 in September/Ocotber 2019. From the last external audit of SSM, conducted in September 2018, no deviations were identified, however, some proposals were made for improvement of the management system. These proposals will mainly be considered in 2019 as part of efforts to improve the management of objectives, and by means of improved potential to manage our processes.

8.8. Regulatory supervision

Regulatory inspections and safety assessments are carried out by SSM as authorized by the Ordinance on Nuclear Activities and Radiation Protection Ordinance, and as instructed by the Government.

8.8.1. SSM's supervisory practices

SSM has during 2021 reorganised the authority to increase transparency and separation of licencing, supervision and regulation. The supervision of licensees with different scope and nature of operation have therefore increased in coherency.

Since 2015, development projects have been performed with the aim of improving and simplifying the Authority's supervision and thereby increase the quality and efficiency of SSM's supervision.

The supervisory process is divided into the following eight sub-processes:

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

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

8.8.2. Supervisory programme

A new supervisory programme was tested in 2017, and formally introduced in 2018. The programme is designed to provide a better overview and introduce a more clear risk-information and it entails considerable changes to the planning, implementation, and follow-ups of supervision. The supervisory programme is structured into two basic parts, baseline supervision and demand-based supervision (see figure 11).

SSM has during 2021 continued to develop its supervisory processes and methods, which are also part of SSM's overall management system.

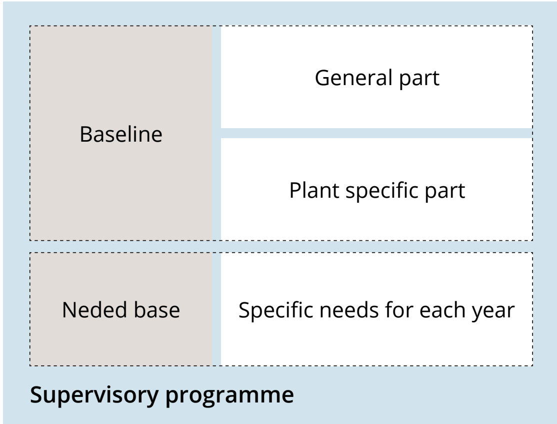

Figure 11. Structure of the Supervision program.

8.8.2.1. Baseline supervision

The requirements building up the baseline supervision plan are divided into six fundamental aspects (see figure 12):

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

Figure 12. 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 nuclear power plants in operation. Over the 10-year period, the baseline supervision programme is supposed 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, including, e.g.:

- Safety analysis (3 years)
- Operations (3 years)
- Management systems (5 years)
- Safety review (5 years)
- Experience feedback (5 years)
- Security (5 years)
- ALARA programme (5 years)

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 from, 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 composed of the site inspector(s) and one or more experts on the subject matter of the inspection. 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, and an assessment of the significance of any deviations. The report is accompanied with 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, two annual meetings with the safety department, one inspection at each power plant, and yearly meetings to review safety and internal audit programmes. Some inspections are made in connection with events, to follow up organisational change, and relating to other current 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 and reported at SSM management meetings. Each surveillance inspection typically takes 1–2 days on site for 1–2 inspectors. Often, a specialist on the subject matter for the visit accompanies the inspector. Table 3 below provides an overview of the performed activities.

SSM can also perform so-called intensified supervision. The use is decided by the director general and is applied when the Authority is dissatisfied with the safety performance of a licensee. Intensified supervision can also be applied to other special safety reasons, e.g. during test

Table 3. Number of supervision activities at NPPs 2016–2021.

Year	Regulatory Activity	Forsmark	Oskarshamn	Ringhals	Total
2021	Compliance inspections	3	8	5	16
	Surveillance inspections	38	15	22	75
	Reviews	16	11	19	46
2020	Compliance inspections	9	8	11	28
	Surveillance inspections	25	22	31	78
	Reviews	25	16	16	57
2019	Compliance inspections	3	3	6	12
	Surveillance inspections	34	52	33	119
	Reviews	21	19	21	61
2018	Compliance inspections	5	4	4	13
	Surveillance inspections	45	34	44	123
	Reviews	25	22	31	78
2017	Compliance inspections	4	5	6	15
	Surveillance inspections	44	30	53	127
	Reviews	15	25	22	62
2016	Compliance inspections	6	5	2	13
	Surveillance inspections	37	53	50	140
	Reviews	32	13	43	88

operations after a large plant modification. The intensified supervision regime means that more inspections are done and particular progress reporting is required. Intensified supervision has been applied in several cases.

Under SSM regulations, inspection of the licensee programmes, activities and results of surveillance, and in-service inspection of mechanical components, are performed by an accredited control body ("third-party control"). If the requirements are fulfilled, a compliance certificate is issued by the control organisation (see Section 14).

8.8.4. Periodic Safety Reviews

Periodic safety reviews (PSR) were introduced in Sweden in the early 1980's as a result of the TMI nuclear accident. 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 to have the licence holder re-assess, verify and continuously improve the safety of its nuclear installations. In addition, the PSR addresses 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 radiation safety at present, and the licence holder's ability to maintain and increase it in the future. SSM's review is partly based on regulatory supervision, while including an assessment of the licensee's ability to operate the facility until the next PSR.

Recently performed periodic safety reviews are on the part of Oskarshamn 3 (2017–2018), Forsmark 1 and 2 (2018–2019), and Ringhals 3 and 4 (2019–2020). These reviews take into account new regulations and requirements laid down in the EU's revised Nuclear Safety Directive (2014/87/Euratom) (see section 7).

8.8.5. SSM's integrated safety assessments

SSM's integrated safety assessments comprise annual nuclear safety and radiation protection assessments of each major facility under SSM's supervision. Based on all compliance inspections, surveillance inspections, reviews, authority decisions and other relevant information, evaluations and a general appraisal are made of the nuclear safety, radiation protection and non-proliferation control status of the facility in relation to relevant requirements. The basic material should also cover 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 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. In order to perform the integrated safety assessments more effectively and to improve the quality of the assessment, SSM has developed a database with the aim of covering all identified deficiencies and issues from performed supervisory activities. The database was taken into operation in 2012.

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 purposes to be met, and taking the necessary steps to remedy a situation if necessary. Under the Act on Nuclear Activities, the Radiation Protection 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. Here, an overarching principle is to avoid taking a measure that is more restrictive than necessary in the case. Also, the SSM management system provides guidance on how different measures should be taken for compliance with this principle. 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 submitted for review and approval. This can be applied in combination with a fine.
- 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:

- Adjustment of the supervision (connected to intensified supervision)
- Temporary care (Radiation Protection Act)
- Sealment (Radiation Protection Act)
- Correction at the licensee's expense
- Refer suspected cases of criminal violations to a public prosecutor
- Impose additional licensing conditions.

8.10. Regulatory research

Based on the provisions concerning research, as laid down in the Ordinance (2008:452) with instructions for the

Swedish Radiation Safety Authority, the overall objective of the research funded by SSM is to:

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

SSM supports basic and applied research, and also development of methods and processes. However, for development work, the intention is to have the developed method or process preferably used by the Authority in support of the Authority's work.

SSM:s total annual research funding budget is about 95 MSEK. Of this amount, around 70 MSEK is earmarked for research relating to nuclear safety.

8.10.1. National research

Research is a prerequisite for SSM to be able to conduct its regulatory activities and to achieve its overall objectives. Research to support supervision in the nuclear field focuses on strategic areas such as safety assessment, safety analysis, reactor technology, material and fuel properties, severe accidents, non-proliferation, human factors, and emergency preparedness. Ageing of reactor components is an important area of focus, since Swedish reactors have entered or will soon enter into long term operation (> 40 years).

In the area of radiation protection, key aspects are for example research about source terms, production and spread of activated corrosion products, new detection and measurement methods, and waste treatment. More generally, research on radioecology, radiation biology and radiation dosimetry is also ofimportance.

In order to contribute to national competence and research capacity, SSM also supports research in the area of severe accidents. This is partly directed at Chalmers University of Technology and the Royal Institute of Technology, in addition to providing support for a national project, APRI, which is being run jointly with Swedish industry and academia. The purpose of these projects is to contribute to strategic national engagements in OECD/NEA and EU projects. Similar funding is directed at Uppsala University and the Royal Institute of Technology in the area of nuclear non-proliferation. Support is also provided for a long-term activity in the area of cross-section measurements and analysis of nuclear data at Uppsala University.

8.10.2. International research collaborations.

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 projects. Over many years, a general trend has been observed in Europe of increasing international cooperation in the area of nuclear safety research.

Internationally, SSM collaborates in research projects conducted mainly by the EU and OECD/NEA. Ever since Sweden joined the EU, the importance of participating in joint European work has increased. Not only does SSM have its own active role, the Authority also provides funding for Swedish organisations that participate in EU projects. SSM plans to continue providing this support in the future.

As examples, the following international projects can be mentioned:

– NKS (Nordic Nuclear Safety Research): Nuclear safety research is performed within NKS in two programme areas: reactor safety, and emergency preparedness and response; also, within bilateral agreements with Finland.
– SCIP (Studsvik Cladding Integrity Project) and SMILE (Studsvik Material Integrity Life Extension) The projects Sare OECD/NEA international Joint Projects conducted in Sweden.
– ESARDA (European Safeguards Research and Development Association): ESARDA is an important joint project focusing on the area of safeguards.
– Fukushima-related projects in cooperation with other OECD/NEA countries in, for example, TCOFF-2 and FACE.

Moreover, SSM cooperates with other government agencies internationally, e.g. the NRC (US), IRSN (France), STUK (Finland) and ENSI (Switzerland). In particular, close cooperation with the NRC is prioritised in order to have access to models and computer programs developed for three-dimensional coupled thermal-hydraulics simulations, neutron kinetic calculations, as well as severe accident analyses.

8.10.3. Long-term national competence

SSM has established from previous investigations of the prerequisites for maintaining national competence that there is a need to strengthen the national framework for knowledge management in areas relating to radiation safety, both for the purpose of meeting today's needed competence, and for anticipating needs arising in the years to come. One of the root causes of this vulnerability in the knowledge management system nationally is the present underfunding of several areas of research that are critical to society.

SSM has taken the initiative to develop a proposal for a national strategic direction aimed at addressing the national competence needs in the field of radiation safety over the next ten years. The proposal is based on conclusions from SSM's previous government assignments within national competence. It is is also prompted by a recommendation in the area of "Competence for Safety" that emerged from the IRRS mission in 2012 and IRRS follow-up mission in 2016. The proposal is broadly anchored with national stakeholders with responsibility or interest in the field of radiation safety (universities, industry, other authorities, etc.). The proposal contains a vision "A secure national competence supply in the field of radiation safety enables the socially useful use of radiation and contributes to protecting people and the environment from undesirable effects now and in the future" with proposals for a total of 21 priority actions in five strategic focus areas; national coordination, research policies for viable research environments, international research collaboration, education for the needs of society, and attractiveness of the radiation safety area to relevant target groups (students, reserachers and other professionals).

8.11. Communication

SSM's ordinance 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

Our governance policy states that the Authority's role includes working proactively and preventively in many arenas – to develop, improve and promote radiation protection and nuclear safety, and to ensure compliance. The governance policy states further that we shall influence patterns of behaviour for improvement of radiation safety within our mandates and make use of appropriate tools for influencing behaviours, and that our work should be perceived as beneficial to interested part. Communication and consultation are strategic tools used by the Authority for influencing behaviours and adding value on the part of the interested parties.

8.11.2. Communication policy

SSM's communication policy is an overall governance document that sets out how our mission and fundamental values should characterise our communication with interested parties. The policy specifies the responsibility of employees and managers for internal and external communication. It also states that SSM, as per our ordinance, shall, through information and transparency, contribute to providing the public with insight into all activities covered by our mandates. The policy also emphasises our fundamental values – credibility, integrity and openness – in communication:

Credibility

- Our messages are based on the laws and regulations governing our operations.
- We clearly convey that our recommendations and decisions are based on objectivity and facts.

Integrity

- We communicate based on our mission: achieving a radiation-safe society. We do not allow ourselves to be influenced by irrelevant interests.
- We clearly separate between our mission and actions from those of others.

Openness

- We communicate proactively and comprehensively and have accessible information about our mission, matters and mandates.
- We are also open about issues that might have a negative impact on us.
- We are attentive to the needs of interested parties, and seek new ways of communicating with them.

SSM's communication policy states that all employees are responsible for communicating in accordance with our mission and fundamental values. It also states that all employees have the right to inform the media (freedom of speech). This means that all employees have the statutory right to anonymously inform the mass media about our operations..

8.11.2.1. Overall communication strategy

SSM's communication policy is accompanied by an overall communication strategy, listing its key target groups as follows:

- Employees
- The public
- Licensees

The strategy emphasises that communication is a strategic tool for achieving the vision of a radiation-safe society, and contributing to the fulfilment of SSM's mission. It also emphasises that in order for the Authority to influence the behaviour of the target groups, they need to know and trust us. Consistent and targeted communication work is a basis for ensuring knowledge and confidence.

The communication strategy sets out how SSM's vision and governance goals can be achieved from:

- Strategies for guidance of communication work, and
- Criteria for navigating selection of communication activities.

The strategy has both an internal and an external perspective and applies to all employees. The strategy does not claim to cover all communication work of the Authority.

SSM's communication strategy is accompanied by guidelines for communication, and in some cases by separate strategies, e.g. SSM's reputation crisis communication strategy.

8.12. Follow-up of the 2012 IRRS review mission

A full-scope IAEA IRRS mission to Sweden was performed February 2012, with the resulting recommendations having been addressed by SSM in an action plan. Following arrangements made with the IAEA, a follow-up mission took place in April 2016. Two out of the subsequent 22 recommendations given by the IRRS team in 2012 were considered by Sweden in 2016 to remain open since more work was needed to close these recommendations.

The general conclusion of the 2016 IRRS follow-up team was that they were satisfied with the approach of Sweden to address the findings of the 2012 IRRS mission, and to improve the regulatory system for nuclear safety. Eleven recommendations out of the 22 identified in 2012 were closed, and a further nine were closed on "progress and confidence". Two recommendations remained open in 2016. Twelve suggestions out of the 17 identified during the 2012 IRRS mission were closed and the remaining five were closed on "progress and confidence".

The two recommendations that remain open refer to 1) provisions to maintain competence for nuclear safety and radiation protection on a national level, and 2) the systematic evaluation of operational experience from non-nuclear facilities and radiation protection events and activities, including dissemination of all significant experience. The work on these areas continues.

As a further result of the 2016 IRRS follow-up, an additional four suggestions were received. These are listed below.

SSM should:

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

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

The Swedish Government has officially requested that the IAEA carry out the next IRRS mission in Sweden. This full-scope IRRS mission is scheduled to take place at SSM in November 2022 with a preparatory meeting to be held in April. The IRRS mission is held back-to-back with an ARTEMIS-mission planned for April 2023.

SSM has developed a proposal for a national strategic focus with respect to the still open 2012-recommendation on provisions to maintain competence for nuclear safety and radiation protection on a national level. The proposal contains a total of 21 priority initiatives to satisfy the national competence needs in the field of radiation safety during the coming ten-year period. The basis for the proposal were two analytical investigations on the provisions on long term supply of competence and clarification of research needs within radiation safety, respectively. The proposal has been broadly anchored through referrals to national stakeholders in the field of radiation safety (universities, industry, authorities and others). These stakeholders have been part of a collaboration platform that has been used for several years in the agency's strategic work with national competence supply. The proposal was submitted to the Government in March 2022.

Article 9. Responsibility of the 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 of developments since the previous national report

During the current review period, the following developments are of relevance with regard to the obligations of Article 9:

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

9.1. Regulatory requirements

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

Section 10 in the Act on Nuclear Activities states that the holder of a licence for nuclear activities shall ensure that all measures are taken which are needed for:

- Maintaining safety, taking into account the nature of the activities and conditions under which they are conducted,
- The safe management and disposal of nuclear waste arising in the activities or therein arising nuclear material which is not reused, and
- The safe decommissioning and dismantling of facilities in which nuclear activities are no longer carried out.

It is also stated that the holder of a licence for nuclear activities shall, in connection with near-accidents, threats or other similar circumstance, report without delay to the regulatory body such information that is of consequence for the assessment of safety.

In the bill and the legislative history for the Act on Nuclear Activities, it is stated that the licensee shall not only take measures to maintain safety, but also measures to improve safety where this is justified.

Furthermore, according to the Act, SSM shall ensure that regulations and procedures applied are cost effective and useful for individuals as well as companies. The regulations and procedures must be formulated in a way implying that the regulatory body does not take over the prime responsibility for safety and radiation protection.

Also, 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.

SSM's regulations on safety in nuclear facilities (SSMFS 2008:1 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 by these regulations (Chapter 2, Section 9, item 8) that safety shall be monitored and followed up by the licensee on a routine basis, with deviations identified and rectified so that safety is maintained and developed further in accordance with set objectives and strategies. The meaning of this provision is that continuous preventive safety work is a legal requirement, which includes safety reassessments, analysis of events in one's own facility and other installations, and analysis of relevant new safety standards, practices and research results. All reasonable measures that are useful for safety shall be taken as a result of this proactive and continuous safety work, and they must be documented in a safety programme that is to be updated annually.

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

- Approval 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.

For nuclear facilities, the SAR, OLCs, plan for emergency response and and plan for physical protection must be formally approved by SSM before construction or commissioning are initiated. Plant and organisational modifications and changes in the safety documentation are to be notified to SSM. If warranted, SSM may impose additional conditions and requirements.

9.1.1. Development of new regulations

SSM has developed new regulations for nuclear safety, which enter into force 1 March 2022, i.e., after the current reporting period. These are SSMFS 2021:4, SSMFS 2021:5 and SSMFS 2021:6.

The biggest change relating to the responsibility of the licensees in the new regulations is the transfer of responsibility for development and maintenance of site-specific environmental monitoring programmes (Chapter 4, Section 11 of SSMFS 2021:6), from SSM to the licensee. However, the initial porgramme of the licensee still has to be approved by SSM.

According to Chapter 7, Section 4 of SSMFS 2021:5, planned modifications in the SAR, OLCs, programme for limiting radioactive discharges, environmental monitoring programme, plan for physical protection and plan for emergency response shall be notified to SSM for review, before being implemented.

9.2. Compliance of the licence holders

A number of measures being taken give evidence that the Swedish licensees are taking the 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. These safety policies are the highest level documents expressing key corporate values, and are valid for all parts of each company. The policies express a fundamental perspective on matters of safety and establish levels of ambition and priorities, such as the following:

- Always put safety first.
- Take own safety initiatives.
- Maintain an open dialogue with the regulators and with other companies on safety issues.
- Regard regulations as the minimum standard, meeting this with conservative margins.
- Take an active and leading role in research and development.
- Strive for the continuous improvement of safety.

Implementation of the safety policies is described further in section 10.2.1.

9.2.2. Continuous improvements at the plants

The principles applied to improvements at nuclear power plants are discussed in section 6.2. It is made clear by these descriptions that the utilities make substantial own initiatives to assess and improve the reactors.

9.2.3. International peer reviews

International reviews are performed on the initiative of the licensees. Several Swedish nuclear power plant staff members also participate each year in WANO as well as OSART review missions abroad. Participating as an expert is considered to be of great value to the individuals as well as to their plant organisations.

9.2.3.1. WANO peer review

Oskarshamn NPP

In autumn 2017, a WANO follow-up of the peer review conducted in 2015 took place at the Oskarshamn NPP. A total of 13 areas for improvement (AFI) were followed up.

WANO review was performed in April 2019 including a Conduct of Crew Performance Observations, CPO, for control room training at the simulator, and a CPO for work in connection with a “safety train outage” in 2019. A corporate peer review was also performed in the summer 2019.

In December 2021 a WANO follow-up of the peer review conducted in 2015 took place at the Oskarshamn NPP. A total of 8 areas for improvement (AFI) were followed up. An action plan for dealing with the AFI has been established by the senior management team. The action plan has been merged with OKG’s strategic plan. Thus, it is fully integrated in the development strategy of the company. This allows the actions to be tracked for their progress and evaluated in terms of their effect as part of the standard procedures of management review and performance management.

In August/Septemeber 2023 is the next WANO Peer review planned to be conducted.

Forsmark NPP

A WANO Peer Review was performed in Forsmark in October 2019. The purpose of the Review was to determine strengths and areas in which improvements could be made. The Review resulted in some areas for improvement (AFI). These identified areas was addressed, following an action plan agreed between Forsmark and WANO.

WANO performed a follow-up at the Forsmark NPP in November 2021. The follow-up resulted in 3 areas for improvement (AFI). The areas are within the following: Operational risk management, Configuration management (improve instructions) and Configuration management (coherent changes). Work with these issues are ongoing. The next WANO Peer Review is planned for 2024.

In addition, Forsmark has requested and performed several member support missions (MSM), within the areas equipment failure, lifting and rigging, independent oversight, risk assessment, scram reduction and design authority. Other areas supported by WANO are significant operating experience reports (SOER), where several recommendations have been implemented over the past years.

Ringhals NPP
In May 2019 WANO performed a follow up on the "Areas for Improvements" (AFI) identified during the 2017 WANO Peer Review. Based on the results from the follow up mission Ringhals updated the action plan. Enhanced interaction with WANO representative was carried out 2019 and 2020 with quarterly visits by the WANO representatives. Ringhals formed a specific forum for monitoring progress regarding work related to AFI:s and meetings were chaired by the station director.

Ringhals were scheduled for a peer review in April 2021, which was postponed due to the pandemic. A new date was set to December 2021 and the Peer Review was carried out November 24th – December 10th. The result indicated that progress had been made. In addition, as part of the 2021 Peer Review, WANO conducted a Crew Performance Observation in October 2021 and an Outage Observations at unit 4 outage in the summer of 2021.

WANO assessed Ringhals work with recommendations part of the significant operating experience reports (SOER) during the 2021 Peer Review. 92% of the recommendations were assessed as satisfactory implemented (SAT), compared to 76% after the 2017 Peer Review.

During the period Ringhals has requested several member support missions (MSM), within areas including operation, engineering, emergency preparedness and coaching.

9.2.3.2. IAEA SALTO peer review

Oskarshamn NPP
In December 2017, OKG conducted an IAEA pre-SALTO peer review for OKG unit 3. The mission resulted in three good performances and 19 issues. The LTO project at OKG has been dealing with issues arising from the pre-SALTO mission, together with other actions needed for safe long-term operation of unit 3.

Planning for future IAEA peer reviews is preliminary scheduled as follows:

- 2022: second pre-SALTO
- 2024: full scope SALTO
- 2025: follow-up SALTO

The aim is to ensure long-term and safe operation of OKG unit 3 and meet the new requirements from the Swedish Radiation Safety Authority, SSM.

Forsmark NPP
The Forsmark NPP's units 1 and 2 passed 40 years of operation and subsequently enter LTO in 2020 and 2021, respectively. Forsmark initiated a IAEA SALTO peer review program in November 2016 and performed av pre-SALTO in June 2019. The Review laid the foundation for further development efforts. A pre-SALTO follow up was performed in October 2021. The follow up resulted in 4 issues resolved, 14 satisfactory progress and 1 insufficient progress. A full scope SALTO mission is planned for 2023.

Ringhals NPP
In March 2018, an IAEA SALTO review mission was performed for unit 3 of the Ringhals NPP. The SALTO review mission resulted in 9 recommendations, 8 suggestions, 13 encouragements, 19 good performances and 3 good practices. In September 2020, a mission to reviewed Ringhals' response to recommendations and suggestions made during the initial mission was performed. The follow-up mission team found a good progress in the field of ageing management and preparedness for safe long-term operation. The plant had made significant improvements in the area of ageing management and had shown continued commitment to preparing for safe LTO. Some activities were still in implementation and some were fully completed. The plant had progressed in solving most of the issues identified during the SALTO mission in 2018. Some issues required further work by the plant, and the resolution degree was determined as following:

- 1 issue was assessed as insufficient progress to date;
- 11 issues were assessed as satisfactory progress to date;
- 5 issues were assessed as issue resolved.

Furthermore, the follow-up mission team found several good practices and good performances, including:

- The LTO project is implemented using primarily the plant's own staff;
- The plant has successfully developed and implemented a comprehensive risk informed inservice inspection methodology for piping;
- The plant has used a novel approach to identify corrosion in concrete structures exposed to marine environment

9.3. Regulatory control

SSM's regulatory activities involves promotion 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 control that the deviations have been given sufficient attention.

Reporting requirements are also an important aspect of the SSM's assurance that licensees continue 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 has to complement it, or SSM can impose further requirements or conditions on the proposed solution before it may be implemented. If more investigation time is needed, SSM can stop the implementation until the case has been investigated further. Futher information on this process can be found under section 10.5.3.

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 of developments since the previous report

Significant developments during the current review period related to Article 10 are the following:

- As a consequence of the owners decision to shutdown of Oskarshamn units 1 and 2, SSM conducted increased supervision of the safety status and licensees activities in order to closely monitor the situation. OKG have in recent years adjusted to the scope and nature of simultaneous operation and decommissioning.
- During 2021-2022, Ringhals NPP has been subject to increased supervision in order to monitor/follow the licencees adjustment to decommissioning.

10.1. Regulatory requirements

Policies that provide due priority to safety are recognised as normal safety policies and safety strategies. Safety management provisions and tools for managing a nuclear power plant apply in such a way that safety is prioritised and a good safety culture is estabilished and maintained. A good safety culture that gives safety issues the attention warranted by their significance is also a prerequisite for robust implementation of a management system.

Section 3 of the Act on Nuclear Activities states that the requirements on safety shall be fulfilled at all nuclear activities.

Chapter 2, Section 2 of SSMFS 2018:1, requires that a facility-specific implementation of a "defence in depth" shall be used to achieve safety and security for all licensed activities involving ionising radiation.

Chapter 3, Section 1 of SSMFS 2018:1, requires that the operating organization of all licensed activities involving ionizing radiation, is stuctured to ensure that safety and security can be maintained in both a short- and a long-term perspective. Also, Chapter 3, Section 2 of SSMFS 2018:1, states that 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, further requires that for all licensed activities involving ionising radiation, a management system shall be implemented and kept up to date so that requirements on safety and security are met in all relevant activities. Also, Chapter 3, Section 5 of SSMFS 2018:1, requires that the management system uses established goals, strategies, plans and objectives for the organization, to achieve this. Chapter 3, Section 6 of SSMFS 2018:1, requires that the leadership and management shall promote the safety and security culture required for the safe operation.

Chapter 3, Section 14 of SSMFS 2018:1, states requirements to systematically esure that all persons working in the licensed activities involving ionising radiation (own and hired staff) shall be given the working conditions needed to safely carry out work. Chapter 3, Section 14 of SSMFS 2018:1 futher requires that both facility design and tools used during work, and physical environment shall be adapted to facilitate safe working conditions.

According to Chapter 3, Section 16 of SSMFS 2018:1, experiences important to safety in licensed activities involving ionising radiation, from own operation or other similar operation, shall be collected, assessed and used to imrprove safety. As a part of this, Chapter 3, Section 17 of SSMFS 2018:1 states that, persons working with the activities shall be encouraged to report events and conditions that could imply a safety risk.

Requirements laid down in Chapter 2, Section 1 of SSMFS 2008:1 state that radiological accidents shall be prevented through a verified and robust design on the part of each nuclear facility. Such a design shall include multiple barriers. This is further elaborated in the general advice for the regulation, where the items below should be prioritised in order to develop and maintain effective implementation of a defence in depth in five levels, based on IAEA-INSAG-10.

In Chapter 2, Section 9 of SSMFS 2008:1, these requirements are given for safety management having the aim of giving the right priority to safety:

– Documented safety objectives and safety strategies must be in place for ensuring that safety is maintained and enhenched.
– Activities shall be planned in such a way that necessary time and resources are allocated for safety measures and safety reviews.
– Safety decisions shall be preceded by sufficient safety investigation and review; for instance, an independent safety committee should be used to review issues of principal importance for safety.
– Safety shall be assessed and followed up on a routine basis, with deviations identified and corrective measures taken so that safety is maintained and developed according to the established safety objectives and strategies.

Chapter 2, Section 10 of SSMFS 2008:1, requires that the licensees have an up-to-date safety programme. It is stated, that after commissioning, the safety of a facility shall be regularly analysed and assessed in a systematic manner. Reasonably practicable technical and organisational measures for safety improvements that are identified as a result of this analysis and assessment shall be included in an established safety programme. This programme shall be evaluated and updated annually to identify priorities and time schedules for measures to be taken.

The regular analysis and assessment should take into consideration technical and organisational experience from the plant's own activities as well as from other similar plants, results of relevant R&D-projects and development of safety standards. Organisational experience includes for instance; results of Man, Technology and Organisation (MTO) analysis, evaluation of organisational changes, evaluation of work conditions, and self-assessments of the working climate and safety culture.

10.1.1. Development of new regulations

SSM has developed new regulations for nuclear safety, which enter into force 1 March 2022, i.e., after the current reporting period. The requirements from SSMFS 2008:1 mentioned under 10.1 will be found mainly in Chapter 2 of the new regulations SSMFS 2021:6. A difference from SSMFS 2008:1 is that Chapter 2, Section 1 of SSMFS 2021:6, more clearly requires that the management system of a nuclear power plant uses defined goals and guidelines, that can be used for evaluation, to promote the maintenance and improvemen of safety (and security).

In addition to the old requirements Chapter 2, Section 3 of SSMFS 2021:6, requires the licensee of a nuclear power plant to have an organizational function for independent review of decisions important to safety or security, independent safety assessment, monitoring of safety performance, and that continuously works to improve all nuclear safety activities. To this, Chapter 2, Section 21 of SSMFS 2021:6, requires the licensee to continuously and systematically monitor and evaluate the safety performance of the nuclear power plant using several performance indicators. Chapter 2, Section 20 of SSMFS 2021:6, now clearly requires the licensees to have an implemented operating experience programme.

Chatpter 2 of SSMFS 2021:6 also includes reuirements that clarify the importance of safety assessment in decision-making, in work preperation and in the implementation of modifications to the nuclear power plant.

10.2. Compliance of the licence holders

10.2.1. Safety policies

The safety policies (see section 9.2) issued by Vattenfall and Uniper, express the most important corporate values regarding nuclear safety. They have been interpreted and further developed in the management systems for each nuclear power plant. The safety policies are reviewed periodically and the policies of the plant managements are reviewed by external and internal safety audits.

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. Furthermore, for many years local safety review committees have been established at plant level to advice on principal safety issues.

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. At Vattenfall there are two parallel management structures, one for safety and one for operational responsibility. The roles often coincide. At OKG there is one management structure applied for operational structure. Safety management are included in the reponsibility of all managers at OKG.

The basic principles 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 required by SSM's regulation SSMFS 2008:1. The programmes are 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 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 indicators are classified into four groups: Maintain and Develop the Plant, Maintain and Develop the Competence, Develop Structures and Behaviours, and Reinforce Trust in the Ringhals NPP Internally and Externally. 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.

A description is provided below on safety management development at Ringhals over the past three years. Safety management has been adjusted in accordance with the Ringhals CEO's allocation of tasks across the organisation by introducing operation and construction management. Safety issues with a direct impact on the plant safe operation are dealt with by the operation management, and safety issues without a direct impact on the plant are dealt with by the operation and construction management

Safety evaluation has been divided into four safety rating levels according to complexity and impact on the individual, construction, or the environment.

- Safety management level 4 is represented by the skift manager or the shift engineer who is responsible for the safety within the limits of procedures and technical specifications. Level 4 should continuously evaluate ready and mandate to order changes to the facility's operation within assigned management responsibility. Level 4 is also responsible for all work permits on safety relates equipment. Safety related deviations should be reported to the safety management level 3.

Forsmark NPP

The level of safety in plant operations is monitored in several ways, including the use of performance indicators. The indicators are classified into four areas: Safety and Environment, Production and Plant, Competence and Staffing, and Efficiency and Cooperation. The indicators measure factors such as fuel integrity, Safety Incident for employee, radiation exposure, unviability of safety systems, and outage deviation. There are 16 indicators on company level. These are further broken down on department level. The indicators are periodically reviewed (monthly or quarterly) by the management teams. Any deviation from expected performance is analysed and actions for improvements are decided on by the plant manager.

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 under the heading "Goals and Safety Indicators".

Structured work on KPIs forms the basis for continuous development of the management structure. Currently, the concept of "Operational Excellence" is being rolled out throughout the organisation. Visual management, in which KPIs are published on "visual boards" as a basis for decisions, follow-ups and planning, is a vital part of Operational Excellence.

10.4. Use of WANO Performance Indicators

All licensees utilise the complete WANO programme of Performance Indicators including the WANO Indicator Index. This is a weighted index consisting of ten specific indicators. The calculation of the Indicator Index was developed by INPO and is used for evaluation and setting goals for NPPs.

WANO Index is a method to be able to quarterly create an overview over performance indicators. The Index have values from 0 to 100 and calculates as weighted values. Higher result is a better performance.

The following 10 indicators are included in the Index, listed from highest (weighted) to lowest:

- Unit Capability Factor UCF (0,15):
- Forced Lost Rate FLR (0,15)
- Unplanned Automatic Scram UA7 (0,10)
- Safety System SP1 (327), 2 (322), 5 (650) (0,10) Fuel Reliability Indicator FRI (0,10):
- Collective Radiation Exposure CRE (0,10)

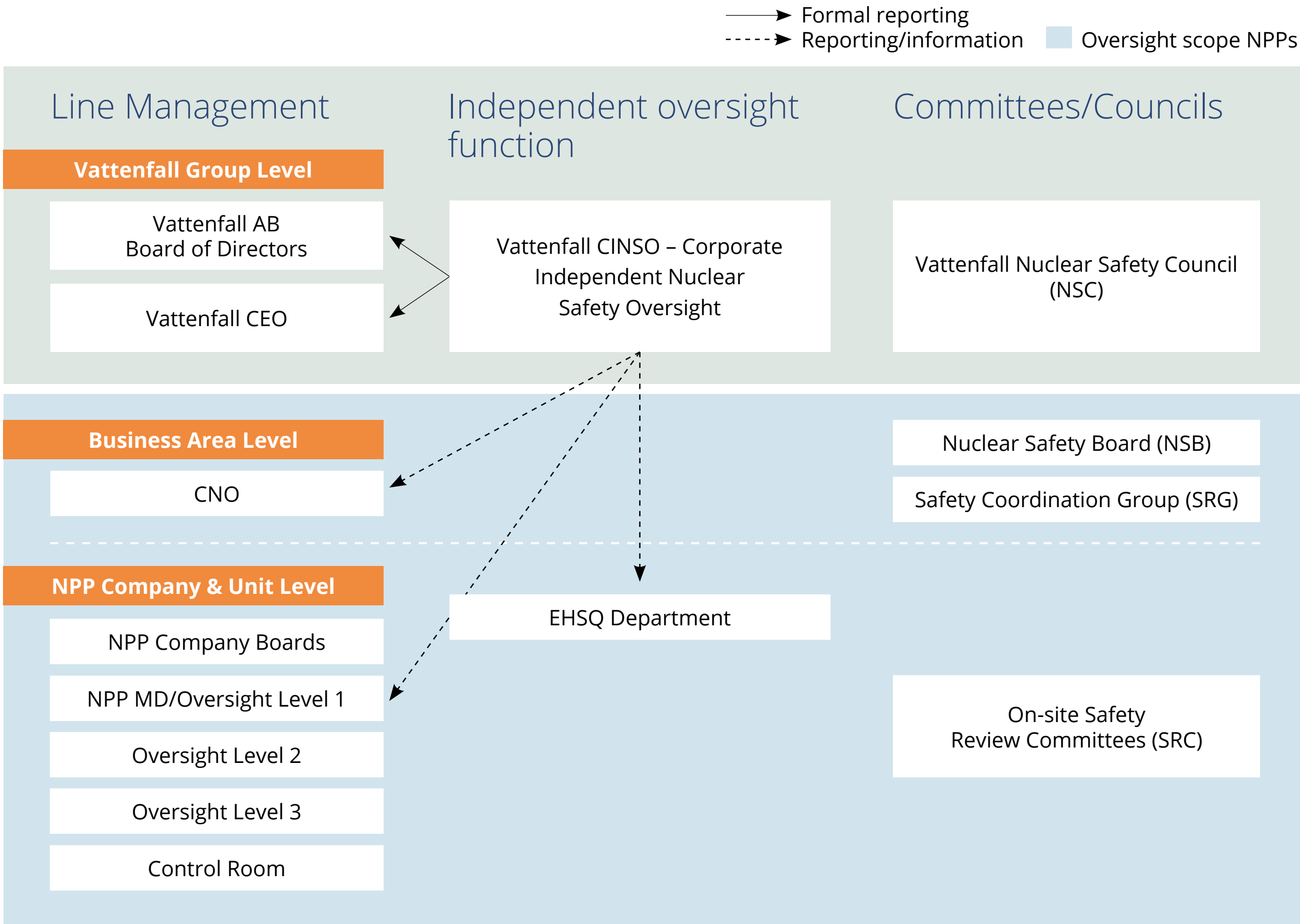

Figure 13. Schematic illustration of Vattenfall's Corporate Independent Nuclear Safety Oversight.

- Chemistry Performance Indicator CPI (0,05)
- Industrial Safety Accident Rate ISA (0,05)

10.4.1. Vattenfall's Corporate Independent Nuclear Safety Oversight

Independent Oversight at Vattenfall Corporate Level

The CEO of Vattenfall conduct independent oversight of nuclear safety and performance through two functions independent of the line organisation: the Corporate Independent Nuclear Safety Oversight (CINSO) function, and the Nuclear Safety Council (NSC). (See figure 13).

In addition to the NPP independent safety organisations, Vattenfall has established an independent nuclear safety oversight function on high corporate level, namely the Corporate Independent Nuclear Safety Oversight (CINSO) group reporting directly to the CEO of Vattenfall. 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 on nuclear safety and performance. By reporting its findings, the CINSO function is also to provide added value to the Chief Nuclear Officer (CNO) and the licence holders. The CNO reports directly to the CEO.

The NSC advises the CEO on matters of nuclear safety and performance from an external perspective.

The members of the NSC are appointed by the CEO, and the CEO is Chair of NSC. The NSC consists of external experts possessing extensive experience from the nuclear field. The CNO and head of CINSO participate in the NSC meetings.

10.4.1.1. Whistle-blowing function

CINSO has a "whistle-blowing" function i.e. anyone within the Vattenfall organisation may contact CINSO regarding concerns on nuclear related safety issues.

The CINSO whistleblowing function has a broad scope regarding safe nuclear operations. Any serious concerns related to nuclear and radiation safety could be reported to CINSO, whether they be issues on technical matters, competence, safety management, safety culture etc., in cases of non-compliance by the line organisation.

10.4.2. Corporate independent oversight (CINSO) at Sydkraft Nuclear Power Sweden AB (SNP)

In Sweden, the licence holder has the full responsibility for nuclear safety according to the Act on Nuclear Activities and national regulations. This means that the licence holders of the operating nuclear companies have the full responsibility for taking measures to comply with the legislation. Additionally, all nuclear activities within Uniper shall comply with the Uniper Nuclear Safety Policy, which also constitutes an important point of reference for the corporate independent nuclear oversight performed.

CINSO is independent of the line organisation, and reports directly to the CEO at SNP. The purpose of CINSO is to create an additional layer in the defence in depth by advising SNP´s CEO and top management on safety and performance in SNP´s nuclear business. Processes and performance should be systematically assessed with identified gaps reported to the line organisation for decision making and actions.

The basis for the process of CINSO is to challenge safety performance over and above legal requirements and the level of standards and guidelines from international organisations. The activities should be planned adequately in order to ensure that all relevant aspects of SNP´s nuclear-related business are covered, thus providing the means to work systematically and be proactive. This is done as part of a continual review plan that is reviewed annually to also cover current areas of interest.

Assessments are made with the aim to achieve best safety performance from a corporate point of view, thus adding value by reviewing quality and safety against safety criteria and best practice. Nuclear safety assessments are performed in order to identify areas for improvements and to give a second opinion for the line organisation's safety oversight.

Depending on the severity of identified gaps, reporting is to be performed immediately or according to a reporting schedule. Recommendations made by CINSO are followed by relevant indicators until completion.

The main recipient of outcomes from CINSO is the CEO of SNP. Regular reporting also takes place to SNP's board of directors and to the managing directors of the plants.

A number of different evaluations of the function of CINSO have been conducted. The effectiveness of the independent oversight process is self-assessed annually.

Uniper also has a Nuclear Safety Council which serves as the highest independent function. Uniper Nuclear Safety Council, UNSC, consists of senior nuclear experts and provides recommendations to the CNO based on a combination of observing the organisation and the plants and by studying assessment and performance reports. Most members of the UNSC are external senior experts who give an additional, external view on safety aspects.

10.4.2.1. Whistleblowing function

Employees at Uniper are to report any potential violations of the Code of Conduct and other violations of law or internal company policies. All employees have the opportunity to securely submit reports on any violation, also anonymously if desired, via the Uniper "whistleblower hotline".

Reports on potential violations within the company may be directed to any member of the Uniper Compliance Team and to supervisors serving as internal ombudsmen. This opportunity is equally available to all third parties (e.g. customers and suppliers) who have a business relationship with Uniper.

Each report received will be treated with the utmost confidentiality. Also, all employees who report potential rule violations benefit from special protection according to the principles of the Code of Conduct. In other words, a whistleblower need not fear any retaliation resulting from his or her report.

Investigations and evaluations relating to compliance incidents are coordinated by the chief compliance officer at Uniper.

10.4.2.2. Legislation board at OKG

Uniper, as the owner, exercises control over OKG. Uniper governs OKG through recommendations and business strategies.

OKG, as a licensee, 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 OKG from the perspectives of current legislation and safety requirements.

10.4.3. Safety culture programmes

Maintaining a strong safety culture when operating and decommissioning nuclear power plants 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.

10.4.4. Safety Management at OKG

In order to strengthen the conditions for, and understanding of, a safe and efficient business, OKG has over the past three years maintained focus on safety management, operational excellence and safety culture. The aim has been to increase the competence of the employees and to create an understanding of how their own tasks have an impact on radiation safety and the importance of performing them correctly. Among other things, these efforts have taken place in the form of dialogue seminars for all employees and certain hired staff.

10.4.5. Safety culture during a period of preparation for decommissioning

Oskarshamn NPP

Since the last report the work with safety culture within the framework of decommissioning has been streamlined with the safety culture strategy and activities being generally adopted at the OKG NPP. The same values, expectations and actions are applied to decommissioning as well as operations.

Ownership for safety culture has been firmly established in the management of the decommissioning and is an integral part to maintaining safety at the sites.

Some activities have been performed to accommodate the shift from radiological safety to a more conventional industrial safety perspective. This has been a gradual progress as the plant has transitioned from activities that are radiological in nature, such as removal of fuel from the reactors, tracing and removing radioactive materials and cleaning out radioactive environments to more conventional jobs such as dismantling, cutting and logistical handling of parts and debris.

With the transition from primary hazards from radiological to industrial a tighter cooperation has been established with the work environment to ensure a safety culture perspective. This has been activities such as joint meetings, safety culture perspective in work environment inspections, joint perspective and attendance of Pre Job Briefs among other activities.

Changes in organizational structure within the decommissioning project has required a renewed focus on psycho-social wellbeing and its effect on safety culture. Surveys have been performed to gauge the feeling and attitude of workers and managers in a transitional situation. Coupled with management dialogue a re-established focus has been on prioritizing management in the field, conventional coaching and safety coaching on select jobs has been prioritized areas.

Continuous sharing between the different decommissioning sites has been performed enhance safety culture. Since the same activities and work is being performed at multiple sites care has been taken to utilize the experience and learning in each activity to enhance performance when it's being performed at other sites.

The pandemic has had an influence on how safety culture is handled but is not specific to decommissioning. See chapter 12.2.1.2.

Ringhals NPP unit 1 and 2

The decision to decommission Ringhals units 1 and 2 was made in April 2015. In May 2015, a dedicated project, called STURE, was assigned to prepare for the decommissioning. The purpose of the project is to prepare for decommissioning, mainly regarding technical and organisational aspects, and thereby support the line organisation focusing on safe and reliable operation.

One part of the STURE project is a sub-project on human resources and safety culture. The purpose of this project is to identify and secure overall company actions needed within the areas of human resources, competence and safety culture.

The safety environment of a plant requires regular and sufficient attention so that a healthy nuclear safety culture can be maintained. The transitional period between a decision and a shutdown poses a challenge to the safety culture. From literature studies and experience exchange, three risks have emerged as essential to address:

- Loss of motivation,
- Loss of knowledge and experience, and
- Decreased quality in work processes, with degraded technical safety as a consequence.

Goals, strategies and measurements

The goal is to prevent safety culture degradation due to the shutdown decision, i.e. a healthy safety culture should be maintained. The strategy of the project is to decrease or mitigate the consequences of the three risks mentioned above. This is carried out in cooperation between the project's human factors and safety culture specialist, together with the line organisation's representative, who has the formal responsibility.

Methods for identifying signals from the organisation have been developed. These are monitored continually and corrective actions are identified, when applicable. For key actions, the effect of corrective actions is monitored. Applicable activities include:

- A method was developed in 2015 for regularly evaluating whether signals on degraded safety performance due to a shutdown decision can be identified within the organisation, or whether signals can be identified relating to the company's capability to successfully manage the transition; this method has been applied every three months since its inception.
- An interview programme involving 10 managers was introduced in 2017. This programme is carried out quarterly to convey an up-to-date picture of organisational status regarding the change process, motivation, competence, challenges, etc. on the part of different departments and groups. An analysis of aggregated results is also performed on a yearly basis.
- Comments and conclusions from the Swedish Radiation Safety Authority's supervisory activities are compiled yearly, and relevant corrective actions are evaluated.
- A supplementary follow-up of signals indicating a high workload was carried out in 2017, with a follow-up on motivation to be performed in 2019.

Actions

Several actions have been taken in relation to safety culture in the stage of transition to decommissioning:

- A safety culture workshop was held in 2016 in order to identify and discuss safety culture challenges related to the transition to decommissioning. In addition to the risks identified from literature and experience exchange, the workshop resulted in five focus areas (groupthink, normalisation, clear standards, motivation, lack of holistic perspective).
- After the safety culture workshop, communication took place in 2016 and 2017 covering the five focus areas. The topic was on encouraging managers and employees to reflect upon their current and future work situation.
- Two workshops with employees regarding the future at Ringhals were held in 2017. Their purpose was to focus on new opportunities in the future.
- A "transition to decommissioning" perspective is applied to other safety culture evaluation activities, such as the company's overall safety culture evaluations, which were performed in 2016 and 2018.
- A workshop was carried out in 2018 on the topic of organisational and social work environment.
- Another strong emphasis is placed on high-priority topical issues in the area of communication (see section 11.2.2.2).

10.5. Regulatory control

SSM performs a number of regulatory activities in order to verify that the licensees give adequate priority to safety. Some examples are provided below.

The supervision described in section 8.8 is targeted to assess how safety is prioritised. Examples include inspections of licensee safety programmes, management of organisational changes, management of safety reviews, and management and assessment of incidents (conservative decision making).

SSM applies a special methodology for rapid response surveilliance inspections following significant events. Also, the decision-making process on the part of the licensees regarding the operational status of the reactor following an event or identified deficiencies has received increased attention in recent years.

Another tool used for evaluating whether the licensees are assigning adequate priority to safety is a yearly integrated safety assessment (see section 8.8.5), which provides an updated and comprehensive regulatory assessment of facility safety.

Furthermore, SSM monitors the work of licensees on safety culture issues. This is mainly conducted through its regular inspections. The role of SSM in this context is to ensure that the licensees have proactive safety management in place. SSM expects the licensees to create 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. If such deficiencies are not corrected, the ability of the operating organisation to handle difficult situations and maintain safety will deteriorate.

10.5.1. Regular top management meetings with the licensees

At least once a year, the director general and department directors of SSM meet with the management group of each nuclear power plant to discuss current issues and safety priorities. Annual meetings are also held with the corporate executives of the utilities.

10.5.2. Special or increased supervision

Ringhals NPP and the licencees adjustment to decommissioning has been subject to increased supervision during 2021–2022.

OKG have adjusted to the scope and nature of simultaneous operation and decommissioning since a period of special supervison which was established in 2012 and ended in 2016.

10.5.3. Actions taken by SSM to prioritise safety

One of the basic concepts of SSM's supervisory programme is to dedicate its 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 facilitate SSM's prioritisation of forthcoming supervisory activities relating to key safety issues. Inspection results, international work, research and other inputs may indicate that SSM needs to devote regulatory resources to specific facilities and safety issues.

Moreover, the general safety regulations (SSMFS 2008:1) allow 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, in addition to as 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 also 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, and assisted by external experts if necessary. Large plant modifications must be notified in the form of a preliminary safety analysis report in order to systematically clarify all the interactions with the existing safety case. Following the commissioning and the first entry into routine operation, necessary findings are to be incorporated in the SAR, and the SAR shall be finalised so that it describes and represents the nuclear power plant's as-built status.

SSM has an established a procedure with specified criteria to assess the notifications and to decide whether a notification is sufficiently important from a safety point of view to warrant detailed review (see section 14.3.5). A standing group of experts (ABG) has been established by SSM in order to conduct a first assessment of all notifications. This group makes a proposal regarding each notification at the management meeting of the nuclear power plant safety department. The proposals are categorised as follows:

- No further action
- To be postponed until the notification meets the expected quality
- The notification should be further reviewed regarding specified aspects (in this case the licensee is allowed to introduce the modification during the SSM review)
- The proposed modification shall not be allowed to be introduced until SSM has finalised it´s review.

The process of pre-reviewing of notifications is an efficient and effective procedure that meets the expectations of SSM. It is also made clear that SSM has the necessary regulatory control over the modifications without having to review everything in great detail or to grant permission. This has enabled SSM to allocate resources to more important safety tasks. The criteria in use puts 20–25% of all notifications into the recommendation category "review to be performed".

This system allows SSM to concentrate its review resources on safety issues of key significance, while also retaining full insight intothe measures taken by the licensees.

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 of developments since the previous report

Oskarshamn units 1 and 2 are permanently shut down and Ringhals units 1 and 2 were closed in 2020 and 2019, respectively. This has reduced the number of employees needed, and this number will be reduced further. At the same time, this will increase the need for employees within the area of decommissioning. The licensees have handled the situation by conducting a proactive transitional activity. The licensees have reduced redundancies in their operational organisations and the number of individual agreements for leaving the companies has been smaller than initially expected. This approach has ensured sufficient competence in the organisations and a distribution based on the needs.

Since last reporting period, the following developments have taken place with regard to the obligations of Article 11:

– Significant financial funds have been invested in Swedish nuclear power plants during the last few years.
– A revision of the Financing act was promulgated in 2017, clarifying the principles for how the nuclear waste fee is calculated and how assets in the Nuclear Waste Fund are to be managed in order to reduce the state´s financial risk. Based on the revised act, nuclear waste fees and finacial guarantees for Nuclear power plants have been decided by the Government for the period 2018–2020.
– General transfer of competence is still of high priority at all Swedish nuclear power plants.
– New working methods for transferring employees have been developed, as a consequence of the need for more employees in the area of decomissioning and the opposite for reactors in operation.

11.1. Regulatory requirements

In order to obtain a licence in Sweden, large adequate financial resources must be committed in order to manage the far-reaching safety obligations required by the Act on Nuclear Activities and SSM's regulations. Each prospective licensee must be assessed in this respect.

In addition to this basic requirement, power plant licensees must pay a fee on each produced kWh to a state-controlled fund, the Nuclear Waste Fund, as per the Act on Financing of Management of Residual Products from Nuclear Activities (2006:647). This is to ensure that financing is available for the future decommissioning, management and disposal of spent fuel and nuclear waste, including the research needed for these activities. The fees are calculated on the assumption that each reactor will generate electricity for 50 years, though always with a minimum remaining operating time of six years. If there is insufficient assets in the Fund to pay for the costs, the licensees will nevertheless still be liable. For a reactor site with no reactor in operation, the remaining costs for a permanently shut down reactor shall be paid to the fund within three years. In addition, the power plant licensees shall provide two separate financial guarantees as security in order to account for possible early shutdowns and for costs in connection with unforeseen events. The Government´s decision in December 2017 on fees and financial guarantees for the period 2018–2020[2] for the first time took into account the utilities decisions for the early permanent shut down of reactors in Oskarshamn and Ringhals, resulting in fewer production units paying for the future liabilities.

Licensees are also required to pay regulatory and research fees invoiced by the regulatory body. These fees are laid down in ordinances and payable to the Government, see also section 8.5.9.

2 The nuclear waste fees for 2018-2020 are 0.033 SEK/kWh for Forsmark Kraftgrupp AB, 0.064 for OKG AB and 0.052 for Ringhals AB. Required financial guarantees amount to an average of 14 billion SEK per licensee.

As mentioned under 10.1, Section 3 of the Act on Nuclear Activities requires that the safety requirements shall be fulfilled at all nuclear activities. Section 13 2 of the same Act, further requires that licensees shall have the required operating organization, financial, administrative and personnel resources to achieve this.

In the area of human resources, Chapter 3, Sections 10 and 11 of SSMFS 2018:1 clearly stipulate requirements for staffing, competence and training of personnel at all licensed activities involving ionising radiation. The licensee has to ensure that the staff has the competence and suitability needed for all tasks of importance for safety or security. This must be documented. Long-term planning is required in order to ensure a sufficient and available workforce having adequate competence and suitability for the safety-related tasks. A systematic approach should be used for the definition of competence requirements, and for planning and evaluation of all safety-related training. Annual competence assessments shall be performed. To the extent applicable, these general requirements also apply to using contractors. Another requirement for safety-related tasks is to ensure a careful balance between using in-house personnel and contractors. The competence necessary for ordering, managing and evaluating contracted work should always exist within the organisation of a nuclear installation.

In addition to the general requirements in SSMFS 2018:1, Sections 6 and 7 of SSMFS 2008:26 contain requirements on training principles and practices for radiation protection, valid for both own personnel and contractors, in two levels depending on tasks assigned to the individual worker. The first level of this training (minimum requirement) must be repeated every third year. Section 8 of SSMFS 2008:26 also states that the training performed should be documented.

Specific regulations govern operational staff at nuclear power plants and research reactors (SSMFS 2008:32 Regulation on the competence of operation personnel at nuclear reactor facilities). These regulations also encompass operations managers and plant managers to the extent the latter are involved in the operational decision making. Operational staff must be formally authorised by the licensee for the specific position. The authorisation is valid for three years under certain conditions.

Chapter 10, Sections 1–3 of SSMFS 2014:2 also specifies more detailed requirements on competrence and training regarding emergency preparedness and emergency response at nuclear facilities.

According to Chapter 4 Section 2 (and annex 2) of SSMFS 2008:1, the principles for training and examination of competence for all personal of importance to safety shall be documented in the SAR.

11.1.1. Development of new regulations

SSM has developed new regulations for nuclear safety, which enter into force 1 March 2022, i.e., after the current reporting period. For nuclear power plants, the regulations SSMFS 2008:1, SSMFS 2008:32, SSMFS 2008:26 and SSMFS 2014:2 are superseded by the new regulations SSMFS 2021:4, SSMFS 2021:5 and SSMFA 2021:6, from 1 march 2022. The new requirements on competence and training are manily found in Chapter 3 of SSMFS 2021:6. While previous requirements of SSMFS 2008:32 focused on specific roles and positions in the organisation, the new requirements instead uses a broader perspective of tasks to be performed, using a graded approach to the safety significance of the tasks performed by individual personnel. The new requirements also more clearly requires a systematic planning of competences and human resources, criteria for competence requirements, training, authorization and re-authorisation of personnel, by the licensee. Chapter 3 of SSMFS 2021:6 also include new and clarified requirements regarding quality of education and training of personnel.

11.2. Compliance by licence holders

11.2.1. Financial resources

The majority owners of the Swedish nuclear power plants are Vattenfall and Sydkraft NP, with ownership shares as shown in figure 3 of section 1.2.3. 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 producers in Sweden and elsewhere in Europe. Besides the nuclear power plants, they also have substantial assets in hydropower, thermal power and wind power. Both groups are financially stable and have good financial records.

To date, all safety investments in the nuclear power plants are decided by the bord 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.

Table 4. Number of employees working for the licensees.

Nuclear Power Plant	2021	2020	2019	2018	2017	2016	2015
Oskarshamn*	561	555	575	629	672	865	957
Forsmark	1145	1152	1154	1166	1168	1166	1154
Ringhals**	1017	1194	1277	1375	1420	1498	1627

* 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.

11.2.2. Staffing

The number of employees working for the licensees has been changing somewhat over the past few years, see Table 4. 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, as before, between 500 and 1,000. The decision in 2015 by the plant owners to decommission four reactors at Oskarshamn and Ringhals, and the subsequent initiation of decommissioning activities at the respective sites, have led to stepwise decreases of staffing numbers at the plants, while at Forsmark, the number of employees has been relatively stable.

A challenging factor regarding the continued use of consultants is that several of them having experience from the start of the nuclear programme have changed positions and or are no longer 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 nuclear power plant organisations is obvious when considering the average age of the plants. At OKG, the average employee working today is about 49 years old. In addition to these figures, about 15 employees per year face retirement from OKG over the forthcoming years. Of OKG's 565 present employees, the ratio male-female is about 80/20. The situation is comparable to the situation at FKA and RAB.

All licensees work actively to transfer knowledge from soon to retire, experienced staff to the next generation. The planning 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 modernization and development projects as well as in international R&D projects. Current planning at the different sites is described below.

The decision to permanently shut down the four oldest units in Sweden has made the competence and staffing plans even more important. Activities regarding competence planning have therefore been intensified and the plans are more detailed. The goal is to secure competence prior to the closure and to support a good transition process.

11.2.2.1. Transferring of competence at the Oskarshamn NPP

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

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 is still 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 OKG to meet the challenges of keeping two units in decommissioning and one unit in long-term operation. OKG must be successful in maintaining strategic competencies and obtaining new competencies simultaneously.

OKG has thus performed a staffing and competence analysis for the remaining business timeframe for the period 2015-2050. The aim of this analysis has been to assess the need for various competencies and estimate staffing levels during the entire expected life span of the company. The experience and the result from the transition within the company is that new working methods are developed as a result of a reduced total workload, with fewer employees and 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 therefore there is a recurring need for reconsideration parts of previous analyzes. In accordance with OKG's routines, a review of the staffing analyzes is carried out annually. For example, in the framework of the development of the work with demolition and demolition, OKG reviews the staffing analyzes over time.OKG has completed the planned transition as regards the number of employees in two steps – the first step in autumn 2017 and the second step in autumn 2019. A total of 150 employees left OKG as a result of termination or individual agreements during these years. During the same period of time approximately 220 employees changed positions or organisation affiliation.

A change of this kind requires careful preparation, and great importance is attached to managing identified risks so that safety and serviceability are not compromised during the transition work. Risk analyses have been conducted continuously at different levels and having different time perspectives. Skills requirements that arise in the business are handled in a company transitional meeting, where decisions on further management are made. The magnitude and nature of the needs that arise paint an ongoing picture of the state of competence in the company, and indicate whether there is a need for more extensive measures in any specific area.

On a more detailed level, mapping of key competencies has been carried out at the company. This basis has given OKG a comprehensive picture of key positions and individuals within the company, which in itself has provided the prerequisites to be able to plan strategies and conduct long-term development planning for the whole organisation in a more robust manner. Examples of activities that have been run to address the problem of staffing and competence of staff within OKG and in the industry are strengthening of the brand, expanding contacts with the education system, and deepening collaboration with regional businesses and various types of industry. This includes BWR Future, an investigation in which Nordic licensees and suppliers jointly map available competencies in the area of boiling water reactor technology. OKG 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 supply of additional, changed and existing competence areas requires a structured and goal-oriented work with competence assurance. It also requires an effectiv use of the tools that are available, such as plans for competence development, competence transfer and succession planning. This applies to both the competence needed for the decommissioning of unit O1 and O2 and the competence needed for the long-term operation of unit O3.

Transition work at the Oskarshamn NPP

The overall strategy for the transition work has always been to have the work and its approach create an image of the company that all employees are proud to be part of, and to have those who are let go have the desire to start working for the company again if the possibility arises.

The decision to end operation of units 1 and 2 made redundancies necessary. However, thanks to the company's proactivity immediately after the announcement to shut down units 1 and 2, measures were taken to minimize the future redundancy, and the figures for redundancies and individual agreements were smaller than was initially expected.

A transitional meeting was created, the purpose of which was to have all the competence needs that arise in the company dealt with there for further decision making. This is to ensure that sufficient competence exists and that it is distributed where it is best needed. As a result, external recruitments have been minimized during the transition period.

Since the announcement of closure 2015, a total of 480 employees have left the company. Of these, a total of 150 employees left OKG as a result of downsizing 2017 och 2019. During the period från 2015 until 2021 about 330 employees departed for natural reasons, such as retirement or other jobs outside OKG Staff turnover was during the years 2016 and 2017 higher than normal, and the reason for this was likely the uncertainty sensed by many people during the transition of the company and the currently very favourable local labour market. From 2018, staff turnover returned to normal.

During the summer and autumn of 2016, OKG and the owners produced a staffing analysis, and in parallel, work began on developing new competence requirements for OKG's operations. In 2017 step one in the planned transition as regards the number of employees was completed. In this step all employees were assessed against the new requirements for the position they had at the time. The competence assessment and the previously completed mapping of formal competence were important tools for future staffing of the new OKG.OKG then conducted negotiations with the trade union organisations, where the staffing level was established and the proper procedure was decided. The main principle was that the number of years of employment and sufficient competence were the primary selection criteria. The company produced a basis for staffing at the individual level, which also became the subject of negotiation before a message could be submitted to all co-workers. In 2019 step two in the planned transition as regards the number of employees was completed in similar ways as step one.

In connection with the redundancies, recurring checks of fitness for duty were carried out in the business, and throughout the process, transparent and factual information was provided to employees. All departments at OKG also carried out recurrent psychosocial surveys in order to be able to catch signals early on if the general conditions changed. The questionnaires also provided the basis for internal discussions and adapted support measures. When all employees were informed, the managers could also start planning for transfer of competence, handing over assignments, and receiving new employees. In support of this work, checklists were developed.

Prior to adapting the staffing, the department head presented a departmental implementation plan for the transition in order to create an overall picture of the change and document the measures that would be implemented to manage the changeover. The plan was a living document throughout the transition. It was of great importance to be prepared to be able to quickly manage the changes that the process entails. Other important measures are the management's accessibility for conversations and support in everyday life and in dialogue stations, supplemented by the CEO and HR manager's round of visits to all departments to meet employees in a direct dialogue. Altogether, these measures have been crucial to the success of the implementation, progress and result alike.

To be able to ensure the competence of control room staff at unit 1 and unit 2, which was one of the largest risks identified, a number of measures were taken. From the first moment after the owners' notice regading decision on closure, continuous meetings were held where both the CEO and the HR manager, together with the plant managers, met with employees in joint dialogue. In addition to this, specific agreements were concluded for the benefit of the operators.

One conclusion from the year of transformation was that it is important to continuously evaluate risk analyses and associated measures. Some changes in the business have taken place faster than planned, while others have been slower. For this reason, it has been crucial for the management to continually monitor signals from the organisation.

At the end of 2020, the company management evaluated the transformation with both internal and external competencies.

In 2020, an annual process began for long-term competence management with the purpose to meet and deal with the challenges and oppurtunities that follow from simultaneously operating one single unit in production and two units for decommissioning. As a result of the annual process, joint work has been established within Uniper Nuclear Sweden in the areas such as competence assurance, attractive employers and supplier market.

11.2.2.2. Competence assurance at the Ringhals NPP

In the next few years, it is estimated that 30 employees are expected to retire from Ringhals each year. Strategies for transferring key competencies are based on an annual competence and staffing plan covering future needs and the balance between Ringhals employees and contractors or consultants. The need for competence transfer is an annual process. The "competence transfer" means an intentional learning programme having a clear goal in a situation where a person (mentor) with important knowledge will retire, resign, or where Ringhals from a vulnerability perspective needs to change a specific skill. The mentor then transfers the competence to one or more persons (mentees) so that the knowledge is retained at Ringhals.

The competence and staffing plan is based on an annual inventory regarding the strategic competencies that Ringhals needs for fulfilment of short and long term company goals.

A specific method for competence transfer was developed and has been in place since 2009. The method involves the following steps:

- Inventory: To annually create a comprehensive list of all possible candidates for skills transfer.
- Selecting: To determine which persons' competencies should be transferred.
- Competence Inventory: To create an understanding of the skills that each mentor is expected to transfer. Also, to select one, or several, mentees, and to assess the need for support from human resources (HR) to implement all the skill changes.
- Training: The purpose of this training is to give the stakeholders a shared understanding of the following areas: what skills transfer is, what each role entails, the areas included in the transfer of skills, and the support or assistance that is available.
- Competence Shift Plan created: To create a skills transfer plan that describes in detail how the work will be performed in terms of objectives and activities. Identify forms of monitoring and for starting skills exchange.
- Competence Exchange Activities implemented: To implement the planned activities for achievement of the set of competence transfer goals.
- Monitoring and evaluation conducted: Follow up to ensure that the objectives of competence shift are achieved and to consider experience for further process development.

The decision for permanent shut down of Ringhals 1 and 2 was taken in April 2015. In May 2015, a dedicated project was assigned to prepare for the decommissioning. The purpose of the project is to prepare for decommissioning, mainly regarding technical and organisational aspects, thereby supporting the line organisation focusing on safe and reliable operation. A sub-project concerns Human Resources (HR) and safety culture.

Goals, strategies and evaluations

A long term goal for the HR transition was developed to secure the right competence and staffing as of that time and forward to minimize potential redundancies. This is essential in the ambition to decrease risks regarding loss of motivation, loss of knowledge and experience, as well as degradation in work processes.

The following goals for the HR transition have been developed:

- Create a clear picture of the future and a well-defined change process up until 2022.
- Secure and adapt competence and staffing continuously.
- Managers will have abilities and feel secure in handling the change process.
- Everyone will receive information and have opportunities for dialogue and support.
- Everyone will have an individual professional development plan, both short term and long term.
- We will cooperate internally and externally to identify good solutions from company and employee perspectives.

To support the goals, the following strategies were identified:

- Continuously strive to perform actions that lead towards current and future needs regarding organisation, strategies, ways of working, competence needs and the number of employees.

- Strong focus on listening and flexibility. Adapt the plan to upcoming needs.
- Minimise the risk of redundancies in the form of natural personnel turnover or transitions to other units of Vattenfall, i.e. decommissioning, or externally. The company cannot promise more than it can keep.
- Collect experiences and good practices from decommissioning and HR transitions.
- Communicate and visualise future possibilities with a focus on units 3 and 4.

Evaluation of performance indicators, i.e. leadership index, engagement index and personnel turnover, was established. Methods were developed for identification of other signals from the organisation. Indicators and signals were monitored on a monthly basis and acted on by senior management. Trends were monitored over these years. If needed, corrective actions were taken. As far as concerns key actions, the effect of corrective actions was monitored.

Actions on an overall organsational level
Several actions have been taken on various management levels in the organisation.

The most important actions are:

- In 2015, individual dialogues were initiated between managers and employees to deal with feelings relating to the decision. Since then, individual dialogues are one of the most important communication tools during the change process.
- Incentives for control room operators were implemented in 2015 and revised in 2016. A bonus scheme was implemented in 2017 for the control room operators of units 1 and 2.
- Training in change management was provided for managers, union representatives and HR staff in 2015 and 2016.
- Principles for management of the HR transition were negotiated in 2016. New meeting fora for addressing questions concerning competence and staffing were implemented on departmental level and company level in 2016.
- A simplified internal recruitment process was implemented in 2017.
- Individual dialogues regarding individual wishes for the future were conducted in 2017 and 2018, in addition to a gap analysis comparing future needs with employees' wishes.
- An incentive programme called "65 plus" was introduced in 2019 to encourage elderly employees to remain in the workforce instead of retiring.

Actions on departmental level
Operations, and especially the control room operators of units 1 and 2, have been an area of special concern due to the risk of losing competence and motivation. Several actions have been taken on departmental level, for example:

- A risk forum addressing risks and needs during 2015–2016.
- Estimating and mapping the needs of employees from 2020 and onwards.
- Investigating and mapping the employer's ambitions in relation to the company's future needs.
- Preparation to reduce shifts (from seven to six) in the event of large staff turnover.
- Regular meetings with employees for information and involvement.
- Training and transferring operators from units 1 and 2 to units 3 and 4 to increase flexibility and motivation.
- Contractors help to bridge gaps.
- Analysis of minimum staff during defueling ready in 2019.

Actions have also been taken by other parts of the organisation. Within engineering and maintenance, minor organisational changes are continually made to reduce the number of employees. One major challenge is restricted recruitment when employees depart – preparing for unit 2 operation – while retaining key skills and expertise. The actions were taken to increase flexibility within and between departments as well as achieve effective use of consultants and contractors.

Communication
Close collaboration was maintained between the project and communications. A communication strategy and plan have been developed.

Communication has mainly focused on opportunities:

- Decommissioning – development and possibilities.
- Opportunities for personal development – focus on internal recruitment.
- A long time between the decision and shutdown from a human perspective – time to plan and address questions and challenges.
- Two reactors will close, two will stay in production. The company will still be a major employer.
- Decommissioning opportunities for employees forming a new business area.

Communication has mainly involved weekly updates via a newsletter on the intranet with a personal tone of voice. The risk of losing one's job is a personal matter and should be addressed with this in mind. Multiple channels have been used: meetings, open fora, opportunities to pose questions anonymously to the management, and editorials in the staff magazine and on the intranet.

11.2.2.3. Competence assurance at the Forsmark NPP
The goal for transferring competence is set in the business plan. To create a positive attitude, the human resource department and the respective managers have to be engaged and take responsibility for carrying out the action plans.

The process of transferring competence (knowledge, skills and attitude) consists of several steps:

- Whose competence is important to transfer? The identified need of transferring necessary long-term competence is documented in the annual strategic action plans, following a dialogue conducted between the respective managers and HR staff.

– What kind of competence? The chosen individuals work in groups developing the existing task analysis, focusing on the specific competencies of each person. In view of explicit and tacit knowledge by means of, for example, interviews and observations, new information is gathered on performance of the tasks.
– To whom shall the competence be transferred? The results of renewed and in-depth competence task analysis are used to complement available working methods for the competence transfer and documentation, e.g. instructions, material for training, work rotation, supervision and guidance, pre-job briefing, and daily practices. Depending on the level of knowledge and experience of recipients or mentees suitable methods are identified. The measures must be discussed in the development dialogues and documented in the personal development plans.
– How to transfer competence and by whom? Several methods can be used depending on the recipients or mentees and supervisors. In the case of employees who will serve as supervisors, the measures are to be discussed in the development dialogues and documented in the personal action plans.

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 period 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 review period varies in the range of 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 the local centres situated near the power plants. 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 control

Through its supervision, SSM has concluded that the licensee compliance with SSM's requirements for competence assurance is satisfactory. 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, SSM has previously observed delays and quality problems in the modernisation and power uprate programmes at the nuclear power plants. It is paramount that these kinds of problems do not negatively affect the safety of the plants. SSM is therefore continuing to focus attention on the licensees' systems for ensuring quality of services purchased, e.g. assuring supplier and consultant competence. In addition, the licensees' reliance on contractors and consultants might decrease in the forthcoming years, due to the permanent shutdown of four units. It is difficult to predict whether this will affect the long-term availability of contractors with the right competence. On the other hand, the shutdowns might lead to an increase of contractors with other competencies, and is therefore something that will be considered by SSM in the future.

11.4. National availability of qualified experts in nuclear safety and radiation protection

As described in Section 1.2.7, all actors in the nuclear industry in Sweden are working systematically with competency management and competence retention.

SSM and the industry are also working systematically to monitor the availability of qualified experts. In September 2018, SSM submitted a government assignment on the national long-term competence supply in the field of radiation safety to the government. The final report describes how a healthy competence supply consists of university education that attracts students to study in the field, research that provides university programmes with competence and meets society's need for expertise, and employers who attract and employ the skilled labour.

The report shows that there are shortcomings in the supply of skills in the radiation safety area in Sweden, mainly due to the following:

– Students are not being attracted to the field as decommissioning is taking place.
– Financial pressure has made the nuclear industry reduce its research budgets.
– Nuclear programmes at the universities suffer from a lack of students and declining research budgets.
– Certain competencies needed mainly in emergencies are in low demand by employers for their day-to-day operations, thus making it difficult for research projects of this kind to find matching sources of funding.
– There are no incentives for central government sources of research funding to liaise on concerted investment for sustaining dynamic research environments relating to radiation safety.

The report submitted to the Government includes the following suggestions:

– A comprehensive national strategy with coordinated efforts is needed for achieving a higher level of effectiveness in the knowledge management system.
– Increase the funding provided to the critical core of research environments needed to maintain the knowledge management system.
– Formalise the interaction between stakeholders in the system for central government research funding to guarantee that the relevant research environments as described above will be sustained.
– Ensure that education programmes critical to society in the field of nuclear safety and radiation protection can be run, and that the content of courses relating to the field is given defined objectives as necessary and subjected to quality assurance.

In addition, one recommendation was given to employers within the field:

– Several stakeholders should run campaigns and issue communication for attracting students so that they enrol in nuclear safety and radiation protection education programmes and choose occupations in the field.

Since September 2018, some progress has been made. The industry has with good results carried out campaigns to attract employees, one university nuclear programme that was previously closed down due to few student applications has reopened, and SSM is reforming its work to strengthen the national strategic perspective on long-term knowledge management.

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 of developments since the previous report

- New general requirements have been implemented 2018 including further development of many of the requirements related to human and organisational factors.
- Hosting of the first Country-Specific Safety Culture Forum.
- New requirements for nuclear power plants in operation have been developed and enter into force in March 2022, i.e. outside of the current reporting period. The requirements will cover Human and organisational factors.

Introduction

The area of human factors has developed over many years and is now to many people known as "human and organisational factors" in order to further highlight the breadth of the areas covered. This is also reflected in the development of SSM's Code of Statutes.

12.1. Regulatory requirements

In June 2018, new general requirements were implemented in the form of regulation SSMFS 2018:1. This regulation governs a wide range of requirements related to human and organisational factors, replacing several requirements contained in SSMFS 2008:1. What differs the new general requirements from earlier requirements in this area is a more detailed regulatory framework with additional requirements and clearer guidelines that are provided.

The regulation SSMFS 2018:1, in conjunction with certain requirements contained in SSMFS 2008:1, impose extensive requirements relating to human factors on the following:

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

Chapter 3, Section 1 of SSMFS 2008:1 states general requirement on that the design of a nuclear facility shall enable maintenance, surveillance and in-service inspection of structures, systems and components important to safety. The same section also general requires that the design as far as resonably possible, shall facilitate radiation protection (and physical protection). Chapter 3, Section 3 of SSMFS 2008:1 also states that the design of a nuclear facility shall be adapted to the ability of operating personnel to monitor and operate the facility during both operational states and accident conditions. Also this adaption shall be assessed.

According to Chapter 4 Section 2 (and annex 2) of SSMFS 2008:1, the principles for design of control rooms and other operating positions where the human/machine interface is important to safety, shall be documented in the SAR.

In addition, the regulation SSMFS 2008:17 contains more specific requirements on:

- Design to allow operators sufficient time to understand situations and take safe actions,
- Design of the central control room and the secondary control room/control post,
- Evaluation of control room design as well as verification and validation of new solutions, and
- Design requirements for detection and control of core instability.

SSM requires that the licensees have adequate staff with competence concerning human factors in order to conduct independent safety reviews (see section 14.1.3) of relevant issues. There is no explicit requirement to have staff with behavioural science competence in the line organisation of the operators; however, SSM recommends this in order to integrate the human-technology-organisation (MTO) perspective early on as part of plant modifications, experience feedback, investigation of events, assessments of safety culture, etc.

12.1.1. Development of new regulations

SSM has developed new regulations which enter into force 1 march 2022, i.e., after the current reporting period. New requirements in SSMFS 2021:4 will supersede the requirements related to human factors of SSMFS 2008:1 and SSMFS 2008:17, for nuclear power plants. Chapter 4, Sections 18–20 of SSMFS 2021:4 present general requirements on incorporating human factors engineering principles in design of a nuclear power plant, with specific requirements on control rooms and other operating positions in Chapter 7, Sections 21–24. In general, the new requirements are more clear in describing the aim of minimizing risks for human errors, and that procedures and human tasks shall be included in the design, together with structures, systems and components. The new regulations SSMFS 2021:4 also include a separate chapter, Chapter 3, for requirements on the process of design, construction and commissioning. The requirements in this chapter also enhance the importance of a comprehensive view of safety during this process including the human/machine interface and the importance to validate i.e. operating and other procedures during design and commissioning.

12.2. Compliance of the licence holders

Maintaining a strong safety culture in the operation of nuclear power plants 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's, 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 interaction between MTO has become an established component in the nuclear safety work of all Swedish nuclear power plants, supported by policies, responsibilities and organisational structures. Currently, all the licensees have MTO 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 MTO issues, experience feedback, safety culture, management development and organisational issues. Typically, MTO 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, Human System Interface (HSI). 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 MTO 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).

A network for Human Performance and Safety Culture (HUSC) involving the NPP licensees in Finland and Sweden as well as SKB, KSU and Westinghouse. The network was established in 2006. The aim of the network is to exchange information and develop expert knowledge. This initiative is still ongoing.

12.2.1. Ongoing activities

Oskarshamn NPP

Ever since OKG's long term programme for improving safety culture (referred to as the "Action plan for safety culture at OKG") was implemented in 2004, OKG 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.

OKG has, apart from a continuous work with safety culture as a strategic tool to enhance safety, emphasized the practical application of safety culture and its tools.

A review of existing Human Performance Tools with optimizations and changes to facilitate ease-of-use has been performed. Coupled with this OKG has constructed a work- and behavior simulator with the express goal to create a learning experience for managers and workers that show 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 show how they apply at a simulated plant work place.

The simulator is created to allow management of all levels to educated and discuss the different areas of the simulator with their personnel as well as clarify their expectations on how to maintain safety at the plant.

The simulator has been utilized during normal operations but a special focus has been applied ahead of outages where the majority of internal and external personnel with work connected to the outage has been educated. It has been very well received by both management and workers alike.

Furthermore, safety culture and work environment has become more tightly integrated with joint strategic planning to enhance the synergy between two interconnected fields.

OKG has also integrated a national culture perspective in safety culture. Analysis and workshops with regards to how an overarching national culture effects behaviors and actions has been performed on both a plant and corporate level.

This has further led to focus on how management and workers work with accountability to ensure and evaluate safety at the plant.

The pandemic has created challenges with regards to how the site should work with safety culture. Much of the work is normally done in the personal interactions between management and staff, worker to worker and organization to organization. Due to the separation that the pandemic required these interactions have been disrupted. OKG has during this time had focus on Safety messages, messages focused on different safety related topics with expectation that the message is presented by the managed and discussed in the group as well as online workshops and tighter and clearer dialogues between managers on how to handle the new risks that the pandemic brought.

A human performance simulator was developed at OKG 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. Also, during 2018 the package regarding pre-job briefing (PJB), post-job debriefing (PJD) at OKG was updated and restructured to better support the users. The procedures were updated with new checklists and different levels of PJB and PJD, the existing requirements were clarified, and new requirements were set regarding documentation.

In 2017 and 2018, OKG carried out cross-group seminars for all managers, employees, long term contractors and partners. The focus of the seminar was on discussing the interconnections between safety culture, safety management, and operational excellence.

At OKG, weekly safety messages have been distributed for discussion by the entire organisation. This format was implemented in 2014 and has been ongoing since then. In 2015, the maintenance, production, engineering, and shared services departments contributed with two safety messages each. In 2017, this format expanded to now also include the safety department and managing director. All employees work together with the safety culture department to formulate messages for discussion by the organisation.

Forsmark and Ringhals NPPs

At the Forsmark and Ringhals NPPs, the role of coordinating safety culture development and activities is since 2018 delegated to the safety and compliance departments. Expertise and best practices are shared between the two plants. Development of nuclear safety culture is part of the normal procedures incorporated in the management system, and encouraged by the reactor safety programme. The programme is revised annually and approved by the chief executive officer.

A comprehensive evaluation of safety culture is performed at each site every four years. The evaluation follows a Vattenfall corporate instruction for assessing safety culture, and consists of both quantitative and 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. The safety culture survey is administered every two years. Other sources of input for the comprehensive evaluation of safety culture include a summary of feedback from group discussions following the safety culture survey, evaluation of event analyses, evaluation of licensee operational events, interviews, evaluation of trends in indicators, and comments from IAEA OSART missions, WANO reviews and SSM reviews and inspections.

Safety culture questionnaires are used as a tool for development of the safety culture, together with other activities. A shared initiative has been taken by the licensees to improve the questionnaire.

At the Ringhals NPP, a human performance improvement project was carried out during the period 2015-2019. The purpose of the project is to increase the focus on continuous improvements to human performance in order to achieve safe and well-performed results throughout the company. All managers and staff receive an extensive training programme that includes areas such as usage of human performance tools, managers coaching in the field, feedback training, self-assessments, how to utilize staff competence in human performance development with group dialogues, and fallibility models. The focus on human performance improvement and general competence for safe and good job performance were increased throughout the organisation. Managers and supervisors now have the tools for continuation of everyday improvements to human performance.

12.3. Regulatory control

The unit of Coordination and Human and Organisational Factors at SSM is, since june 2021, located within the unit of Supervision. The section consists of five professionals, with a behavioural science background. The MTO specialists conduct inspections, safety reviews and other supervisory activities. The unit is also responsible for coordinating the supervision, e.g SSM´s supervision prgrammes and the integratet safety assessement performed annualy.

Current tasks for the unit include inspections and reviews of management systems, organisations and organisational change, safety culture and management of safety, operational decision making and time for consultation, competence, training and staffing including fitness for duty, working conditions for safety, MTO perspective of plant modernisations and modifications, in accordance with the supervision programme. In many cases, the MTO specialists lead the inspections in which they are involved.

12.3.1. Current regulatory research

The unit of Coordination and Human and Organisational Factors has procured projects on e.g. dealing with challenges faced by organisations under economic pressure and human capability for dealing with unforeseen events. SSM also provides funding for postgraduate studies and an associate professorship in Man-Technology-Organisation at Lund University. For many years now, the Authority has provided support to the Halden Reactor Project in Norway.

Strengthened supervision due to shutdown decisions

From 2015, SSM performed strengthened supervision of the Ringhals and Oskarshamn NPPs, after the decisions were taken on the shutdown of Ringhals units 1 and 2 and Oskarshamn units 1 and 2. The strengthened supervisions have now been completed, and SSM continue to follow the licennsees ongoing work with decommissioning in several supervisiory activities, e.g assessement of event reports, rapid-, and surveillance supervision. The plants under decommissioning are also integrated in SSM´s supervision programme.

12.4. National culture

12.4.1. Workshop on national culture traits

One area that came into focus after the Fukushima Daiichi accident was the challenging issue of the relationship between national culture and nuclear safety culture. All cultures have certain characteristics or traits that reinforce nuclear safety culture, and all cultures have characteristics that might not provide this reinforcement. A Country-Specific Safety Culture Forum (CSSCF) was 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 2018[3].

The purpose of the forum is to enable licence holders and the regulatory body in a specific country to explore which factors and characteristics of the national culture can influence safety culture. The design of the forum is meant to facilitate an open and explorative dialogue on possible essentials for maintaining a healthy safety culture. In addition, the dialog should also explore suggested actions for mitigating potentially negative aspects and identifying best practices.

The explorative dialogue that took place during the forum, in conjunction with material from interviews and focus group sessions ahead of the forum, resulted in six themes, or characteristics, which can be recognised as rather typical Swedish cultural traits, or national attributes in Sweden. (See figure 14 on next page.)

To some extent, these national attributes can all reinforce nuclear safety culture, or might have a negative impact on nuclear safety culture if they are not taken into account.

The first-of-its-kind forum conducted in Sweden was considered a success, building on a foundation for continued reflection and work relating to national cultural traits and their impact on the safety culture of licence holders, the regulatory body, and the Swedish safety infrastructure as a whole.

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

Figure 14. National attributes recognised during the CSSCF forum.[4]

4 This figure depicts only certain aspects of national attributes in Sweden. These were among the themes that emerged during the CSSCF forum, discussed by participants representing the nuclear infrastructure in Sweden.

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 of developments since the previous report

- New general requirements have been implemented.
- Change in legal conditions for supervision concerning suppliers.

13.1. Regulatory requirements

In June 2018, new general requirements were implemented in the form of regulation SSMFS 2018:1. Among many areas, this regulation covers quality assurance, thus replacing similar requirements that were contained in SSMFS 2008:1. What differs the new general requirements from earlier requirements in this area is a more detailed regulatory framework, including additional requirements and clearer guidelines that are provided. SSMFS 2018:1 requires nuclear activities with regard to related design, construction, commissioning, operation and decommissioning to be managed, controlled, assessed and developed by means of a management system so designed that requirements for safety will be met. The management system, including the necessary routines and procedures, must be kept up to date and be documented. This view on the integration of quality and safety with other business concerns into a total integrated management system is in line with the IAEA Safety Requirements on Leadership and Management for Safety, GSR Part 2.

The management system should cover all nuclear activities at a nuclear facility. Chapter 5, Section 2 of SSMFS 2008:1 specifies more detailed requirements on establishment of appropriate operating procedures and guidelines, applicable for situations correspronding to normal operation, anticipated operational occurences, design basis accidents and design extension conditions. Also requirements on priciples for these procedures and guidelines are included, as well as requirements on quality assurance and update due to experience feedback.

It is furthermore required by Chapter 3, Sections 7 and 8 of SSMFS 2018:1 to have the application of the management system, and its efficiency and effectiveness, audited systematically and periodically. An established audit programme shall be in place. It is furthermore required by Chapter 2, Section 8 of SSMFS 2008:1 that the internal audit function should have a sufficiently strong and independent position in the organisation and should report to the highest management of the plant. 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.

Furthermore, Chapter 2, Section 8 a of SSMFS 2008:1 requires that it should be made clear by the management system how contractors and vendors are to be audited, and how to keep the results of these audits up to date.

The legal conditions for supervision of suppliers have been changed through changes made in the Act on Nuclear Activities (1984:3). This gives the regulatory body the possibility to monitor how the safety requirements are followed concerning activities conducted by suppliers or their subsuppliers and contractors or their subcontractors or other parties delivering services to the licensees.

13.1.1. Development of new regulations

SSM has developed new regulations for nuclear safety, which enter into force 1 March 2022, i.e., after the current reporting period. For nuclear power plants, the regulations SSMFS 2008:1 will be superseded by the regulation in SSMFS 2021:4, SSMFS 2021:5 and SSMFS 2021:6.

Changes in the regulations include that Chapter 2, Section 4 of SSMFS 2021:6 specifies that the scope, design and layout of all procedures, shall be adapted to their important to safety (or 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. The new regulations also more clearly and in more detail, specifies requirements on applicability, principles and quality assurance of the operating procedures, compared to the older requirements in SSMFS 2008:1. New requirements are included regarding temporary operating procedures (Chapter 5, Sections 12), and deviations from operating procedures (Chapter 5, Sections 13). Chapter 5, Sections 15 and 16 of SSMFS 2021:6 specify detailed requirements on procedures for core management and handling of fuel assamblies.

The new regulations SSMFS 2021:6 also more clearly express 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 and security.

The new requirements of Chapter 2, Section 3 of SSMFS 2021:6, specifies that the licensee shall have an independant part of the organization, supported by the top management, with the function of independent review and supervision of that all requirements on safety and security are met for design and operation of the power plant. This part of the organization shall also be in contact with SSM.

Other important additions in the new regulations, relating to quality assurance, are also Chapter 3 of SSMFS 2021:4, containing specific requirements on management and quality assurance of design and construction work, and Chapter 2, Section 8 of SSMFS 2021:6 together with Chapter 7 of SSMFS 2021:5, containing new requrements on safety (and security) demonstration for quality assurance during implementation of modifications at the nuclear power plant.

13.2. Compliance of the 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. Since the previous national report was issued, the licensees have continuously management system to have a stronger focus on integrated processes and information modelling.

13.2.1.1. Forsmark NPP

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

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

FKA 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 GS-R part 2 (new version of GS-R-3) was published.

13.2.1.2. Ringhals NPP

RAB's management system is an integrated, modernised and user-friendly management system. This means that RAB has an overall structure which includes clear steering, evaluation and development of processes to fulfil goals and strategies. RAB also has a process for handling of requirements which involves corrective actions and verifications. The ambition of RAB is to fulfil external requirements for management systems, derived from nuclear as well as conventional industry models.

13.2.1.3. Oskarshamn NPP

No structural or principal changes regarding management and governance have been made to the operating system. 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. An introduction is ongoing, focusing on methods for process mapping in the organisation.

Procedures for requirement management and requirement handling have been mapped, and associated routines have, in connection with this, been simplified and adapted to the processes. Spring of 2017 was characterized by continued implementation in the management system of the requirements contained in the new ISO standard for the environment, 14001:2015.

13.2.2. Audit programmes

At licensee 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 nuclear power plant level.

The licensees have processes in place for performing audits and running audit programmes. These processes are used to monitor how well the quality 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 quality audits are performed on a regular basis so that all areas are covered over a three years period. At FKA and RAB, 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 by IAEA Safety Guide GS-G-3.1.

Forsmark and Ringhals NPPs

FKA and RAB also utilise different methods for self-assessment. The management system at both plants requires performance of self-assessments at different levels in the organisation. Both methods for performing self-assessments are based on IAEA Safety Guide GS-G-3.1.

Oskarshamn NPP

During this review period, several development activities have been carried out by the internal audit organisation of OKG in order to create more added value for the organisation. Staffing of internal audit teams has changed so that the auditors are now part of the safety and quality department. Previously, auditors from the entire organisation were used. Audit teams are led, and the audits evaluated, by lead auditors who work on the section's internal audit within the safety and quality department. This change was made to ensure that auditing resources are available to meet the needs of the audit programme.

A new audit training programme covering the audit process and related methodology has been developed. Auditors have taken part in this programme. The audit process itself has been strengthened by means of human performance tools for reinforcement of safety and quality. Another development activity has been initiated to bolster evaluation of identified audit findings by supporting the managers to a greater extent. Here, the objective is to ensure that findings are manage systematically to prevent their reoccurrence.

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. 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 control

As per the new supervisory programme, SSM conducts baseline inspections in all areas. The MTO section has recently conducted baseline inspections of the licensees' management systems, organisations, and organisational change management. The purpose of the baseline inspections regarding 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 also to determine whether the management system is suitable, up-to-date, accessible and effective enough.

As far as concerns the baseline inspections in relation to an organisation, the purpose is to determine the current status of the licensees' organisations and their systematic work on ensuring 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 judge the suitability of the organisation. The inspections also include looking into licensee management of organisational changes.

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

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 of developments since the previous report

During the current review period, the following developments have taken place with regard to the obligations of Article 14:

- Sweden has intensified and developed its management of ageing issues and long term operation, as well as supervision in this area.
- The development process for new regulations for assessment, as was mentioned in the previous report, has been extended. The regulations will come into force on 1 March 2022 which is after the current reporting period.

14.1. Regulatory requirements

14.1.1. Requirements for Comprehensive and Systematic Safety Assessment

The requirement for a safety programme is defined in Chapter 2 of the regulations concerning safety in nuclear facilities (SSMFS 2008:1). Requirements on safety assessment, safety reviews and reporting are mainly defined in Chapter 4 of SSMFS 2008:1. Since the previous report, the requirement on identifying events, event sequences and conditions that are of importance to safety and associated assessment has been superceeded by Chapter 2, Section 1 in the new regulations (SSMFS 2018:1) on basic rules for all licensed activities involving ionising radiation. This also applies to the requirement on keeping the assessment up to date. The legally binding requirements and the corresponding general advice are summarized below.

14.1.1.1. Safety analysis report

A comprehensive deterministic safety analysis shall be performed before a facility is constructed and before it is taken into operation. In addition to the deterministic analysis, the facility shall be analysed using probabilistic methods in order to provide a more complete picture of an overall safety level.

A preliminary safety analysis report is required to be prepared and approved before a facility may be constructed and, for an existing facility, before major refurbishing or rebuilding work or major modifications are carried out. The safety analysis report (SAR) must be renewed before commissioning, and completed before the facility may be taken into commercial 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 safety analysis report is to be kept up to date.

The SAR shall reflect the plant as built, analysed and verified, and show how current safety requirements are met. All safety systems as well as all other plant structures, systems and components of importance for the defence in depth shall be described in the SAR. New safety standards and practices, which have been assessed by the licensee and found applicable, shall be documented and incorporated into the SAR as soon as the corresponding modifications or other plant measures have been taken.

14.1.1.2. Safety programme

The licensee must have a safety programme in place. After a facility has been taken into operation, the safety of the facility shall be regularly analysed and assessed in a systematic manner. Such analysis and assessment shall cover applicable rules for design, construction and operation as well as assumptions and methods applied. Reasonably practicable safety improvement measures, technical as well as organisational, resulting from such analyses or assessments, are to be documented in the safety programme and implemented in a timely manner. The safety programme shall be reviewed and updated on an annual basis.

14.1.1.3. Periodic Safety Reviews

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 comparable level of safety as new nuclear facilities. Thus, the PSR process is an important instrument for ensuring safe long-term operation of nuclear facilities in Sweden, see section 14.3.5

14.1.1.4. Long term operation

SSM determines the specific point in time for submission of periodic safety reviews for each facility, which according to the Act on Nuclear Activities (see section 7.1.2) must be performed at least once every ten years. In the general advice for the regulations, it is clarified that the periodic review of the facility's safety, including radiation protection, should provide a basis for determining, at an established point in time, whether the facility can continue its operation until the next periodic safety reviews with the level of safety assumed in the licence for the nuclear facility. Since the previous report, SSM has also decided to adopt a standpoint accepting status of continued operation (LTO) in connection with the PSR reviews.

The general advice also specifies that the periodic safety review should cover 17 safety review areas. It is also clarified that if the facility does not fulfil relevant, new safety standards, measures should be implemented if this is considered to be reasonable and suitable with respect to the benefit to safety, taking into account the existing design assumptions of the facility.

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 material condition of the reactors comply with design requirements and operational limits and conditions.

Chapter 5, Section 3 of SSMFS 2008:1, includes requirements on continuous surveillance, maintenance and testing of structures, systems and components important to safety to ensure that they meet the safety requirements. Programmes are required for maintenance, surveillance, inspection and testing. The programmes must be carried out using methods validated for their purposes. Measurement and test devices shall be calibrated in line with instructions. Programmes shall be documented and kept up to date with regard to new experiences and developments in science and technology. In order to ensure that maintenance, as well as continuous inspections and controls, are carried out in line with safety requirements, the licensee must have documented procedures.

Functional testing to verify operability has to be performed before structures, systems and components are taken into operation following maintenance or other interventions. Programmes for testing of active components should reflect consequences of a fault and the probability of this occurring. The functional testing has to be carried out with the frequency and scope providing confidence that the equipment will fulfil its required function, as credited in the safety analysis. The functional tests shall reflect the circumstances 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 equipment, limits and conditions, damage control, accreditation of control organisations and laboratories, in-service inspection and control , repair, replacement and modification of structures and components, as well as on compliance control and annual reporting to SSM.

Regulation SSMFS 2008:13 requires certain inspections and inspection intervals for specified components, such as the reactor pressure vessel and its nozzles, etc. In addition to such compulsory inspections, the nuclear power plants are required to allocate the mechanical components in the plants to a number of inspection groups. The inspection groups determine the extent of the in-service inspections. The inspection programme, resulting from the use of the principles, shall be reviewed by the accredited inspection body to certify that the programme complies with the regulations and 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 as described above. In inspection groups A and B, the non-destructive inspection systems used shall be qualified by an NDT qualification body to detect, characterize and size any existing defects to the required standard. Apart from the division into inspection groups, mechanical components must be divided into five 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 the respective 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 the SSM regulation. In addition, a qualification body, approved by SSM, qualifies the non-destructive testing systems used and certifies their suitability for the component and applicability in question. The inspection companies (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

Chapter 4, Section 3 of SSMFS 2008:1 specifies requirements for licensees' safety reviews. The objective is to ensure that all relevant aspects of a safety issue 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.

The safety 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 measures maintain or improve the level of safety.

Areas which, as per regulation SSMFS 2008:1 and the regulations contained in SSMFS 2014:2 concerning emergency preparedness in nuclear facilities, are subject to the licensee's own safety review, include the following:

- Technical or organisational modifications to a facility which might affect the conditions specified in the safety analysis report,
- Principal modifications in the safety analysis report,
- Modifications in an emergency response plan,
- Modifications in the OLC,
- Modifications in procedures concerning the control of readiness for operation as well as procedures and guidelines intended for abnormal operation and accidents,
- Investigations carried out as regards deficiencies in barriers and in defence in depth, and the measures taken as a result of the deficiency, and
- Plans for necessary measures for ensuring safe confinement of non-conforming waste (nuclear waste arising which, in terms of quantity and type, deviates from specification in the safety analysis report).

14.1.3.1. Development of new regulations

SSM has developed new regulations which enter into force 1 March 2022, i.e., after the current reporting period. During operation of a nuclear power plant, Chapter 2, Section 2 of the new regulations SSMFS 2021:6 requires that all decisions significant for safety or security, are adequately and comprehensively prepared and informed in order to prioritize safety. Further, Chapter 2, Section 6 of SSMFS 2021:6 requires that all works to be performed at a nuclear power plant have to be prepared and controlled by a administrative system, to verify that the work does not entail unacceptable risks and that OLCs are not exceeded. Chapter 5, Sections 1 and 2 of SSMFS 2021:6 also requires a continuously verification of that the power plant at all times are ready for operation and that operations are within the OLCs.

Chapter 2, Section 5 of SSMFS 2021:6 specifies general requirements for implementation of programmes for i.a. surveillance and in-service inspections. Chapter 6, Section 2 of SSMFS 2021:6 specifies the aim (to verify equipment availability) and scope of these programmes (structures, systems and components important to safety), while Chapter 6, Section 3 further specifies the basis for surveillance through functional testing. Also Chapter 6, Section 4 of SSMFS 2021:6 requires that faults or deficiencies found during i.e. preventive maintenance shall be correted as promptly as possible.

14.1.3.2. Safety reviews

In the new regulations, requirements relating to safety review during operation of a nuclear power plant are divided into several levels of review. While Chapter 2, Section 5 of SSMFS 2021:6 requires that continuous experience feedback and review shall be included each implemented programme in order to keep them up to date, Chapter 2, Section 21 of SSMFS 2021:6 states requirements on continuous systematic monitoring and review safety (and security), for the plant operation as a whole, using measurable performance indicators. A comprehensive annual follow-up and assessment of this work is also required, which shall be reported to SSM.

From Chapter 2, Sections 5 and 20 of SSMFS 2021:6, a licensee is also required to have an implemented operating experience programme (see also 19.7.3). This programme forms an important tool in the safety reviews mentioned above.

Chapter 5 of SSMFS 2021:5 presents detailed requirements on the PSR required by Section 10 a of the Act on Nuclear Activities (1984:3). The chapter and the associated Annex 3 specifies aim, approach and scope of such a review.

14.2. Compliance of licence holders

The Act on Nuclear Activities (1984:3) stipulates that a licensee shall continuously and systematically evaluate and, as far as possible and reasonable, improve the safety of its activities and its facilities with regard to:

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

14.2.1. Safety analysis reports

Earlier major development of the Swedish safety analysis reports (SAR) is described in previous national reports.

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 testing.

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

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 1204 °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 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 (see section 18.1) were met.

The regulation SSMFS 2008:17 issued in 2005 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. Since the previous report, deterministic safety analyses for Forsmark 2 have been renewed for their applications for routine operation following power uprates.

The deterministic safety analyses for Oskarshamn 3 was renewed and accepted by the regulator and Oskarshamn 3 have permission for routine operation after the power uprate.

14.2.1.2. Probabilistic safety assessments

All nuclear power reactors have complete level 1 and level 2 PSA studies including all operating modes and viritually 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 requirements 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 is used to evaluate plant modifications. 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 CCF, actions to improve fire protection, improvement of operator support, and improvements to maintenance and testing. Since the previous report, PSA has been used to evaluate safety improvements for transitional measures pending installation of the new independent core cooling system (ICCS) and of the new ICCS itself.

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 Common Cause Failure (CCF) data is 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 purchased[5]. Access to the R Book and the C Book is possible via the Nordic PSA Group (NPSAG)[6].

5 Contact TUD@vattenfall.com
6 See www.npsag.org

NPSAG was founded in December 2000 by the nuclear utilities in Finland and Sweden. SSM, the Finnish regulator (STUK) and the Swedish Nuclear Fuel and Waste Management Company (SKB) participate as associated members. The associated members may take part in the funding of the projects run within the NPSAG. NPSAG is a forum for discussing issues relating to PSAs of nuclear power plants, with a focus on research and development needs. The group monitors and discusses current issues relating to PSAs both nationally and internationally, as well as PSA activities conducted at participating utilities. The group initiates, finances and co-ordinates research and development activities and discusses how new knowledge shall be used. The licensees strive to implement results from the NPSAG projects in their PSAs.

14.2.2. Periodic safety reviews

The licensees are required to submit a PSR of each reactor unit 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 long term operation (LTO). The PSR for Ringhals 3 was submitted in April 2019 and the regulatory review was completed in June 2020.

The Act on Nuclear Activities (1984:3) 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 give 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.

As an example, for Oskarshamn NPP unit 3, the last PSR was reported in 2017. The review led to findings (strengths and weaknesses) and improvements within the organisation. An aggregated analysis and overall assessment identified four strategic development areas, for example "Take advantage of personnel as enablers and barriers " and "Further development of the organisation's ability in operational excellence". These strategic areas have become part of OKG's strategic planning and safety programme. The goals have subsequently been broken down into relevant activities for each department and unit. An example of an activity linked to the first area mentioned is a cross-group seminar on the topics of safety management, safety culture and operational excellence. Nearly all managers, employees and a selection of partners participated in this seminar, which was held on several occasions in 2018.

14.2.3. Safety programmes

All licensees have safety programmes in place, as required by SSM regulation SSMFS 2008:1. 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.

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 operational limits and conditions (OLC) 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

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

Organisations required for qualification of Non-Destructive Testing (NDT) systems and techniques, as well as for carrying out and evaluating such inspections, have been established in accordance with regulatory requirements. SQC (Swedish Qualification Centre) serves as an independent body for qualification of NDT systems to be used by NDT companies that operate at Swedish nuclear power plants.

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, damage or indications found in Swedish or other nuclear power plants, or new and relevant research findings.

Extensive replacement of piping, found to be sensitive to specific damage mechanisms, has been carried out in the power plants. Many of these replacements were carried out to mitigate potential future damage as knowledge was gained on damage mechanisms. In other cases, replacements were carried out when the damage occurred.

14.2.5. Safety reviews

In order to verify that the operation of a nuclear power plant is in accordance with the applicable national safety requirements and standards, different types of safety reviews are performed regularly at the plants. The regulation on nuclear safety, SSMFS 2008:1, requires 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 utilized.

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. Typically, the independent review function consists of 10–15 experienced engineers with competence profiles to cover all forthcoming matters. In some cases, consultants are utilised to back up the function.

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 10.2.9). 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 LTO (Long Term Operation)

Implementation and development of ageing management at the nuclear power plants 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 long term operation (LTO), i.e. operation beyond the designed lifetime (typically 40 years), have been performed following review reports published by SSM in 2012 and guidance from the IAEA. The Swedish nuclear reactor fleet has experience as regards LTO, e.g. from the units Oskarshamn 1 and 2, and Ringhals 1 and 2. Presently four reactors in Sweden are in LTO, see table 5. Note that operation beyond the original designed lifetime for a Swedish reactor does not result in a Licence Renwal. The license to operate is not limited in time. Instead we have present a Periodic Safety Report, PSR, every 10 years where the possibility for safe operation over the next ten years is evaluated.

Table 5. Swedish reactors to enter LTO.

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

For more information about Long term operation and the alternate term "continued operation", see section 14.3.5.2.

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 Aging Lessons Learned (GALL) Report (NUREG-1801). In order to check consistency, Swedish licensees have used IAEA's generic lessons learned report[7] (SRS 82) and NUREG-1801, as described in the EU-TPR ageing assessment[8].

7 Ageing Management for Nuclear Power Plants: International Generic Ageing Lessons Learned (IGALL), IAEA Safety Reports Series No. 82
8 2017:36, Topical Peer Review 2017. Ageing Management, Swedish National Assessment Report.

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.

Ringhals NPP

The Ringhals nuclear power plant has worked on implementing and developing methods for ageing management at the plant. The Ringhals power plant 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 this 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 TLAAs for the remaining time of planned operation: 60 years for units 3 and 4 and 50 years for units 1 and 2. The IAEA was invited by Ringhals for a peer review of the project and discussion of other preconditions for LTO through the SALTO mission services. The project ended in 2017 and underwent an IAEA SALTO in 2018. IAEA has been asked to return for a follow-up in 2020. The LTO programme at Ringhals is given as an example in figure 15.

Oskarshamn NPP

At OKG a project has been formed to develop the excisting Aging Management Program to meet new requirements from the Swedish Radiation Safety Authority, SSM. The existing program is based on IAEA NS-G-2.12, Ageing Management for Nuclear Power Plants. These new regulations uses IAEA SSG-48 as a guide for the work. The result of the work within the project will be an updated program for Aging Management together with new scooping, article groups and Aging Management Reviews, AMRs. The project also handled all relevant TLAAs during 2021.

Forsmark NPP

The 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 is being reviewed by IAEA in av 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.

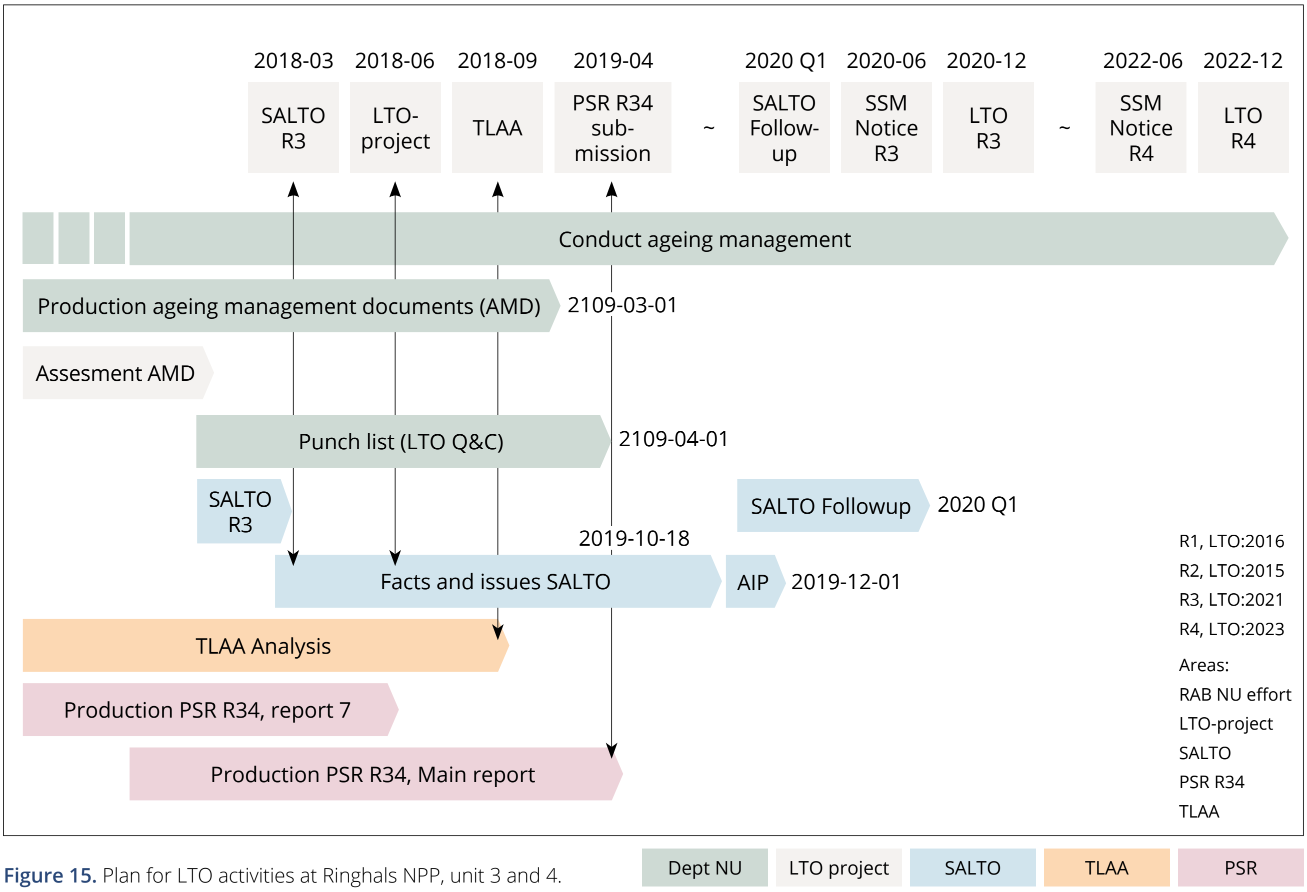

Figure 15. Plan for LTO activities at Ringhals NPP, unit 3 and 4.

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 is to be the link that fulfils the ageing perspective in all programmes. The related programmes are:

– Maintenance
– Equipment 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 optimize the efficiency of the programme
– Exchange experiences with external organisations
– Ensure that experience 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 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 is to be the 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 within OKG. 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 aging-related degradation and competence management.

14.3. Regulatory 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

Generally, SSM reviews safety analysis reports due to applications for power uprates or notifications (see section 10.5.3) relating to (for example) 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 a 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, including updates due to measures taken following the stress tests, power uprates (Ringhals 4, Oskarshamn 3 and Forsmark 2), and the modernization programmes to comply with SSM's regulations concerning the design and construction of nuclear power reactors, contained in SSMFS 2008:17.

14.3.1.1. Deterministic Safety Assessment

In the following cases, SSM reviews the Deterministic Safety Analyses (DSA):

- As part of power uprate reviews,
- When a licensee notifies the Authority (see section 10.3) of new analyses due to e.g.
- New fuel types,
- Plant changes,
- 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 are presented below of SSM's review activities performed during the current CNS review period.

Ringhals 1 routine operation review
Since the previous report, SSM has reviewed and approved the application for routine operation at Ringhals 1, after the modernisation to meet the requirements in the regulations concerning the design and construction of nuclear power reactors, SSMFS 2008:17.

Manual measures credited in the safety analyses
One example of a new area of focus since the previous report is the issue of time for performing manual measures that are credited in the safety analyses. Section 4 of the regulations concerning the design and construction of nuclear power reactors, SSMFS 2008:17, stipulates that manual measures in connection with necessary activation and operational change of reactor safety functions may only be applied if the personnel are given sufficient time – time for consideration – in order to safely take the measures. Since the previous report, SSM has placed an increasing focus on assessing the time needed for taking manual actions in deterministic safety analyses. SSM has imposed a requirement on the licensees to identify and report all necessary manual actions and to validate that the time for these is sufficient, for example by using a full scale simulator of the plant. This work is ongoing and has thus far resulted in notifications of several updated analyses from the Ringhals NPP, which are currently under review.

Mitigation of unidentified degrading power supplies
Another topic that has been an area of focus in recent years is mitigation of unidentified degrading power supplies. After the undetected phase inbalance at Forsmark 3 in 2013, SSM issued an injunction to conduct plant assessments to identify possible mitigation measures to limit the consequences of degraded power supplies. This was followed by an injunction in 2017 to justify plant behaviour and configuration based on the insight that it may be subjected to unidentified degrading power supplies. The licensees generally concluded that preventive and protective measures are suitable measures in an existing plant, as well as enhanced electro-mechanical separation measures in the independent core cooling function to be implemented before 2021.

Robustness of structures and components in the lower drywell of the containment
Another example where SSM has required new assessments to prove requirement compliance is an injunction in 2018 to have the licensees of Forsmark 1-3 and Oskarshamn 3 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. The injunction was based on an investigation taking into account both national and international research results.

During 2021 SSM reviewed the licensees of Forsmark 1–3 and Oskarshamn 3 analyzes. SSM assesed that both licensees have 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 injucted the licensees to develop action plans on how to ensure that the locks have a load capacity of 30 kPa against steam explosions. The action plans must be reported to SSM no later than June 2022.

14.3.1.2. Probabilistic Safety Assessments

As of 2014, the licensees submit a yearly report to SSM that includes information regarding the Probabilistic Safety Analysis (PSA) status as well as relevant information regarding plant changes, method changes, R&D, and operational experience of importance for the plant-specific PSAs. SSM's PSA supervision also includes reviews of updated PSAs, living PSA reporting, treatment of fire and other hazards in the PSA, topical meetings with licensees, and surveillance inspections. Another 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.

In the area of PSA, SSM performs surveillance inspections at all sites every second year. The PSAs for Forsmark 2 and Ringhals 4 have been reviewed within the applications for routine operation following the power uprates.

14.3.2. Periodic safety reviews

SSM requires that licensees present a plan for conducting the PSR in order to reach a consensus concerning the 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 a PSR is submitted to SSM, SSM conducts comprehensive reviews and assessments of the submitted reports and their references. In its reviews, SSM compares the statements made by the licensees with findings from the 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 Nuclear Safety Directive amendment. The regulatory assessments of the PSRs are submitted to the Government.

During the last six years, SSM has concluded reviews of eight PSRs from nuclear power plants in operation, i.e. Forsmark 1-3, Ringhals 1- 4, and Oskarshamn 3. In all of these reviews, SSM concluded that the safety improvements suggested by the licensees had the potential to provide an appropriate basis for continued operations. SSM also identified additional areas of improvement to ensure safe future operation of these reactors.

14.3.2.1. Forsmark 1–3 PSR

In the case of Forsmark 3, SSM decided that the licensee should implement its action plan to improve the identified weaknesses in a timely manner. SSM also decided that the licensee should present a plan for rectifying the weaknesses identified by SSM. Five months after the review was finished, SSM performed a follow-up on how the licensee proceeded with the improvements. The supervision showed that most of the highest ranked improvements had been taken care of.

In the review of PSR for Forsmark 1 and 2, SSM identified some shortcommings in the area Safety analyses and safety report. SSM required a reassessment and which Forsmark has subsequently submitted. SSMs review of this is onging.

14.3.2.2. Ringhals 1–4 PSRs

The reviews of the PSRs for Ringhals 1 and 2 were specific , since the decisions to cease operation of the plants were taken at the beginning of the SSM reviews. Due to the new circumstances, the licensee had to update its action plans for safety improvements. The greatest change was that Ringhals 1 cancelled its plans to modernise the control room. In the case of Ringhals 2, the major change was that the plan for a new analysis package for the deterministic safety analyses was cancelled. In the cases of both Ringhals 1 and 2, SSM decided that the licensee should complete the implementation of its updated action plans to rectify the identified weaknesses and report on its progress every six months until all improvements regarding requirement compliance were implemented. To date, 43 out of the 44 improvements have been implemented. SSM also decided that the licensee should implement improvements relating to weaknesses identified by SSM. As far as concerns Ringhals 2, SSM also concluded that the licensee should present an updated evaluation regarding the need for modernization of the deterministic analyses. This re-evaluation was reviewed by SSM and the conclusion was made that the necessary steps had been taken.

SSM's review of PSR for Ringhals 3 and 4 was completed in June 2020, in which some shortcomings were identified and that Ringhals needed to address. However, all these were judged to be of little importance to safety and were managed and completed by the end of 2020.

14.3.2.3. Oskarshamn 3 PSR

SSM has decided that the licensee of Oskarshamn 3 (see also 14.2.2) should present a plan for rectification of the weaknesses identified by SSM. (The licensee's own amendments were not included since most of them were already to have been implemented according to plan.) SSM also decided that OKG should present the results of its Time Limiting Ageing Analysis (TLAA) review in 2021, since the reactor will pass 40 years of operation before the next PSR.

14.3.3. Safety programmes

Since the previous report, SSM has not conducted any direct supervision of the safety programmes, however, a safety programme is one of the seventeen areas in the periodic safety review. In this respect, the safety programmes for Forsmark 3, Ringhals 1 and Oskarshamn 3 have been reviewed.

14.3.4. Inspection and testing of plant structures, systems and components

14.3.4.1. 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 (the 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.

As far as concerns the only qualification body in Sweden (SQC), its approval was renewed in 2016, though subject to terms and conditions. These were followed up at an inspection performed in 2018, along with previous inspection findings. The conclusion was that the licensee complied for the most part with the regulatory requirements.

14.3.4.2. Inspection and surveillance of plant structures and components

Corrosion of the containment steel liner in Ringhals 3

A hole through the steel liner in Ringhals 3 containment (2020).

In the past, there have been several instances of detected flaws in nuclear containments in Swedish reactors. The last flaw occurrence was detected in Ringhals 3 containment in 2020.

The Ringhals 3 (PWR) reacor was constructed during 1970s and began its operation in 1981. It has a reinforced concrete containment with a wall thickness of 1–1.5 m. There is also a steel liner with a thickness of 5 to 8 mm, embedded in concrete. The containment is supposed to withstand high pressure and keep its integrity in order to prevent the leakage of radioactive materials into the environment. The designers of Ringhals 3 containment had chosen a design with an embedded steel liner in order to protect the liner and to achieve leak tightness. The weakness of this design is a difficulty to inspect the liner visually or by other means.

The integrity of the containment in Ringtails 3 (as well as the other containments) is routinely tested by means of containment air tests (CAT). The CAT-test in 2016 indicated a diffuse leakage through the reactor containment wall, although the results were within the accepted limits. During the following years 2017 and 2018, the personnel in Ringhals removed concrete samples in suspicious areas in order to inspect the steel liner. However, they did not succeed to localize the leak source at that time.

Finally, in 2020 the personnel removed another concrete sample and found a hole through the liner. The hole was immediately (2020-04-30) reported by Ringhals to SSM and classified as “category 1”, which means that a special investigation and permission from SSM is needed before a re-start of the reactor.

A following investigation established that the hole had a diameter of 5 cm and fully penetrated through the steel liner. Furthermore, there were corrosion damages of various depth in the region proximal to the hole. Nearby, there wood pieces were found, of which the largest piece had a size of 140x350x45 mm.

The investigators concluded that the wood pieces were used during construction of the containment in 1974 in the areas with complex geometry (such as pipes penetrations). The wood pieces should have been removed but were forgotten due to human errors. With time, they created a corrosive environment that resulted in the steel liner to be damaged.

The investigators believed that the hole had already evolved through the liner in 2016, but thick concrete walls helped to achieve acceptable leak tightness during the CAT-test. However, it is reasonable to believe that the higher pressure during accidental conditions could have led to a lack of integrity due to the presence of corrosion damage.

After repair, a new CAT test was carried out at full design pressure with accepted results and SSM gave a permission (2020-07-07) to re-start the reactor, based on a condition to proceed with the investigation next year. During the next year outage of the reactor (2021), Ringhals personnel removed several samples of concrete and investigated the condition of steel liner and reinforcement. No damage or other wood pieces close to the steel liner or reinforcement were found, which led to a conclusion that the previously detected corrosion hole was caused by singular human error.

The detected hole, as well as other instances of damage, indicate a need of better methods in order to inspect and ensure the integrity of nuclear containments. Furthermore, given the origin of this mistake, there is a need of better quality checks during the construction works.

Corrosion in the bottom part of the containment liner
The seventh national report described an ageing problem involving corrosion in the bottom part of the containment liner in Ringhals 2 (see section 6.1.3 of Sweden’s seventh national report), which was identified during a regular integrated containment air test in 2014. At that time, the work had not been finished, and a continued degradation search led to uncovering of a total area of 380 m2 of liner. Areas with instances of corrosion damage deeper than 3 mm were then repaired (the liner is 5-6 mm thick). The work on uncovering the liner was terminated when the licensee found a correlation between the magnitude of the damage and the root cause of the corrosion. Based on this, the licensee assessed that the parts of the liner that remained covered would not have instances of damage deeper than 3 mm.

In 2015, the licensee submitted an application for permission to restart the reactor with the remaining instances of damage. The regulatory assessment was difficult, since the licensee had recovered the liner before the permission was sought . In early 2016, the plant remained shut down, with ongoing investigations, analyses and discussions. In October 2016, SSM decided that the licensee could restart the reactor, but for a limited period, i.e. until the end of 2019. SSM’s integrated assessment was that the licensee had shown that the safety margins against breach of the integrity were sufficient for this limited period. Due to uncertainties, the authorisation to restart the reactor was subject to certain conditions regarding further analyses, controls and examinations.

Environmental qualification
During 2015, SSM started to examine the status of environmental qualification at all licensees. SSM found some components and equipment at the Forsmark NPP and at OKG where the validity of environmental qualification had expired due to ageing. In the following years, the licensees have investigated, qualified and exchanged equipment, primary in the containment, during the period to maintain and restore the status of the equipment.

Surveillance programmes
Since the previous report, SSM has reviewed the surveillance programmes for the reactor pressure vessels of Ringhals 1-4, Forsmark 1-3 and Oskarshamn 3.

14.3.4.3. Functional tests

Since the previous report, SSM has performed supervision at the Ringhals, Oskarshamn, and Forsmark NPPs within the area of functional tests as part of the baseline supervision programme, see section 8.7.1.

14.3.5. Ageing management and long term operation

14.3.5.1. Ageing management programmes

As stated in section 14.1.2, SSMFS 2008:1 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 and I&C components.

Concrete structures also need to be covered by the ageing management programmes.

In the past ten years, SSM has intensified its reviews and inspections of the NPP programmes for ageing management, considering the ages of Swedish NPPs. SSM had found deviations in some of the plants' ageing management, and has consequently requested improvements.

Follow-up reviews and inspections were performed to verify that measures implemented by the licensees are effective. The results of these inspections are described in 2019 in Sweden's EU Topical Peer Review on ageing management, which is presented in Section A of this report. The inspections showed that all licensees in different degrees had implemented the requirements stated in Chapter 5, Section 3 of the Swedish regulation SSMFS 2008:1.

SSM noted that the licensee had identified a need for further improvements and these were compiled into an action plan that was submitted in ENSREG 1st Topical Peer Review Swedish National Action Plan..

The National Action Plan was reviewed by SSM in 2021 to see how the work was progressing with the actions planned. The results were submitted in Follow up of ENSREG 1st Topical Peer Review Swedish National Action Plan for Swedish Nuclear Facilities. Status of progress of implementation of Ageing Management Programmes to other risk significant nuclear installations was incorporated by SSM into the TPR process in January 2021. The Swedish Central Interim Storage Facility for Spent Nuclear Fuel (Clab) submitted their self-assessment accordingly and also submitted an action plan in accordance with the TPR process.

SSM´s review of the progress of the action plan concluded that all licensee now have an overall Ageing Management Programme that fulfils SSM requirements and international expectations. SSM also concluded that all licencee are working according to plan and all actions are to be completed in 2024.

SSM is awaiting the outcome of these improvements.

14.3.5.2. Long term operation

Long term operation (LTO) is not defined in Swedish legislation, nor in associated regulations, see section 7; instead, the term "continued operation" has been suggested. The requirement on having an ageing management programme is applicable to all reactors in operation, regardless of age.

Nevertheless, SSM recognises the fact that the reactors were originally constructed and analysed for 40 years of operation. Since the previous report, SSM has decided to adopt a standpoint accepting continued operation (LTO) in connection with the PSR reviews, as described in the EU-TPR report[9]. In this respect, a key aspect for the licensees for justifying continued operation is to show that the identified TLLAs meet the criteria established. The TLLAs should consider the entire remaining period of time for which the continued operation is planned. If the licensee has not provided SSM with the time limiting ageing analyses in time for the PSR review, SSM will require this by issuing a decision to provide SSM with these analyses well in advance prior to 40 years of operation. This was done for Oskarshamn 3, see section 14.3.2, "Periodic safety reviews".

14.3.6. Safety reviews

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

14.4. Implementation of 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 this reporting period, the focus of the regulatory body and licensees alike was on ensuring safety functions and safety barriers through the introduction of extensive work on ageing issues. This was followed by setting up updated ageing management programmes by the licensees to guarantee the elimination of impact from degradation and other processes on specific safety-related components and systems. The programmes were subject to several IAEA SALTO review missions and the results were incorporated.

An important instrument for implementing the second principle of the Vienna Declaration on Nuclear Safety is the periodic safety review (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 continued operation ("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.

9 2017:36, Topical Peer Review 2017. Ageing Management, Swedish National Assessment Report.

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 of developments since the previous report

During the current and previous review periods, the following developments are of relevance with regard to the obligations of Article 15:

– A new Radiation Protection Act (2018:396) was decided by the Swedish Parliament (Riksdag) on 26 April 2018 and entered into force on 1 June 2018. This was supplemented by the Ordinance on Radiation Protection (2018:506). The new Act and Ordinance transposes several key provisions of Council Directive 2013/59/Euratom laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation.

– On 24 May 2018, new regulations on basic rules for all licensed activities involving ionising radiation were decided (SSMFS 2018:1). These regulations came into force on 1 June 2018. They transpose additional provisions of Council Directive 2013/59/Euratom that were not included in the new Radiation Protection Act.

– A new lower dose limit for equivalent dose to the lens of the eye is stated in the Ordinance on Radiation Protection. Requirements on the application of this are specified in SSMFS 2018:1. These include the situations where measurements need to be conducted. A joint project has been carried out together with all Swedish nuclear facilities in connection with this lower dose limit. Shared methods and guidelines have been developed.

– Radiation protection education and training have been continuously reviewed and strengthened.

– Efforts to reduce releases of radioactive substances to air and water have been effective. The activity amounts, as well as the corresponding calculated doses to the public, have decreased or remained at the same order of magnitude.

15.1. Regulatory requirements

A new Radiation Protection Act (2018:396) was decided by the Swedish Parliament (Riksdag) on 26 April 2018 and entered into force on 1 June 2018. This is supplemented by the Ordinance on Radiation Protection (2018:506), and by national radiation protection regulations specified in SSM's Code of Statutes, SSMFS. A more detailed specification of SSMFS is provided in section 7.2.

15.1.1. Occupational radiation protection

Presently, Swedish occupational radiation protection requirements governing nuclear facilities are in accordance with the binding requirements of the new Radiation Protection Act. The new Radiation Protection Act transposes several key provisions of Council Directive 2013/59/Euratom laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation.

SSM's regulations SSMFS 2018:1 and SSMFS 2008:26 contain extensive requirements relating to occupational radiation protection in connection with activities involving ionizing radiation as well as workers at all nuclear facilities. Chapter 4 of SSMFS 2018:1 contains general requirements on facility design, workplace radiation monitoring, radiation protection competences, categorization of workers, occupational dose monitoring and assessment, as well as health surveillance of workers. The regulations SSMFS 2008:26 contain additional more detailed requirements in these areas. Note that SSMFS 2008:26 are replaced from 1 March 2022 by new regulations.The requirements are based on the fundamental principles of radiation protection as defined by the International Commission on Radiological Protection (ICRP): justification, optimisation of protection and application of dose limits.

Regulations regarding an appointed radiation protection manager, the actual radiation protection expert available onsite (not deemed a manager in the line organisation), are specified in SSMFS 2008:24. These requirements have been supplemented by additional requirements on an organisational function for radiation protection expertise in SSMFS 2018:1.

The new, lower dose limit for equivalent dose to the lens of the eye is stated in the Ordinance on Radiation Protection. Requirements on the application of this are specified in SSMFS 2018:1. These include situations where measurements need to be conducted.

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 ionizing radiation, and SSMFS 2008:23 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 dose to the public from discharges of radioactive substances to the environment, and required monitoring of releases of radioactive substances to water and air. All unmonitored leakages must be investigated and an upper boundary has to be set for possible unmonitored leakages to air and water from each facility.

Compliance with the dose constraint is demonstrated by calculating the dose to representative individuals. A new and more site specific methodology for calculating the dose was approved by SSM in 2019. The methodology is used for calculating the dose to representative persons in three different age groups from one year's 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 new 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 nuclide-specific discharge limits. The dose limit for members of the public is 1 mSv per year. Hence, in order to protect the public, the dose constraint is 0,1 mSv per year and site for discharges of radioactive substances to the environment (authorised releases).

Releases though the main stacks of nuclear power reactors shall be controlled by means of continuous nuclide-specific measurements of volatile radioactive substances, such as noble gases, continuous collection of samples of iodine and particle-bound radioactive substances, as well as measurements of carbon-14 and tritium.

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

Limitation of releases shall be based on optimisation of radiation protection 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 malfunctions.

Environmental monitoring in the areas surrounding nuclear facilities is currently performed according to monitoring programmes determined by SSM. This arrangement will be changed in the future to imply that licence holders will be charged with developing and maintaining site-specific environmental monitoring programmes at the site. The programmes are to be kept regularly updated and subject to approval by SSM.

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 performance. 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.

Nuclear reactor 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. If established reference values are exceeded, the planned measures to achieve the reference values shall be reported.

According to the requirements, releases of radioactive substances to the environment as well as results from environmental monitoring shall be reported twice per year to SSM. In practice however these releases and results have only been reported once a year, since all licensees have been permitted dispensation from this requirement. 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 in practices involving the use of ionising radiation is regulated in SSMFS 2018:3, which stipulates detailed requirements for clearance procedures.

15.1.3. Development of new regulations

SSM has developed new regulations for nuclear safety, which enter into force 1 March 2022, i.e., after the current reporting period. For nuclear power plants, the regulations SSMFS 2008:23, SSMFS 2008:24 and SSMFS 2008:26 are superceeded by SSMFS 2021:4, SSMFS 2021:5 and SSMFS 2021:6.

In the new regulations, the general requirements on prerequisites for protection of workers and members of the public from exposure to ionizing radiation found in Chapter 4 and 5 of SSMFS 2018:1, have been complemented with more specific requirements in SSMFS 2021:4, specifying requirements on design of the nuclear power plant, to enable radiation exposure to workers and members of the public to be kept as low as reasonably achievable.

The requirements on activities for radiation protection of workers as well as the public during operation are mainly found in Chapter 4 of SSMFS 2021:6. In addition to previous requirements this chapter also include requirements on the use of a dose reduction programme (ALARA programme) for occupational exposure, use of dose constraints, use of radiation zones, and requirments on workplace and individual monitoring. The previous requirements on appointed radiation protection managers, have been removed from the new regulations for nuclear power plants, as the requimenents on a organizational function for radiation protection expertise, as stated in SSMFS 2018:1 are assessed to be sufficient.

Chapter 4 of SSMFS 2021:6 also include more detailed and newrequirements on environmental monitoring and assessment of radiological impact on the environment, compared to previous regulations in SSMFS 2008:23. For example, the responsibility for development and maintenance of site-specific environmental monitoring programmes is transferred from SSM to the licensee. The programmes shall however still be subject to approval by SSM. Another change is that the frequency for reporting of discharge and environmental data to SSM is reduced from two times a year to once a year.

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

15.2. Compliance of licence holders

Previous national reports include descriptions of measures taken by the licensees to comply with the new radiation protection regulations. 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 at the nuclear power plants

Radiation protection (RP) resources are centralised at Swedish nuclear power plants, 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, the percentage of hired RP personnel is approximately 30-40 % at Forsmark, 20 % at Ringhals and 25 % at Oskarshamn.

Radiation protection responsibilities reflect the organisational structure. The RP sections are responsible for performing assessments and providing other radiation protection services. The responsibility to comply with instructions rests with management in the line organisation. Planning and discharging 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.

15.2.1.1. Ringhals NPP

The decisions to phase out units 1 and 2 at the Ringhals NPP affected the organisational structure in radiation protection. Measures have been taken to ensure adequate competence and resources during the future decommissioning process. A reorganisation took place in 2919 within the RP department to meet new criteria.

15.2.1.2. Forsmark NPP

Forsmark has a cohesive group for operational radiation protection for all three units. The group has competence and succession plan, with a clear career path, that gives additional development opportunities within the profession.

15.2.1.3. Oskarshamn NPP

The decision to phase out the two oldest reactors at the Oskarshamn NPP affected the organizational structure. A new organization was created with two main directions: production and decommissioning, whereby a new department was created to handle decommissioning.

There are two separate radiation protection organizations at Oskarshamn NPP, one for radiation protection within the decommissioning project of the two oldest reactors, according to previous decisions on decommissioning of these, and one radiation protection organization for the remaining reactor in operation and radiation protection at other operating facilities.

The two radiation protection organizations work with their respective activities; decommissioning and production, but tries to align its work and therefore has a common evaluation forum for status regarding radiation protection and for a common evaluation of radiation protection events, as the same rules for categorization 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 radiation protection organizations with a higher degree of own staff than previously.

Difficulties exist with regard to hiring radiation protection resources from contractor companies in sufficient numbers and with sufficient competence and experience.

15.2.2. Internal procedures for radiation protection

Work is continuing to harmonise procedures at and between sites. This includes behaviour-related instructions, such as procedures and rules for radiation protection, usage of prescribed personal protective equipment in radiation and contamination controlled areas, and controls of 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 radiation protection-related events and incidents.

15.2.3. Radiation protection education and training

A mandatory education programme on radiation protection techniques for own personnel working in the controlled area and for external foremen and supervisors are being updated in cooperation between the Swedish NPPs.

Due to the new national regulations in the field of radiation protection, site-specific instructions and procedures are in the process of being adjusted accordingly. Examples of significant changes include new dose limits and new procedures for measuring equivalent dose to the lens of the eye.

Forsmark NPP and Ringhals NPP

Competence Councils have been established between Forsmark and Ringhals in order to deal with common educational issues within the radiation protection area. An training programme for radiation protection personnel in the area of clearance has been developed together with the other nuclear power plants in Sweden. Targeted radiation protection training is held within the plant renewal projects where the need exists.

At Forsmark NPP an ALARA training and education programme for staff involved in the plant modification and renewal process has been developed and a pilot training course has been held after each step. The training and education programme is intended for personnel involved in planning and construction of plant modifications and the project managers. Feedback and experience from this have been taken into account. The programme has been revised and is now offered on a broader front.

Oskarshamn NPP

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

15.2.4. Activities to prevent spread of contamination

Activities have been enforced further at all sites. The activities cover individual follow-ups of alarms set off at exit gates in connection with identity registration when conducting a measurement, changes in procedures, enhanced checks closer to workplaces, as well as enhanced information, education and training efforts.

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 readersin 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.

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 controlled area and protect the individuals involved.

Ringhals previously reported on ongoing work to improve procedures for clearance measurements. There are currently three clearance stations equipped with HpGe detectors. An average of around 300 nuclide-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.

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 through the care of the radiation protection organizations, 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 and established target values for number of alarms which are 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 cover long-term trends in specific measurement programmes.

Ringhals NPP

At the 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. In 2018, a new shutdown program was tested on Ringhals unit 2 without using RCPs during the cleanup. The purpose of this test was to reduce recontamination and activity spread to systems during the cleanup, and thus reduce dose rates during the maintenance period. During the shutdown, dose rates were monitored in a number of positions, and a nuclide-specific online measurement was performed using the SAM equipment. Online nuclide-specific measurements of system surfaces and reactor water are installed only at the BWR unit Ringhals 1. The online instrumentation is used to track the surface activity buildup in the reactor system with the aim of evaluating the effect of system decontamination campaigns, as well as smaller changes in chemistry and operation. The measurements show that the degree of recontamination of the reactor system surfaces is now roughly 80% of the status prior to the campaign carried out in 2014.

Forsmark NPP
All the Forsmark units have nuclide-specific gamma measurement systems installed 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, nuclide-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 which nuclides that contribute to the dose rate at the measurement location.

15.2.6. Dose reduction and ALARA programmes

All NPPs continue to make improvements to their radiation protection 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, the focus had already come to concentrate more on 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. 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
The alpha value, used at the Ringhals NPP in the optimisation process, has since 2015 been 10.8 million SEK per saved man-sievert (man Sv). The former alpha value, since 2008, was 10 million SEK/man Sv. This alpha value is still valid at the Forsmark NPP.

System decontamination, conducted at Ringhals unit 1 starting in 2014, remains beneficial in 2019 as regards low recontamination of the involved systems. Each year, this saves several tens of man mSv collective dose.

The ALARA committee is undergoing a review regarding the procedures workflow. The main focus for the committee remains to conduct supervision over continuation of long-term radiation protection development. The committee also evaluates ALARA plans and objectives for individual and collective doses, and follows up radiation protection 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 radiation protection experts.

A number of dose constraints have been implemented, and will be revised as an optimisation tool to reduce high individual doses. Dose constraints are established for individual doses: not only effective dose, but also equivalent doses to extremities, and for different levels of dose rate and dose prognosis. The measure has significantly decreased the number of high individual doses.

The recommendations from the joint ALARA Benchmark are being successively implemented. A new model for management of dose prognosis, which was implemented throughout the organisation, will be evaluated in order to enhance the precision of the prognosis.

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 dose prognosis greater than 0.08 man Sv, a specific ALARA plan must always be established.

At Ringhals units 2, 3 and 4, fuel decontamination has been performed annualy.

An alternative shutdown procedure involving RCP operation during hydrogen peroxide cleanup was tested at Ringhals 2 shutdown for refuelling in 2018. The eventual effects on source terms and dose rates will be analysed in order to evaluate future implementation in Ringhals' PWRs.

Forsmark NPP
In line with the ALARA-program, Forsmark has for exempel developed requirements for cobolt content in fuel components and in order to reduce emission of radioactive nobel gases made a system function investigation of the off gas delay system.

The alpha value of 10 million SEK/man Sv is still valid at the Forsmark NPP.

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 the 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 makes 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, which is 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 2021 was 11.8 million SEK per saved man Sv and for 2022 has been calculated up to 12.1 million SEK per saved man Sv. 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 radiation protection. The committee evaluates the strategies for individual and collective doses and monitors radiation protection 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 radiation protection experts.

A number of planning values for dose and dose rate have been implemented as an optimization tool to reduce high individual and collective doses. Dose limits 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 and is also responsible for, through their radiation protection organization, producing dose predictions and then the responsibility for determining these and for following up outcomes related to prognosis. The main focus of the ALARA operations is that responsible and executing organizations, operating in the facilities, should feel the responsibility and commitment of ALARA and the dose outcome of their respective staff.

An extensive project with the FME, Foreign Material Exclusion, has been carried out in order to prevent foreign substances or objects from ending up in the reactor systems. OKG 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.

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 nuclear power plants 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.

Forsmark NPP

Forsmark works actively to reduce emission to air. The work with reducing fuel failures and identify leakage have 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 . At Forsmark 3 during the shutdown 2021, an extensive work was conducted with cleansing the reactor tank bottom from foreign debris. In 2021 all three units in Forsmark were free of fuel failures.

Discharges of waste water has been kept at very low levels for recent years.

Ringhals NPP

Since 2014, Ringhals units 1-4 have been free from any fuel damage. For this reason, they have been able to maintain low activity release rates to the environment. All the units now have very low levels of tramp fissile material on the core (below detection limit on unit 3 and 4); in the case of Ringhals 1, it was considered as an all-time low before the final shutdown in the end of 2020. During 2020, unit 3 implemented up flow conversion (modification of reactor vessel lower internals to avoid baffle jetting), thereby limiting the risk of fuel damage even further. The total amount of airborne releases decreased during the previous period due to the shutdown of unit 1 and 2. However, the reduction rate for the operating units 3 and 4 has levelled off. Installations at Ringhals units 3 and 4 for delaying and reducing releases of radioactive gases have been working as intended for most of the period.

Dishargers to water have been decreasing over the past 10 years, owing mainly to the operation of the evaporator at the liquid waste processing facility at unit 1. However, some challenges still remain. Ongoing initiatives include the reduction of antimony source terms and improvement of antimony cleaning at unit 3 and 4, and the modernization of the Ringhals NPP liquid waste processing facility; serving all the units.

Since 2012 (Ringhals unit 4) and 2015 (Ringhals unit 2 and 3), a programme for ultrasonic cleaning of fuel elements has been implemented. The removal of both activated and not yet activated deposits limits the general source term of the plant including the reactor water, which is also expected to affect the effluents.

At the 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 accounts for approximately 1% of the total dose calculated to the representative person. A new method for calculating doses from normal releases of radionuclides to the public (PREDO) was implemented

2019, affecting both the absolute dose (being increased) and the relative contributors.

Ringhals NPP ALARA-plan has been further developed during the period and now includes a goal for Minimization of radioactive releases as far as reasonably achievable.

Oskarshamn NPP
The decision to decommission the two oldest units at Oskarshamn's nuclear power plant has reduced the releases from the site. For the two facilities that are being under decommissioning, plans have been specially developed for monitoring and limiting releases during the decommissioning 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.

15.2.8. Other events and activities during the review period

Improving the precision of the dose prognosis is a continius work at all three units.

A joint project has been carried out by the Swedish nuclear facilities due to the lower dose limit for equivalent dose to the lens of the eye. Common work methods and guidelines have been developed. From earlier studies, it has been found that the whole body dose, Hp(10), and dose to the lens of the eye, Hp(3), are comparable for most work situations that occur in a nuclear power plant. A number of specific jobs have been identified in which the lens of the eye might receive a higher dose than measured by the whole body dosimeter. New rutines are beeing implemented at all units.

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.

Decommissioning activities are in progress for Ringhals unit 1 and 2 with, for example, RKL (radiological mapping) as ongoing procedures.

Forsmark NPP
The plans for long time operation on the part of 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 minimize leakage of activity to the storage basins.

Oskarshamn NPP
In conjunction with the outages "safety team" have been represented in the reactor facility, by using personnel from different parts of the OKG organization, and with a strong focus on raising OKG's level of occupational safety by means of improved security 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 have been to reinforce the overall safety culture and this work will continue during future outages.

WANO's compilation of registered collective doses at the world's boiling water reactors and with a rolling three-year average showed that Oskarshamn's O3 reactor, at the turn of the year 2017, had the lowest value of all compared reactors. The internal conclusion was that the reactor had a positive trend over a long period of time in terms of the facility's radiological status and purity and that the success was the result of even better cooperation between all parties involved, mainly within the maintenance and radiation protection organizations.

During the 2020 outage, however, it was found that when opening systems, high dose rates were obtained and that there were high levels of contamination in the systems.

An investigation is underway into these phenomena and linked to used fuel types, contaminants in spreading material, and the moisture content of the steam and execution organizations on the operational and technical side have the task, together with and with the help of data from the company's source term group, to investigate the root cause of problems when opening systems and especially ahead of the upcoming longer outage, when the organization again need to open up systems.

Based on the results through the root cause analysis, measures will then be implemented in ALARA terms and the goal for Oskarshamn is that the O3 reactor will be one of the five best reactors in terms of WANO's rolling three-year average for collective dose in 2027.

15.3. Impact and results of radiation protection measures

15.3.1. Occupational exposure

Activities to improve the radiological environment and to decrease exposure of workers at the reactors are described in section 15.2.

Figure 16 shows occupational collective radiation doses at Swedish NPPs in operation during the period 2012-2021. As observed, the annual total collective dose has decreased the last decade 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 have resulted in a decreaser of radiation levels in the work environment. Another explanation for the decrease in exposure is the decision to permanently shut down some of oldest reactor units. At Oskarshamn NPP, unit 2 was permanently shut down in December 2016 unit 1 in 2017. At Ringhals NPP unit 2 was shut down in 2020 and unit 1 in 2021. Phasing out reactor operation lead initially to less workload inside controlled areas and therefore less occupational exposure. The increase in collective dose in 2014 and 2015 illustrated by figure 16 is due to major modernisation work carried out at Ringhals and Oskarshamn.

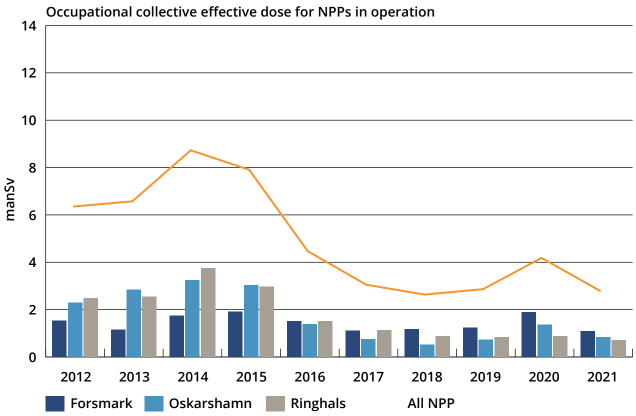

Figure 16. Collective radiation doses at Swedish NPPs in operation during the period 2012–2021.

Internal exposure of workers at the NPPs in operation continue 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 work procedures.

Effective doses to workers depend on the type of work. This can be seen in figure 17, where annual average effective doses for some specific work categories are shown for the time period 2012–2021.

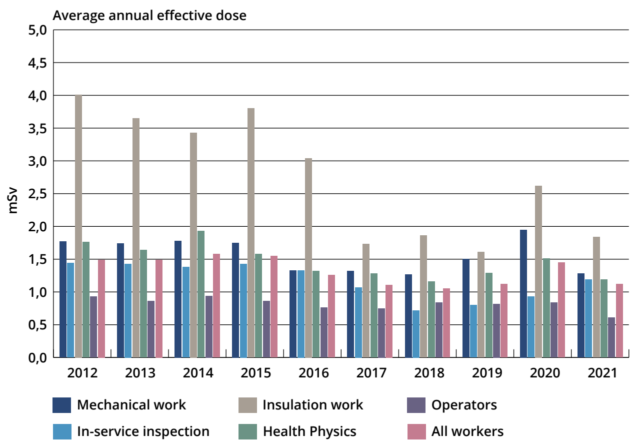

Figure 17. Average individual doses to selected work categories at Swedish NPPs.

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 millisievert per year, which is considered to be an effect of the operator's 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 effective dose exceeding 20 mSv in the last 10 years, and the average annual effective dose has been kept below 2 mSv with a slightly decreasing level. Data is also shown from monitoring of eye exposure. This monitoring program was introduced in 2019 when the new dose limit came into force.

15.3.2. Doses to the public and releases to the environment

The dose limit for members of the public is 1 millisievert per year (effective dose) as set out in the Radiation Protection Ordinance (2018:506). In order to sufficiently protect 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. The methodology used for estimating dose to the public is described in section 15.1.2. There are no regulatory limitations for releases of specific radionuclides. Figure 18 displays effective dose to the public resulting from releases of radionuclides during the period 2010–2020 at Swedish nuclear power plant sites.

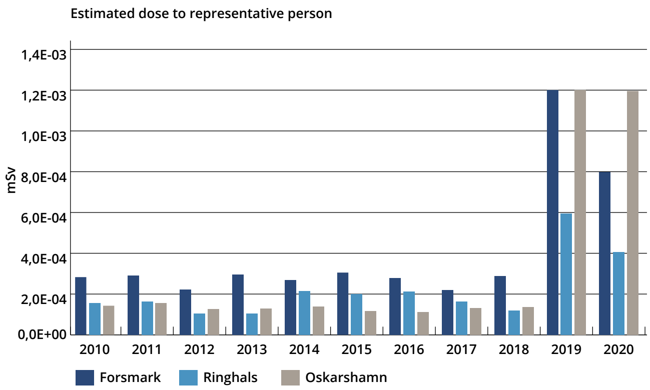

Figure 18. Estimated radiation dose to representative person from release of radionuclides from Swedish NPPs.

The 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 dose observed in 2019 and 2020 is due to the change of methodology used for dose estimations and does not implicate an increase in the actual discharges from the nuclear power plants. The increase in dose is also small compared to the stipulated dose constraint at 0,1 mSv a 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 on the part of nuclear power reactors as a measure as part of applying Best Available Technique (BAT) for reducing releases of radionuclides. These values are defined by the licensees and are valuable for achieving the long-term objective of reducing releases and effluents of radioactive substances.

Table 7. Occupational dose statistics for Swedish NPPs.

Year	Total collective effective dose (manSv)	Average effective dose (mSv)	Highest annual effective dose (mSv)	Number of persons with effective dose > 10 mSv	Number of persons with effective dose ≥ 0,1 mSv	Highest annual dose to lens of eye (mSv)[10]	Number of persons with dose to lens of eye > 10 mSv
2012	6.3	1.5	17.5	23	4251		
2013	6.6	1.5	16.9	20	4416		
2014	8.7	1.6	15.2	13	5229		
2015	7.9	1.5	14.2	34	5091		
2016	4.4	1.3	16.4	5	3510		
2017	3	1.1	10.6	2	2705		
2018	2.6	1	9.7	0	2470		
2019	2.8	1.1	13.6	8	2511	15.1	13
2020	4.1	1.4	12.4	6	2851	13.6	12
2021	2.8	1.1	10.2	1	2459	10.2	1

15.4. Regulatory control

The baseline supervision plan in radiation protection is divided into five supervision groups (see 8.8.2.1): Work in the facility, Optimisation of protection (ALARA programme), Protection of workers, Releases of radioactive substances and Environmental monitoring.

Between 2018-2021 the following groups were inspected:

- Work in the facility, including operational radiation protection, issuance of radiation work permits and radiation protection activities at operation and maintence departments
- ALARA programme, including operational and long term handling of the programme at the company management level
- Releases of radioactive substances, including how releases are kept as low as reasonably achievable, that all releases are monitored and reporting to SSM of increased releases or physical changes to the releases

In 2022, focus is on the supervision group Protection of workers and will include external and internal dosimetry, internal transports of radioactive material, and other work activities specific to radiation protection.

Supervision of the fifth group, Environmental monitoring, is planned for 2024.

In addition to the baseline supervision plan, inspections are carried out on an on-going basis to monitor activities at the NPPs related to radiation protection. Normally, these include meetings workers and representatives of the radiation protection 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 radiation protection and releases of radioactive substances.

Examples of findings from supervision completed in recent years are:

- a need to include radiation protection to a greater extent in operational planning
- challenges associated with maintaining competence in radiation protection
- to further develop internal review processes of the effects of programmes and of measures to prevent reccurrence of incidents
- a need to demonstrate that diffuse releases are accounted for
- a need to analyse the exposure of biota due to radioactive releases

10 Monitoring of dose to lens of the eye started in 2019.

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 of developments since the previous national report

– During the current review period, the following developments are of relevance with regard to the obligations of Article 16:
– A new Radiation Protection Act (2018:396) which entered into force on 1 June 2018. It is applicable to workers and the public during an emergency.
– A new Radiation Protection Ordinance (2018:506) which entered into force on 1 June 2018. It sets reference levels to be applied in the case of a radiological emergency and includes requirements for optimisation.
– Updated regulations, SSMFS 2014:2 (revised through SSMFS 2018:26), concerning on-site emergency preparedness and response, entered into force on 1 June 2018. The regulation contains new rules for logistics centres and provisions concerning the ability to receive aid and support from external organisations. Also, some concepts have been renamed.
– The structure of the regulation has been changed. Some requirements that were previously found in SSMFS 2014:2 (on-site emergency preparedness and response) are now instead found in SSMFS 2018:1 (basic rules for all licensed activities involving ionising radiation).
– New monitoring stations have been installed around the nuclear power plants in Sweden. The new stations will provide information on dose rates at 90 locations around the Swedish nuclear power plants. The last stations went online in late 2018 and are currently undergoing an evaluation process.
– Two ordinances, 2015:1052 and 2015:1053, entered into force on 1 April 2016. These ordinances replace the former Emergency Preparedness and Heightened Alert Ordinance (2006:942) that is now split into two parts without any major revisions of the content having being made.
– The Government has decided on the new emergency planning zones and distances and changes to the Ordinance. The amendments to the Civil Protection Ordinance entered into force 1 July 2020 and will be implemented on 1 July 2022 at the latest.
– A new mobile radiation monitoring system for more efficient fallout mapping has been introduced because of the extended planning distance (EPD) around Swedish NPPs which will be increased from 50 km to 100 km in July 2022
– SSM has developed new regulations, which enter into force 1 March 2022, i.e., after the current reporting period. All requirements for emergency preparedness and response for NPPs in operation are integrated into the three regulations. Because of the new regulations the SSM regulation SSMFS 2014:2 concerning emergency preparedness at nuclear facilities have been revised and does not include requirements for NPPs in operation anymore.

16.1. Regulatory requirements

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

- SSM's regulations (SSMFS 2014:2) concerning emergency preparedness at nuclear facilities (on-site emergency preparedness and response),
- SSM's regulations (SSMFS 2018:1, Chapter 2) concerning basic rules for licensed activities involving ionising radiation,
- Civil Protection Act (2003:778) regarding protection against accidents with serious potential consequences for human health and the environment (on-site and off-site emergency preparedness and response),
- Civil Protection Ordinance (2003:789) regarding protection against accidents with serious potential consequences for human health and the environment (on-site and off-site emergency preparedness and response),
- Ordinance with instructions for the Swedish Radiation Safety Authority (2008:452) (off-site emergency preparedness and response),
- Ordinance on Emergency Preparedness and Surveillance Responsible Authorities' Measures at Heightened Alert (2015:1052) (off-site emergency preparedness and response),
- Ordinance on Total Defence and Heightened Alert (2015:1053) (off-site emergency preparedness and response), and
- Health Care Act (2017:30) (off-site emergency preparedness and response).

The following new regulations will enter into force on 1 March 2022:

- SSM's regulations (SSMFS 2021:4) concerning construction of nuclear power reactors
- SSM's regulations (SSMFS 2021:5) concerning assessment and statement of radiation and nuclear safety for nuclear power reactors
- SSM's regulations (SSMFS 2021:6) concerning operation of nuclear power reactors
- Accordingly, SSM's regulations (SSMFS 2014:2) concerning emergency preparedness at nuclear facilities (on-site emergency preparedness and response) have been revised to only include requirements for nuclear facilities in emergency category 2 and 3, and are no longer valid for NPPs in operation.

16.1.1. Requirements for on-site activities

As far as concerns on-site emergency preparedness and response, the Civil Protection Act (2003:778) and Ordinance (2003:789) stipulate general requirements applying to facilities that conduct dangerous activities. The Act requires preventive measures and emergency preparedness to be arranged by the owner or operator of a facility that conducts dangerous activities.

The Act on Nuclear Activities (1984:3) 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.

Through the Ordinance on Nuclear Activities (1984:14) and the Radiation Protection Ordinance (1988:293), the Government has assigned SSM the mandate to issue specific regulations for licensees in the fields of nuclear safety and radiation protection.

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. These categories are later used (see below) to apply a graded approach of requirements for emergency preparedness and response. Chapter 2, Section 5 of SSMFS 2018:1 further requires that the organization shall have an prepared emergency preparedness and response organization corresponding to their assigned category. The organization 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). Emergency preparedness and response shall be tested through exercises and experiences shall be used for improvement.

The regulations SSMFS 2014:2 uses the concept of emergency preparedness categories (1, 2, 3 and 4) based on the IAEA's emergency preparedness categories. The regulation introduces the application of a graded approach depending on the radiological hazard at the nuclear facility. SSM's regulation SSMFS 2014:2 requires the licensee to take prompt actions in the event of an emergency in order to:

- Classify the event according to predefined alarm criteria,
- Alert the facility's emergency response organisation,
- Assess the risk and magnitude of possible radioactive releases and time-related aspects,
- Return the facility to a safe and stable state, and
- Notify SSM.

The regulations SSMFS 2014:2 require nuclear power plant (NPP) licensees to have in place an emergency response organisation capable of dealing with simultaneous emergencies at all reactor units at their site over a minimum period of one week. Another requirement in SSMFS 2014:2, states that the licensees of facilities categorised as belonging to emergency preparedness category 1 must be capable of setting up a logistics centre in a location distanced from the site. This logistics centre should 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.

Similar to the previous regulations, SSMFS 2014:2 also addresses alarm criteria and alerting, emergency facilities, evacuation plans, training and exercises, and other aspects of emergency preparedness (e.g. iodine prophylaxis, personal protective equipment, monitoring, ventilation filters and meteorological data).

All requirements in SSMFS 2014:2 concerning NPP licensees have been integrated, and to some extent revised or extended, in the new SSM regulations SSMFS 2021:4 concerning construction of nuclear power reactors, SSMFS 2021:5 concerning assessment and statement of radiation and nuclear safety for nuclear power reactors, and SSMFS 2021:6 concerning operation of nuclear power reactors.

Accordingly, SSM's regulations (SSMFS 2014:2) concerning emergency preparedness at nuclear facilities (on-site emergency preparedness and response) have been revised to only include requirements for nuclear facilities in emergency category 2 and 3, and are no longer valid for NPPs in operation. The new regulations enter into force on 1 March 2022.

16.1.2. Requirements for off-site activities

The overarching objective of the Civil Protection Act (2003:778) 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 for individuals, local authorities and central government in cases of serious accidents, including radiological accidents. The act contains provisions on how community rescue services shall be organised and operated, and also stipulates that a rescue commander with a specified competence, and far-reaching authority, is to be engaged in all rescue operations.

The Civil Protection Ordinance (2003:789) states that County Administrative Boards are responsible for rescue operations in cases where the public needs protection from a radioactive release from a nuclear installation, or in cases where such a release seems imminent. The 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, inner emergency planning zones and outer emergency planning zones around major nuclear facilities. The County Administrative Board is required to draw up an off-site nuclear emergency response plan. The Swedish Civil Contingencies Agency (MSB) is responsible at a national level for coordination and supervision of preparedness for an off-site rescue service response to radioactive releases.

The ordinance with instructions for the Swedish Radiation Safety Authority (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 give advice and recommendations on radiation protection to the public and authorities in charge, maintain a national expert response organisation for monitoring, and provide information on the technical state of nuclear installations in the case of a nuclear emergency.

Two ordinances, 2015:1052 and 2015:1053, entered into force on 1 April 2016. These ordinances replace the former Emergency Preparedness and Heightened Alert Ordinance (2006:942) that is now split into two parts without any major revisions of the content having being made. The aim of ordinance 2015:1052, Emergency Preparedness and Surveillance Responsible Authorities' Measures at Heightened Alert, 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, crises and cases of heightened alert. The ordinance requires of each government authority affected by a crisis, for example a nuclear or radiological emergency, that it carry out necessary measures for managing the consequences of such event. In crisis situations, these authorities are to cooperate and provide mutual assistance. Ordinance 2015:1053 on Total Defence and Heightened Alert contains provisions on civil defence during periods of heightened alert.

16.1.3. Development of new regulations

SSM has developed new regulations for nuclear safety, which enter into force 1 March 2022, i.e., after the current reporting period. For nuclear power plants, the regulations SSMFS 2014:2 are superseded by requirements in SSMFS 2021:4, SSMFS 2021:5 and SSMFS 2021:6.

Compared to previous requirements, the new regulations SSMFS 2021:4, more clearly state that the design of a nuclear power plant shall take into consideration the needs for effective emergency preparedness and response, mainly through the specification 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.

Chapter 5, Section 5 of SSMFS 2021:5 presents more detailed requirements on the contents of the site emergency response plan, required by SSMFS 2018:1, which includes i.e. description of and references to procedures, facilities, mobile equipment, technical assistance to operational staff, and coordination with off-site organisations. Requirements on emergency response organization, response time, criteria for alarm for different emergency classes, and protective equipment are found in Chapter 8 of SSMFS:6. Chapter 8, Section 10 of SSMFS 2021:6 also contain new requirements, to clarify the initiation of transfer of process data to SSM during emergencies, as requirement by Section 10 of the Act on Nuclear Activities (1984:3). The latter part has before 1 March 2022, partly been regulated through plant specific decisions.

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 between authorities in order to enable agreement on how to direct handling and coordination of available resources. The Swedish Civil Contingencies Agency (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 recommendations developed by MSB have resulted in a review of SSM's emergency response organisation to enable SSM's role in the emergency response system to efficiently provide advice and recommendations to other authorities.

A national contingency plan is in place for dealing with nuclear accidents. 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.

The County Administrative Boards are responsible for emergency preparedness and response in the event of an accident at a nuclear facility. The Board appoints a rescue commander who decides on issuing a warning and communicating to the population affected, and who determines which actions to take to protect the public. The responsibility for directing rescue services also rests with the County Administrative Board in the affected county or counties, unless the Government decides otherwise. Surrounding each NPP, inner emergency zones 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 inner emergency planning zone are provided with special radio receivers. These are used for warning residents in the event of an emergency at the NPP. The County Administrative Board is also responsible for managing decontamination activities following a nuclear emergency involving fallout.

The Government is responsible for crisis management at national level. The Government's mandate is primarily strategic issues. Responsibility for management and coordination of operational work rests with the relevant authorities. The Government has the overall responsibility to ensure that an effective crisis management system is in place and that crisis communication is credible. The Government is also responsible for maintaining certain contacts with international organisations. The Government Offices assist the Government in crisis management work. Within the Government Offices, the responsibility principle is to be applied during times of crisis. This principle implies that the ministry with mandates under normal conditions also has these responsibilities in the event of a crisis.

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

SSM is tasked with coordinating the emergency preparedness measures necessary for preventing, identifying and detecting nuclear and radiological events that might cause damage to human health or the environment. SSM is the appointed National Competent Authority (NCA) in Sweden. In the event of a radiological or nuclear emergency, SSM provides recommendations and expert advice to other authorities, including those responsible for deciding on protective actions for the public. The recommendations and expert advice include, but are not limited to, protective actions, radiation protection assessments, dispersion prognoses, radiation monitoring and conditions at an NPP. SSM also maintains and leads a national expert response organisation for radiation monitoring and expert support. Furthermore, SSM is tasked with keeping the Government informed about the situation, current and possible developments, forecasts, available resources, and measures taken and planned following a request from the Secretariat for Crisis Management at the Ministry of Justice, or from MSB. SSM is required to provide necessary information for assessment of a situation.

Authorities that have key roles during a radiological or nuclear emergency include the National Food Agency, which is responsible for taking decisions on maximum permitted levels of radioactive materials in foodstuffs, and the Board of Agriculture, which is responsible for taking decisions on maximum permitted levels in feed. Other authorities that have a mandate during crises and that cooperate with SSM, or receive advice and recommendations from SSM, include the County Administrative Boards, MSB, Board of Health and Welfare, Swedish Customs, Swedish Meteorological and Hydrological Institute (SMHI), Police Authority, and Swedish Coast Guard. SMHI assists SSM by providing weather forecasts, weather data and certain dispersion calculations in the event of a radiological or nuclear emergency.

MSB, the National Food Agency, Board of Agriculture, Swedish Defence Research Agency and SSM collaborate closely within the national expert council on remediation (NESA). 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. The work of the council includes revision of national 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 during extraordinary events. MSB has the overall responsibility for Rakel, 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 Rakel 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 19.

In the event of a nuclear emergency abroad, any affected County Administrative Boards still have 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 radiological emergency at a Swedish nuclear power plant (belonging to emergency preparedness category 1), the licensee is responsible for immediately

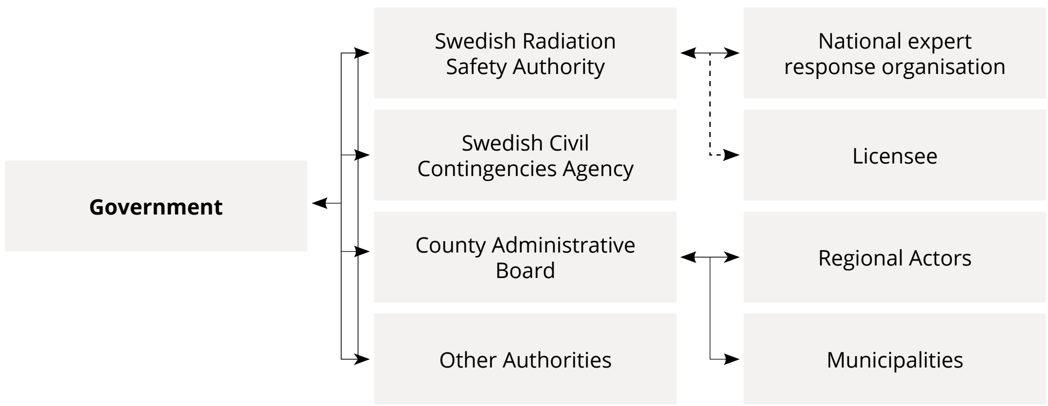

Figure 19. The Swedish national structure for emergency preparedness and response for nuclear emergencies.

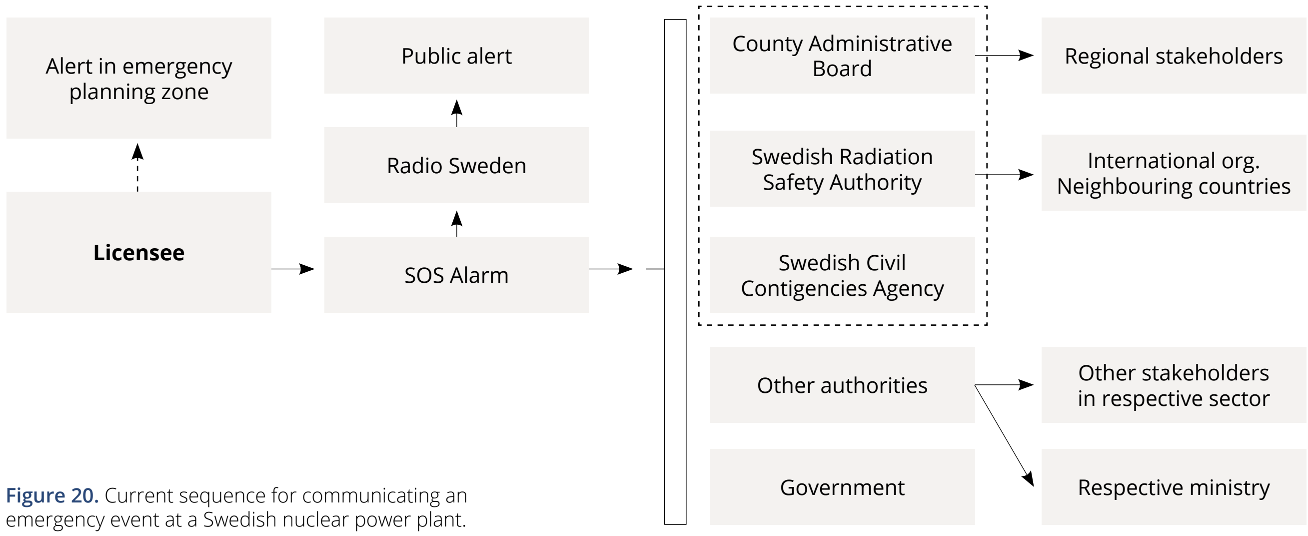

Figure 20. Current sequence for communicating an emergency event at a Swedish nuclear power plant.

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 20.

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.

16.2.2. Emergency preparedness strategy

The 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 has strengthened the requirements in the field of emergency preparedness and response. Among other things, the Government has, in the radiation protection ordinance, set reference levels for the public in emergency exposure situations. 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, which take 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 for the purpose of securing its performance in connection with the forthcoming new emergency preparedness zones and planning distances.

On 22 October 2015, the Government of Sweden commissioned SSM, in consultation with MSB, relevant County Administrative Boards and other involved authorities and stakeholders, to perform a review of emergency planning zones and emergency planning distances applying to activities involving ionising radiation. On 1 November 2017, SSM proposed new emergency planning zones and distances to surround the relevant nuclear facilities in Sweden. The review included sensitivity analyses for the purpose of looking into the feasibility of the proposed emergency planning zones and distances, including events with simultaneous releases from several reactors at a site.

The Government commissioned MSB on 22 February 2018 to propose necessary changes to the Civil Protection Ordinance in order to implement the proposal from SSM. On 1 September 2018, MSB finalised the proposal for the necessary changes to the Civil Protection Ordinance. On 30 October 2018, the Government released both the proposal for new emergency planning zones and distances from SSM as well as the proposed changes to the Civil Protection Ordinance for public consultation. The deadline for submitting comments was set at 1 March 2019. On 19 May 2020 the Government decided on the new emergency planning zones and distances and changes to the Ordinance. The amendments to the Civil Protection Ordinance entered into force 1 July 2020 and will be implemented on 1 July 2022 at the latest.

SSM produced in 2020 a report stating SSM's assessment of which contingency planning is justified for extra distribution and intake of iodine tablets in connection with a Swedish nuclear accident. The report provides support to, among others, the county administrative boards in their contingency planning.

A national strategy for radiation measurements in the event of a nuclear or radiological accident is being developed by SSM, MSB and the County Administrative Boards together with the nuclear power plants. The project focuses primarily on a possible accident at a Swedish nuclear power plant. After this, the project will broaden its scope to cover other nuclear and radiological emergencies.

On the basis of the Nordic Flag Book and in collaboration with the National Food Agency, Board of Agriculture, County Administrative Boards, MSB, National Board of Health and Welfare, and the Police Authority, SSM is in the process of developing national guidelines on protective measures during a nuclear or radiological event at facilities and activities belonging to emergency preparedness categories 3 and 4. The guidelines will supplement the review of Swedish emergency planning zones and distances (SSM Report 2017:27e) which took into consideration facilities belonging to emergency preparedness categories 1 and 2. The guidelines will use the concepts of reference levels, dose criteria and operational intervention levels in an emergency exposure situation, in line with recommendations contained in ICRP 103 and IAEA GSR Part 7. The project will be completed by the end of 2019.

A development project (ETAPP), together with Swedish NPPs regarding electronic transmission of nuclear power plant parameters, was launched in 2012. A first memorandum of understanding was signed by the director general of SSM and the managing directors of the NPPs in the autumn of 2012. This encompassed three phases of development and a specification of requirements regarding these first three phases. In 2015, phase one and phase two were completed, including a transmission solution and a shared standard for visualisation of the parameters. In 2017, all three development phases were completed and an agreement on operation of the transmission and the visualisation tool was signed by the same parties, while awaiting new requirements from SSM. That same year, a second memorandum of understanding was signed regarding education, training and exercises, i.e. phase four. In 2022, the fourth phase will be completed, and the online visualisation tool, together with transmission of process parameters, are in use. From 1 March 2022 there will be requirements implemented regarding this electronic transmission of nuclear power plant parameters with the new regulation SSMFS 2021:4 concerning construction of nuclear power reactors. For the transmission solution there are facility specific agreements in place.

In 2021, SSM has investigated and reported the radiological acceptance criteria regarding exposure of the public to ionizing radiation that the authority thinks should apply to new nuclear power reactors when with the use of deterministic methods evaluating events and conditions in the event classes expected, unexpected, unlikely and special events and conditions. Radiological acceptance criteria indicate a highest acceptable level of radiological consequences for the public when evaluating events and conditions in different event classes and shall be applied to new nuclear power reactors. Anyone applying for a license for a new nuclear facility must, as part of the basis for SSM's opinion to the Government, show that the radiological acceptance criteria for the public specified by SSM are not exceeded. This creates better conditions for new reactors to be designed in such a way that the risk of exposure to the public in radiological emergencies is low.

16.2.3. Radiation monitoring

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 conditions. In addition to the national gamma monitoring network, new stations are currently being installed around the nuclear power plants in Sweden. The new monitoring stations will 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 new stations will, when online in late 2019, provide fast, reliable and automatic information on dose rates to be used in decision making on early public protective actions in the case of an accident at a Swedish nuclear power plant. Figure 21 shows the monitoring stations set up around the Forsmark NPP.

In addition, a new radiation monitoring system for fallout mapping in Sweden has been developed and introduced. The system will be based on mobile gamma spectrometry and be used for detailed mapping of dose rates around Swedish nuclear power plants in the case of a nuclear accident. It is mainly a carborne monitoring system intended to be used along predefined routes. The new system has been distributed to the County Administrative Boards. Training is currently conducted and the system is ready to be used. The system replaced a former system, which involved measurement of dose rates using handheld instruments in discrete positions.

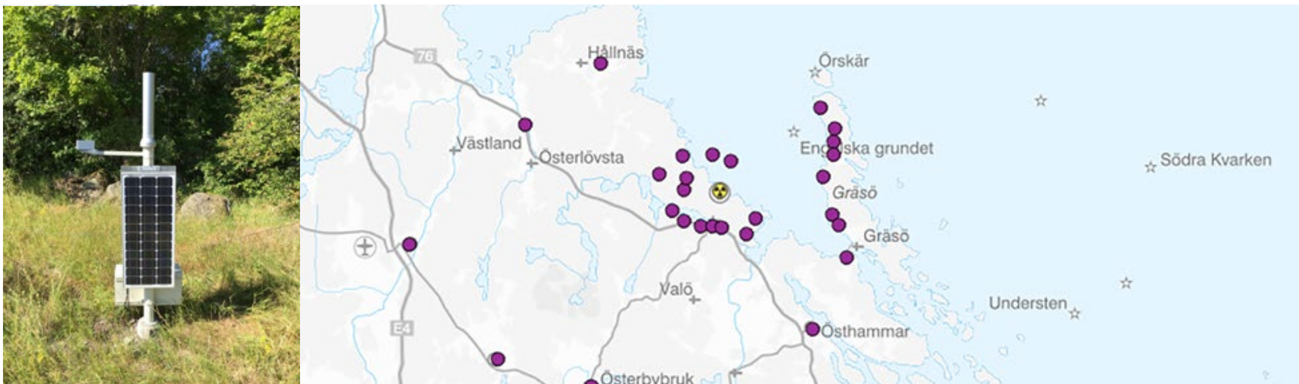

Figure 21. New monitoring stations around the Forsmark nuclear power plant (the inset shows a monitoring station).

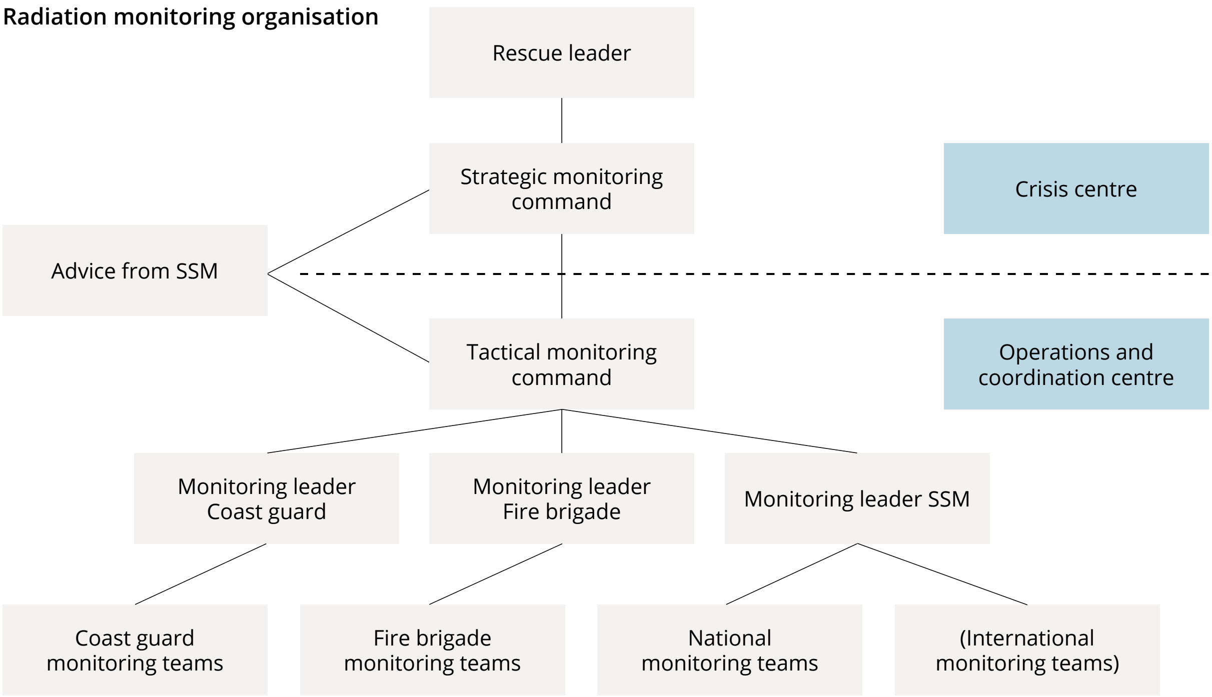

Figure 22. The Swedish radiation monitoring organisation which is set up in preparation for a possible nuclear emergency.

SSM has developed new GIS software for reporting, storing, extracting and visualising radiation monitoring data and environmental samples collected during an emergency. The new software, RadGIS 2.0, replaces RadGIS 1.0, which was developed in the 1990s. RadGIS 2.0 will be used by all Swedish organisations that perform radiation monitoring and sampling during a nuclear emergency. This software, launched on 15 April 2019, will be implemented in the response plans drawn up by organisations belonging to the national structure for emergency preparedness and response.

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. Their air filters are regularly collected and transported to a laboratory for measurement and evaluation. The detection system is sufficiently sensitive to measure activity levels in the order of tens of µBq/m3 and is consequently 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 rescue services from municipalities within each county at predefined locations or routes. During a nuclear emergency, the relevant County Administrative Board coordinates response and monitoring activities with the national expert response organisation and government authorities in accordance with the organisational chart shown in figure 22.

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 23 lists the 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.

16.3. Compliance of licence holders

The licensees at all sites are working on measures to fulfil the new requirements of SSMFS 2014:2, which concern on-site emergency preparedness and response at nuclear installations. This regulation entered into force on 1 July 2018. Measures have been completed regarding requirements for the ability to establish an off-site logistics centre for heavy equipment, and decontamination, monitoring and follow-ups of radiation doses, in addition to other aspects.. The licensees also carry out measures that were identified and reported during and after the European stress tests and were included in the NAcP.

More specific information regarding the work performed is provided below.

16.3.1. Activities at each site

Forsmark NPP

At the Forsmark NPP, documentation has been developed to manage abnormal events. This documentation consists

Expert Response Organisation

- Swedish Defence Research Agency, FOI (Umeå)
- Geological Survey of Sweden, SGU (Uppsala)
- Cyclife Sweden AB (Nyköping)
- Linköping University (Linköping)
- Göteborg University (Göteborg)
- Lund University (Malmö region)
- Swedish Meteorological and Hydrological Institute, SMHI (Norrköping)
- SSM (Stockholm region)

Figure 23. National expert response organisation for nuclear and radiological emergencies.

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.

Since mid-2017, a project is ongoing at Forsmark to update its procedures for severe accidents. Forsmark have built a completely new severe accident management guideline based on IAEA Safety Standards "Severe Accident Management Programmes for Nuclear Power Plants Safety Guide NS-G-2.15". This SAMG will give us support for good 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 reactorbuilding and also for the spent fuel pools. The SAMG manage both ordinary operation and outage. The work was finished at the end of 2020.

A fully mobile logistics centre has been established. The purposes of the centre include receiving equipment, personnel and supply protective equipment, dosimetry services (EPD), screening for external and internal contamination, cleaning personnel, cars, trucks and equipment, rotation of on-site personnel, and receiving heavy equipment prior to transport to the NPP. An exercise was conducted in 2019 that tested the functionality of the mobile logistic centre. The result of the exercise conclude a well-functioning centre.

Ringhals NPP

The project aiming to provide Swedish Radiation Safety Authority (SSM) with process data has been developed and is still ongoing together with SSM.

In order to follow up the strengthened focus on Severe Accident Management (SAM) an inspection by SSM was carried out during February 2020. The inspection showed improvements and acceptable level of drills and education regarding frequency and evaluation, but further activities are expected regarding validation of the Severe Accident Management Guidelines (SAMG) package for Ringhals 3 and Ringhals 4. A plan has been drawn up for the work on the ordered measures.

In 2020, the new system for independence core emergency cooling (OBH) was included in the models which resulted in a significant reduction in both heart rate and the frequency of unacceptable emissions.

In order to clarify management conditions and communication channels within emergency response organisation (RIHAB), a new management philosophy been developed and implemented during 2020. When RIHAB is established, ordinary management structure deleted and the Site Emergency Director (OL) has unrestricted powers to decide on measures within the plant. On the affected units, it is Unit Manager (BL) who decides on operational actions. The principle of subsidiarity must permeate the management philosophy - it means that the room for maneuver must be as large as possible for the person performing the assignment / is closest to the event. The staff methodology is crucial for event management and a condition for being able to conduct qualified management in an efficient manner.

In 2021, the emergency unit and the fire protection unit merged, which has further simplified cooperation between these areas.

The exercise activities have been developed through collaboration between the areas of emergency response organisation, fire and rescue, physical protection and the maintenance department during 2021.

OKG NPP

Post-Fukushima improvement work in the field of emergency preparedness has been implemented. One example is represented by OKG's off-site operational support centre. The latest command management technology, such as sound and video equipment etcetera, 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 kilometres from the nuclear power plant. The Engineer on Duty (EoD) will, following an assessment of the situation, select from 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 nuclear power plants regarding protective equipment. Furthermore, the mutual agreement concluded previously on pooling resources during an event will provide additional reinforcement of an affected plant.

OKG 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. OKG has ten members of staff from the emergency preparedness organisation, who are available around the clock.

In 2018, OKG conducted an internal audit, in 2016 and 2021, SSM conducted compliance inspections, and in 2017, WANO conducted a follow-up of the peer review that took place in 2015 in the area of emergency preparedness. Great emphasis was placed on rectifying the development areas of the emergency preparedness and response organisations, an aspect that was identified from OKG'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 emergency preparedness and response arrangements.

As another outcome set against the background of the nuclear accident in Fukushima in 2011, the requirements for emergency equipment were made more stringent at Swedish nuclear power plants. Among other things, it is up to the licensees of nuclear power plants 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 July 2018. For this reason, OKG has established a logistics centre at a former airport, having an organisation set up to provide assistance at this centre.

Since the last report, 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 OKG 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 nuclear power plants 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 total environmental consequences of a scenario. Local follow-up exercises from the major national exercise (named KKÖ17, see section 16.5) have also been carried out.

16.3.2.1. Forsmark NPP

At the Forsmark NPP, training, retraining and exercises are carried out according to predetermined plans for staff involved in emergency preparedness and response work. The exercises have needed to adapt to the circumstances of the pandemic.

In addition to the annual functional exercises, the FKA 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 organization.

All nuclear power plants in Sweden take turns every two years to exercise with authorities up to government level. Forsmark NPP last national level exercise was 2019, ”Sea Eagle”.

During certain periods, with a high spread of COVID infections, weekly controls of the emergency response staff have been conducted. These controls have shown that the ability to handle emergency situations is maintained.

16.3.2.2. Ringhals NPP

Drills are planned annually with a 3-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. The prioritised actions for improvement are date set and followed up in the corrective action database (AvÄrs).

Evaluators observe the exercise, note the actions taken by RIHAB and identifies deviations and areas for improvement. Moreover, the evaluator and value which actions should be prioritised and they present concrete, feasible proposals that could lead to the development of the business. Evaluators are usually senior role holders of the role they evaluate but can also be personnel from The Swedish Nuclear Training and Safety Centre (KSU).

Future role holders who are under education observe the exercises as a part of the training of becoming a role holder. During functional exercises a senior experienced role holder mentor the newer role holders. 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. Due to the pandemic, the number of call-out drills was fewer during 2020-2021. Existing restrictions have prevented us from being able to gather too many in RIHAB.

The ordered leave routine for Ringhals has been trained once a year. The Ordered Leave routine states that personnel on site shall leave site as soon as possible by their own means.

Training on handling serious accidents according to SAMG has been carried out annually during refresher training for operating personnel. The pandemic has led to parts of training being carried out digitally. It has given us new experiences that we take with us in further training and exercises.

In November 2021, the largest total exercise ever was conducted. The exercise lasted for 12 hours and the practicing elements were KC, Technical Support Centre (TSC), Ringhals Evacuation Centre (REC), fire protection, physical protection, radiation protection and maintenance personnel. A full muster exercise was also included. SSM and The County Administrative Board participated in the exercise.

16.3.2.3. Oskarshamn NPP

At OKG, training in emergency response is based on an exercise and training plan. Each function within the emergency preparedness organisation continuously conducts internal exercises in order to strengthen its capacity. The plan is continuously monitored, and reported on at the last meeting of OKG'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. An adaptation is carried out by selecting a scenario, as well as by means of quick and flexible planning.

OKG has conducted exercises involving the Swedish armed forces and police. In late 2017, a major regional exercise was performed as planned. Its main focus was evacuation. OKG's goal was to put the functions of the logistics center into practice. Future exercise activities will be adapted to this scenario. In 2018, a number of exercises were carried out with the purpose of training staff and verifying the function of the logistics centre. All functions have additional exercises planned. In April 2019, a simulation exercise was carried out involving the entire emergency response organisation, including certain governmental organisations, with the theme of cybersecurity. In 2017 and 2018, 450 people belonging to the response teams were trained in EPO (emergency preparedness organisation) and RP (radiation protection) during severe accident conditions.

During the period, exercises were also held on six occasions at the logistics centre. This was for training of personnel who will staff the logistics centre, as well as to provide practice to the personnel involved in the crisis management organisation.

16.4. Regulatory control

In recent years, regulatory control of on-site emergency preparedness and response has focused on implementation of the new requirements contained in regulation SSMFS 2014:2.

In 2015 and 2016, compliance inspections were carried out regarding new requirements at the nuclear facilities, termination of transitional rules, and further implementation of SSMFS 2014:2.

In 2016, emergency preparedness at the Oskarshamn NPP was inspected. Only a minor remark was noted regarding dosimetry during a radiological emergency.

In 2017, staffing and reorganisation at the OKG NPP were inspected. Due to the decision to close two out of the three reactors at the site, the focus of this inspection encompassed staffing, competence and the subsequent reorganisation of remaining personnel. Another inspection conducted at the Ringhals NPP in 2017 focused on direct communication between the Ringhals NPP and SSM during a radiological emergency situation. The Ringhals NPP has subsequently changed its emergency response organisation and introduced a new function that roughly translates to team leader.

In 2018 and 2019, SSM's supervisory focus is on the requirements imposed on licensees to implement a logistics centre (new requirements regarding a logistics centre, as stipulated by SSMFS 2014:2, for facilities belonging to emergency preparedness category 1). All three operating NPP sites have been inspected, with all of them having been found to be compliant with the new requirements regarding a logistics centre.

SSM's focus in 2020 and 2021 has been the operating NPP's ability to man the crisis organization and potential loss of staff, and their actions taken to prevent the spread of the Covid virus in light of the pandemic. Furthermore, the buildings, equipment and tools for emergency response have been subject to regulatory activities.

Regulatory control has shown that on-site emergency preparedness at Swedish nuclear facilities categorised as belonging to an emergency preparedness category (see Table 8) has been strengthened in recent years, and that the main elements of SSMFS 2014:2 have been effectively implemented.

From 1 March 2022 the new regulations including EPR requirements for NPPs in operation will enter into force. SSM regulatory activities on emergency preparedness and response will in the coming years be concentrated to the licensees' implementation of these requirements.

Table 8. The Swedish nuclear facilities that are categorised in an emergency preparedness category.

Facility	Emergency Preparedness Category
Forsmark NPP	1
Oskarshamn NPP	1
Ringhals NPP	1
Central interim storage facility for spent fuel (Clab)	2
Westinghouse fuel fabrication facility	2
SWAFO waste management and storage	3
Barsebäck (permanently shut down NPP)	3
Chalmers University of Technology (research)	3
Cyclife waste management facility	3
Studsvik fuel and material testing and waste management facilities	3

During the period, the Chalmers University of Technology and Cyclife waste management facility were both classified as belonging to emergency preparedness category 3.

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 USIE[11] and ECURIE[12]. The respective County Administrative Board where the plant is located has the responsibility for planning these exercises, often with the assistance of MSB, a government agency, which is also responsible for the evaluation and follow-up analyses. 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, limited extent exercises 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 with each NPP site on an annual basis. These limited exercises also bring about better 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 for instance include 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.

In 2017, the KKÖ17 full-scale exercise was organised by the County Administrative Board in Kalmar. Also in this exercise, the joint methods and approaches for creating shared direction and coordination regarding decisions on protective actions were tested with very good results, according to the evaluation report. In 2017, the exercise IPilot was carried out, with its main focus on IT intrusion. This was simulated in a computer environment, primarily involving participants from the nuclear power plants. The exercise was a good opportunity for operators to increase their knowledge in the area. Once again in 2018, two exercises were carried out involving only the County Administrative Board and NPPs, where the IAEA's IEC also participated with assessment and prognosis capabilities, including reactor assessment tool reports, with good results.

In 2019 the County Administrative Board of Uppsala arranged the Sea Eagle exercise. It was the largest nuclear exercise ever organised in Sweden and included endurance, command and control, evacuation, overarching and shared situation awareness and prioritization of important activities, information and communication, the ability to measure and indicate ionizing radiation, and receiving international support.

The exercise comprised of four different parts:

1. An alarm exercise to test the alarm chain involving many authorities and organisations.
2. A main nuclear exercise that lasted for 36 hours. 77 different Swedish authorities and organisations from 6 different counties and international actors practiced in a NPP accident scenario involving disrupted conditions (known as a 'grey zone' scenario). This part of the exercise tested the national, regional and local abilities to act and coordinate rescue services during disrupted conditions over a longer period of time which required extra resources and everyone who participated in the exercise worked in shifts.
3. A radiation monitoring exercise, including two days of radiation monitoring in the field including international assistance. This part involved the ability to map, by indication and measurement, which areas have been affected by the fallout of radioactive substances and how high the levels of ionizing radiation are in these areas. Radiation measurement participants were not only from Sweden. Measurement resources in the form of expert teams from Finland, Denmark, Norway and Iceland participated in order to train receiving international support and how to collaborate with international actors.
4. A table top exercise where the long term effects of the accident were discussed. In addition to the county's municipalities, the police and the region, nine national authorities, such as the National Food Administration and the Swedish Board of Agriculture, and several representatives from the business community (who are also an important part of maintaining a functioning society in crisis situations) participated in this part of the exercise.

Due to the Covid-19 pandemic exercises have been cancelled or minimised and adjusted in order not to spread the virus. SSM has conducted digital training and digital

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.

exercises to uphold the capability of the crisis organisation when most of the employees have been working from home. In December 2020 there was an incident at an NPP in a neighbour country which SSM managed in a virtual crisis management format. Challenges which have surfaced in digital exercises are the difficulty in staying informed and sharing information in an efficient way within the crisis organisation when limited to communication at a distance.

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 a nuclear power plant in Sweden or abroad. An agreement at regulatory body level has also been signed with Lithuania.

In 2015, the Nordic radiation and nuclear safety authorities published a revised joint manual for cooperation between the authorities 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 cover response to events and threats of malicious use of radioactive material, as well as threats or malevolent acts concerning nuclear facilities.

In 2013, the Nordic radiation and nuclear safety authorities published the document "Protective measures in early and intermediate phases of a nuclear or radiological emergency – Nordic guidelines and recommendations" (Nordic Flag Book). The document gives comprehensive recommendations on the Nordic countries' shared approach to implementation of the 2007 ICRP system of radiological protection during an emergency exposure situation. The Nordic Flag Book is now under revision in order to encompass changes on different levels such as EU BSS (2013), GSR Part 7 (2015), GSG-11 (2018), new national legislations (-2018) and the Swedish review of emergency planning zones and distances (2017).

16.6.1. Measures taken to inform neighbouring states

SSM has been appointed a Competent Authority 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 NWP, implying 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 between the IAEA member states. 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 regulators in response to and preparedness for nuclear and radiological emergencies and incidents. The manual describes practical arrangements regarding communication and information exchange to fulfil the stated obligations in bilateral agreements between the Nordic countries. These arrangements also apply to a response to events or threats of malicious use of radioactive material and threats or malevolent acts concerning 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. The arrangements defined in this 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 videoconference 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 2018, Swedish national assistance capacities were updated to reflect the current situation. For example, atmospheric dispersion modelling was added due to extensive experience gained in this area in recent years. Sweden contributed to the development of the RANET system by participating in a radiation monitoring workshop held in the Fukushima prefecture in 2018, hosted by the IAEA at its Capacity Building Centre in Japan.

16.6.3. Nuclear accidents abroad

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

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 regions. 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) for 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 of developments since the previous report

During the current review period, the following developments are of relevance with regard to the obligations of Article 17:

– SSM is currently revising its regulations on nuclear activities, including requirements related to external hazards and siting.
– The licensees have revisited the site impact analyses of their designs, with actions taken and planned with the aim of improving robustness and safety. The actions include an update of the dimensioning values relating to external hazards and implementation of any needed measures at the NPPs.

17.1. Regulatory requirements

Chapter 2, Section 1 of SSMFS 2018:1 requires that events and conditions important to safety (or 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 security) requirements. There are no distinctions between internal or external events and conditions in this requirement, so site specific characteristics including i.e. natural phenomena or human induced situations and activities that might affect safety (or security) must be considered.

Resilience to failures and other internal and external events, including natural phenomena and human induced situations and activities, are regulated by Section 14 of SSMFS 2008:17. According to these requirements, a nuclear reactor shall withstand natural phenomena and other events that might arise outside or inside the facility and which can lead to a radiological accident. Natural phenomena and event sequences that do not allow for sufficient time for taking of protective measures when they occur shall be assigned to event class. For each type of natural phenomenon that can lead to a radiological accident, an established action plan shall be available for the situations in which the dimensioning values run the risk of being exceeded. In the general advice for Section 14 of SSMFS 2008:17, examples are listed of natural phenomena that should be taken into account, such as extreme winds, extreme precipitation, extreme ice formation, extreme temperatures, extreme sea waves, extreme seaweed/algae growth or other biological conditions that can affect the cooling water intake, as well as extreme water levels and earthquakes.

Safety classification is regulated by Section 21 of SSMFS 2008:17. According to these requirements, structures, systems and components of a nuclear power reactor shall be divided into different safety classes. The detailed quality and functional requirements resulting from this safety classification are defined and controlled by specifying sub-classes, including mechanical quality class, electrical function class, as well as classification with respect to seismic and environmental tolerance.

In relation to the safety impact of a nuclear installation on individuals, society and the environment, and in relation to having revisited the impact and bases for drawing conclusions from the evaluations, it is stated in the introduction to the SSM regulation that limitation of emissions of radioactive substances from a nuclear facility is to be based on optimization of radiation protection and using the best available technology.

The major project for updating SSM regulations, as described in section 7.2.2, includes amending the regulation governing siting aspects. The background and experiences used in the update project also include, apart from international standards and experiences, the national action plan (NAcP) developed by Sweden as a consequence of the EU stress tests (see Appendix 2), and the SSM decision on installation of an Independent Core Cooling System (ICCS), described in section 18.1.

17.1.1. Development of new regulations

SSM has developed new regulations which enter into force 1 March 2022, i.e., after the current reporting period. The current regulations SSMFS 2008:17 are superceeded by requirements in SSMFS 2021:4, SSMFS 2021:5 and SSMFS 2021:6.

With basis in Chapter 2, Section 1 of SSMFS 2018:1, the new regulations give more detailed requirements on site specific characteristics that must be considered in design and construction of a nuclear power plant. Chapter 4 of SSMFS 2021:4 more clearly specifies the events and conditions important to safety that shall be considered in design and construction of a nuclear power plant. Events and conditions to be considered are specified in Annex 1 of SSMFS 2018:1, which includes site specific:

- 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 nuclear power plant and other facilities or activities

Identification of these events and conditions shall be kept up to date. Also a comprehensive review of these are expected in conjunction with the PSR (see 14.1.4). The Annex 2 of SSMFS 2021:4 also state design criteria for the fulfillment on the main safety (and security) functions of a nuclear power plant that have to be met.

Chapter 3, Section 6 of SSMFS 2021:5 includes clarified requirements on analysis of expected radiological consequences for workers and members of the public during operation of the nuclear power plant. Acceptence criteria for these analysis are presented in Annex 1 of SSMFS 2021:5.

17.2. Compliance of licence holder

17.2.1. Evaluation of site-related factors

As part of the licensing process of the plant, an assessment was made to evaluate site-related factors affecting the safety of the nuclear installation. Based on experience feedback, certain supplements and improvements to the assessment have been made since then. The experiences from the Fukushima Daiichi accident, the EU stress test and the development of the Swedish national action plan (NAcP) have constituted the main background for developing and improving the assessment during the period as of the reporting comprising the seventh national report under the Convention.

The safety analysis of the nuclear installations is based on identifying a number of initiating events undergoing analysis using deterministic methods and, if appropriate, probabilistic methods. The basis for the original design comprised safety features for ensuring the robustness of the facility during external events with a probability of $> 10\{^{-4}\}$ per year. Today, events with a probability of $> 10\{^{-5}\}$ per year are being analysed, and the analyses performed as a result of the NAcP and the analyses as part 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 evaluations (screening) and events that are considered, with the latter being classified into categories based on frequency. The events that are not considered for further evaluations 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.

The deterministic analyses are used to verify that there are no initiating events that can jeopardize the safety of the surroundings and the environment. This is accomplished by verifying that fuel damage is avoided, verifying that the reactor coolant pressure boundary is not overpressurised, verifying that the containment is not overpressurized, 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 non-destructive testing. Safety margin assessments considering all external hazards have been performed. Weaknesses and potential improvements have been identified.

In addition to the deterministic safety analyses, a probabilistic safety assessment (PSA) is performed in terms of external events (excluding a seismic PSA[13]) on the part of each reactor unit. 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. Physical measures as a consequence of the assessments are reported in sections 6.2.1 and 18.2.1. 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 pipe has been evaluated further, located between the reactor containment and the MVSS, that allows for controlled pressure relief of the containment. 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 on a 10{$^{-6}$} per year earthquake and for the severe accident mitigation systems, in addition to the estimated ability to withstand the 10{$^{-7}$} per year probability earthquake.

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 previously not been carried out at any Swedish NPPs. 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

An investigation has been performed of plant characteristics in extreme weather conditions. In particular, the investigation assessed plant robustness against combined extreme weather conditions, such as ice storms and simultaneous heavy snow load on structures. A systematic analysis of other possible combinations of naturally occurring hazards has also been performed.

Some 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. One example is reinforcement of the service building's resilience against external events at Ringhals. The work on addressing this shortcoming is under way, with the measures planned to be in place by 2020. For more information, see the transition solution described in section 6.2.1.

The Ringhals plant's ability to withstand an ice storm has been evaluated, giving an acceptable outcome. A renewed estimation of temperature extremes for return periods up to 100.000 years at Ringhals has also been performed. The emergency diesel generators have been reinforced to withstand low outdoor temperatures in the form of installed manual waste gate valves.

17.2.1.5. Investigation of the frequency 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.

17.2.1.6. Flooding margin assessments

An analysis of incrementally increased flood levels beyond the design basis and identification of potential improvements have 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

FKA has performed analyses of extreme external flooding showing that the plants can withstand the 10{$^{-6}$} per year flooding. RAB has analysed extreme flooding levels, based on statistics, including the consequences of waves. Due to the results of the 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. The ICCS is nevertheless designed for a 0.5 m water over ground level.

13 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).

17.2.1.7. Evaluation of the protected volume approach

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 recognized 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 site

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.

Snow and wind loads are stated by Swedish building regulations. Normal wind load ($>10^{-2}$ per year) is stated 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 from 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 during and before 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.

17.2.1.11. Nearby installations containing materials that might jeopardize the safety of the nuclear installation

Forsmark NPP

The Forsmark nuclear power plant 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 nuclear power plant are also considered.

Ringhals NPP

Hydrogen gas explosions/deflagration taking place at the hydrogen gas plant (HGP) or at the turbine building of Ringhals unit 1 constitute the largest risk. Smaller explosions might be caused by hydrogen gas containers, though the actual impact is judged as negligible. The distance from the reactors of Ringhals units 1 and 2 to units 3 and 4 is too large to bring about an event affecting the latter two units, if initiated at Ringhals' reactors at units 1 or 2.

In these analyses, distance-dependent effects such as pressure, impulse density and heat impact are studied. The analysis regarding existing buildings was performed in the autumn of 2008. Fire constitutes a secondary fault/effect initiated by the explosion/deflagration, and is analysed and evaluated in connection with unit-specific analysis of explosion/deflagration. It is the summed effect of explosion and fire which constitutes the dimensioning case. The present analysis of the HGP only accounts for the explosion/deflagration aspect. A hydrogen deflagration at the HGP has the potential to result in lost external power. The study "Loss of external power" covers this case. If gas releases are detected, existing surveillance automatically closes the air supply. A judgement is made depending on the distance to the source.

The Ringhals NPP has its own harbour, which is dimensioned for bulky transports so that reactor vessels, steam generators and other heavy components can be received. The harbour is mainly used by the marine vessel M/S Sigrid, which is specially designed to transport spent nuclear fuel and low and intermediate level wastes.

There are two fairways close by along the coast. The largest, the "T route" is mostly used by large ships, passing 20 kilometres (10 nautical miles) west of the Ringhals site. All transports of chemicals take place along this fairway. The "Öresund route" lies closer to the coast and is used by cargo ships and tankers, especially vessels that are northbound. The risk of external influence from these vessels may be posed in the form of potential releases from these ships, either by means of an accident or in the form of illicit dumping. Chemicals transported along the west coast of Sweden include hydrocarbons, acids, hydroxides and other aggressive chemicals. Transports of hydrocarbons, i.e. crude oil, represent up to half of all transports made through Kattegat. Transports of acids, hydroxides and other aggressive chemicals only constitute a small fraction of those made through Kattegat. Releases having a potential to harm or endanger the safe and stable operation of the nuclear power plant may possibly occur along the larger "T route" fairway. An impact to the seawater used for cooling might be caused due to the marine transports that take place along and outside the coast.

Main public roads, railroads and fairways with transports of large quantities of goods are located at a distance of at least three kilometres. This means that a potential explosion would be at such a distance making an influence from a fire irrelevant. 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. 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.

Oskarshamn NPP
Similar to the Forsmark NPP, the site of the Oskarshamn NPP is located in a relatively isolated area. The site is situated on the coastline of the Baltic Sea, on Simpevarp Peninsula, part of Oskarshamn Municipality, located 8 km northeast of the village of Figeholm and 20 km northeast of the town of Oskarshamn.

Hydrogen gas explosions at the hydrogen gas plant 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 nuclear power plant 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 nuclear power plant and hydrogen gas plant is not maintained with respect to objects expelled by a blast (missiles). A missile might potentially reach the nuclear power plant, though the buildings are dimensioned to withstand tornadoes, and thus generated missiles.

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

Forsmark NPP
The environmental control programme in place at and around the power plant has the objective of verifying that no unknown sources for releases of radionuclides to water and air exist, or that any unpermitted accumulation of radioactive substances is occurring in the vicinity of the power plant.

Ringhals NPP
With the help of aerial photography of smoke releases during different meteorological circumstances (wind, temperature, precipitation, snow cover, etc.), weather data from the meteorological mast and values of the diffusion parameters, a so-called "dispersion catalogue" for the Ringhals NPP was established. Using this catalogue, the main characteristics of the dispersion can easily be identified.

No special study of the hydrological dispersion conditions has been conducted. The dispersion may, however, be described based on hydrological observations, e.g. how the surface water is affected by the water flowing from the Baltic Sea, and how often it is exchanged (less than once every thirty days), the bottom water being contained between one to four months per year, and the outflow of water from rivers, streams and point releases by industries and sewage installations.

Other forms of identified disturbances consist of light, noise, smells, water use, releases to water and air, effects from electromagnetic fields, and the use of chemical products. Chemical products such as hypochlorite are used to reduce settlement of mussels and barnacles in the water tunnels for cooling waters. It is possible for unforeseen, non-ionising related accidents such as explosions, fires and pipe breaks on raw water lines in the area to occur.

Several studies were carried out regarding the effects of releasing cooling water and its impact on fish and the small-scale fishing industry. All fishing is forbidden in an established and marked area around the mouths of the discharge tunnels. From the harbours of Bua and Videberg on the Värö peninsula, both trawling and coastal fishing take place. The releases from the power plants have no discernible effect on fishing, according to the consistent views of the inspector of fisheries at the County Administrative Board of Halland, the chairpersons of the local fishing associations of Bua and Videberg, and the coastal laboratory of the Swedish Agency for Marine and Water Management in Gothenburg.

Report no. 3463 from the Environmental Protection Agency, from 1988, describes the results of test fishing during the period 1975–85 regarding easily discernible sicknesses and defects. The test comprised 29,000 cod, 13,000 flounder and 7,000 eels. For some of the material, the fish were more laboriously examined. The occurring frequency of sicknesses and parasites was largely representative for the regions of Bohuslän and Halland. No effects due to the Ringhals NPP could be detected; furthermore, no effects were observed on plankton and algal growth, since the area around the Värö peninsula does not deviate from the rest of the coast of Halland.

Oskarshamn NPP
BAT implies introduction of the most effective measure to limit the release of radioactive substances and their harmful effects on human health and the environment, and which does not entail unreasonable costs. One should also consider that the radiation doses to workers may increase when emissions into the environment are reduced. The regulation SSMFS 2008:23 also specifies that the annual effective dose from air and water discharges from all plants in the same geographical area to individuals in the critical group is not allowed to exceed 0.1 mSv. The "critical group" refers to persons who are estimated to receive the largest dose from the plant.

During the stress tests and as part of the NAcP (EU stress test National Action Plan), a review of the Design Basis External Events (DBEE) was conducted. The Swedish requirements (SSMFS 2008:17) concerning the magnitude of the DBEE stipulate that it must correspond to the probability of occurrence of 10-5 per year. As far as concerns earthquakes, a robustness check was made regarding an even more improbable event, 10-6 per year, and for the severe accident mitigation systems, the capability to withstand a 10-7per year probability earthquake was also estimated. An earthquake specific to Sweden is defined in the regulator's report, SKI 92:3. As far as concerns high water levels, the Swedish Meteorological and Hydrological Institute's (SMHI) data was reviewed. The Finnish meteorological institute conducted a second evaluation of the probability of extremely high water levels and waves in the Baltic sea, confirming SMHI's data. The plants' capability to withstand an ice storm was also evaluated, giving an acceptable outcome.

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 environmental impact assessment 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 an own facility and 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 19.7.3.

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, the initiating events are studied that have already been identified due to their estimated event frequency. If it can be shown that an event is more probable than previously assessed, it is moved to another category of events that matches the assumed frequency.

Since the systematics of the original event identification involved identifying the worst case events that might occur within each event category, only a few events have been added to the event list. It is nevertheless possible to have new potential initiating events identified. All new events are categorized in accordance with the occurrence frequency and their safety impact on the facility, as was carried out earlier during the original event identification. Identification of new initiating events is performed partly through the systematic work on probabilistic safety assessments, which are periodically conducted, partly by means of the internal and external systems for feedback exchange and reporting.

Actions related to the NAcP are further described in Appendix 2. All licensees have conducted evaluations and reassessments in accordance with the NAcP. The conclusion has been made that ongoing work relating to extreme natural phenomena will provide prerequisites for management of extreme events, which will result in improving the plants' defence in depth.

17.3. Regulatory control

Generally speaking, site re-evaluations are conducted as part of periodic safety reviews, see section 14.3.2. A review of the NAcP's implementation has been performed. This was reported to SSM at the end of 2015. SSM has also 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 Independent Core Cooling systems, 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 of developments since the previous report

– Re-assessments of the robustness of the electrical power supply are ongoing at all operating reactors in reaction to national and international events indicating a need for a more rigorous approach to electrical system design.
– The first requirement in the decision on introducing an independent core cooling system was to considerably improve independence of existing emergency core cooling systems by the end of 2017; this has been achieved for all reactors in operation at that time.
– The design work for the independent core cooling system has been finalised, and the construction work is completed for all reactors that are in operation after 31/12 2020.

18.1. Regulatory requirements

The SSM regulation, Chapter 2 of SSMFS 2018:1, and Chapter 2 of SSMFS 2008:1, outline licensees' obligations with regard to barriers and defence in depth. This includes requirements on the utilisation of multiple barriers and requires a facility-specific approach for implementing the defence in depth concept for nuclear facilities. It also obliges licensees to analyse and report to the Authority any identified anomalies that can affect the defence in depth or barriers of the facility according to a predefined classification scheme. Chapter 3, Section 1 of SSMFS 2008:1 outlines the basic requirements for defence in depth as follows.

"Defence in depth shall be achieved by:

– ensuring that the design, construction, operation, monitoring and maintenance of a facility are such that abnormal operation and accidents are prevented,
– ensuring that multiple devices are available and prepared measures are in place to protect the integrity of the barriers and, if the integrity should be breached, to mitigate the ensuing consequences, and
– ensuring that any release of radioactive substances to the environment, which may nevertheless occur as a result of abnormal operation and accidents, is prevented, or, if this is not possible, controlled and mitigated through devices and prepared measures."

More specific requirements on design and construction are given in Chapter 3 of SSMFS 2008:1. These can be summarized in the following points from Section 1.

"A nuclear facility shall be designed and constructed so that it:

– is able to withstand component and system failures,
– is dependable and has operational stability,
– is able to withstand events or conditions which can affect the safety function of the barriers or defence in depth, as well as
– enables maintainance, inspection and testing of structures, systems and components important to safety (or security),
– as far as reasonable facilitates radiation protection and security, and
– as far as reasonable facilitates protection and safety during future decommissioning."

More specific requirements regarding design principles for defence in depth in nuclear power reactors are defined in the Swedish Radiation Safety Authority's Regulations and General Advice concerning the Design and Construction of Nuclear Power Reactors (SSMFS 2008:17). These regulations include requirements on simplicity and durability, redundancy and diversification as well as physical and functional separation in the design of the safety functions, requirements regarding automatic control or passive functions, and requirements to ensure that failures in safety classified equipment lead to acceptable levels of safety. SSMFS 2008:17 also includes design requirements concerning resilience to failures and internal and external events, environmental tolerance and environmental impact, control rooms, safety classification, event classification as well as the reactor core.

In addition to the regulations SSMFS 2008:18, SSMFS 2008:1 and SSMFS 2008:17, there are also regulations concerning pressure vessels, mechanical equipment, competence and training for operators, security, and radiation protection.

The regulations SSMFS 2008:1 stipulate that guidelines shall be developed to manage beyond design basis events. Regulations regarding the design and construction of nuclear reactors to cope with beyond design basis events (including severe accidents with core melt) are found in SSMFS 2008:17. Requirements on release mitigation in the event of severe accidents are given in a governmental decision from February 1986. For a discussion about the applicable requirements for an emergency situation, see section 16.1.

Requirements on proven and verified technology are found in Chapter 2 of the Environmental Act (1998:808) and further detailed by the provisions of Chapter 3, Section 2 of SSMFS 2008:1. This requires testing of design principles and design solutions under realistic conditions, or if this is not reasonably achievable, to have them undergo the necessary testing or evaluation with regard to safety..

The regulation SSMFS 2008:1 requires functionally based safety classification. In the case of nuclear power reactors, this is further detailed by the regulations SSMFS 2008:17, which states that structures, systems, components and devices of the nuclear power reactor shall be divided into safety classes. According to the general advice for SSMFS 2008:17, safety classification may be carried out as per the principles contained in the US standards ANSI/ANS 51.1 for PWR and 52.1 for BWR. Classification may also follow IEC standards where applicable; the I&C systems of modernised plants in particular use applicable aspects of IEC61226.

Provisions concerning quality classification of mechanical components in certain nuclear facilities are stipulated in the regulation SSMFS 2008:13.

In December 2014, SSM issued an injunction with requirements for an independent core cooling system. The injunction requires safety measures considerably improving the independence of existing emergency core cooling to be implemented by the end of 2017, and the system for independent core cooling to be installed and in operation by 31 December 2020. The purpose of the measures is 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 are defined by the extended loss of all AC voltage, as well as the by common cause failures in emergency core cooling functions. The two events should be combined with extreme external influence that may arise.

18.1.1. Development of new regulations

SSM has developed new regulations for nuclear safety, which enter into force 1 March 2022, i.e., after the current reporting period. The regulations SSMFS 2008:1 are superceeded by requirements in SSMFS 2021:4, SSMFS 2021:5 and SSMFS 2021:6.

In SSMFS 2021:4, Chapter 2, Sections 2 and 3 require tha application of a site-specific defence in depth in five defined levels, in design as well as in operation of a nuclear power plant.

Chapter 4, Section 12 of SSMFS 2021:4 requires that the design and construction of a nuclear power plant, enables the main safety functions to be fulfilled with as high level of dependability as reasonably achievable. To fulfill this general requirement during operation, the design must consider the both 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 include separate, more detailed requirements on reliability of structures, systems and components important to safety (or 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 (or security), 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. Chapter 4, Section 13 of SSMFS 2021:4 also indicates a strive for the use of proven design and construction. If this is not practical achievable, a separate process of verification and validation of sufficient reliability is required. An important addition to the new regulations is also 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 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).

18.2. Compliance of 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 SSMFS 2008:17, and in practice also take into consideration the WENRA approach of Design Extension Conditions. Swedish nuclear power plants 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 characterized 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 are 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 LOCAs).

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 which 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 as reported previously, see Appendix 1. In many cases, the need for improved separation was identified through PSA. Swedish reactors have been retrofitted to comply with regulatory requirement on functional diversification. The functions of reactivity control, overpressure protection, cooling and residual heat removal, and the containment function, shall all have diversified backup capabilities, see Appendix 1.

The objective of implemented or planned design measures or changes (plant modifications, 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 TMI nuclear accident in 1979, as well as domestic incidents such as the ‘strainer event' in Barsebäck unit 2 in 1992 and the electric power system event at Forsmark unit 1 in 2006, have had a major influence on these measures. Furthermore, the new Swedish regulations on the design and construction of nuclear power reactors issued in 2005 have 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 with in 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 with regard to 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 ICCS that was installed in 2020, seismic events with the frequency exceeding 1E-6 per annum have been considered for the design.

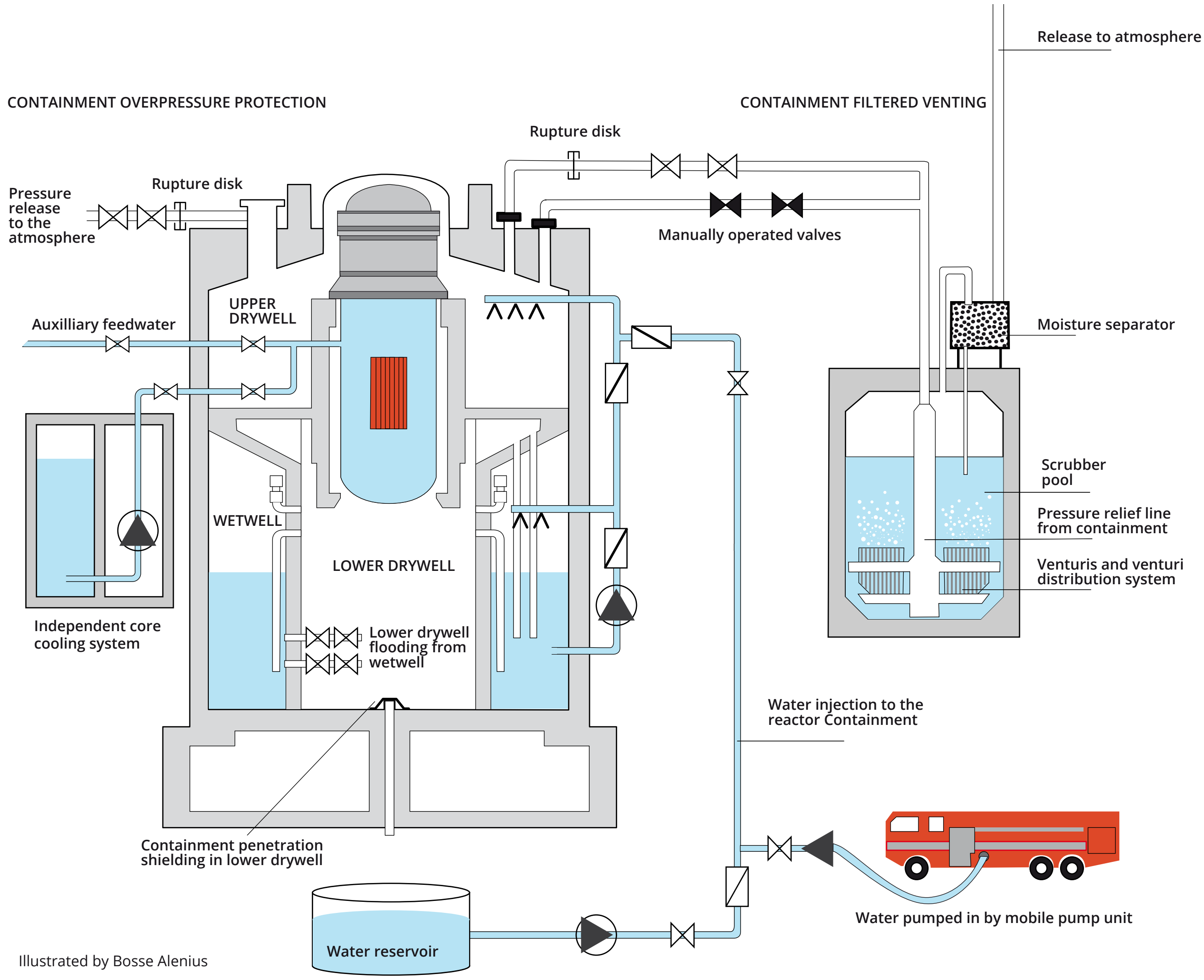

Figure 24. Schematic view of the independent core cooling system and severe accident mitigation features installed in Swedish BWRs. The ICCS schematic is specific for the Forsmark plant.

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 the exceedance frequency of 10-5 per year. For the ICCS that was installed in 2020, extreme water levels with the exeedance frequency of 1E-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 ICCS has 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 nuclear power plants 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 are 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 Three Mile Island accident in the United States 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 caesium-134 and caesium-137 in a reactor core of 1800

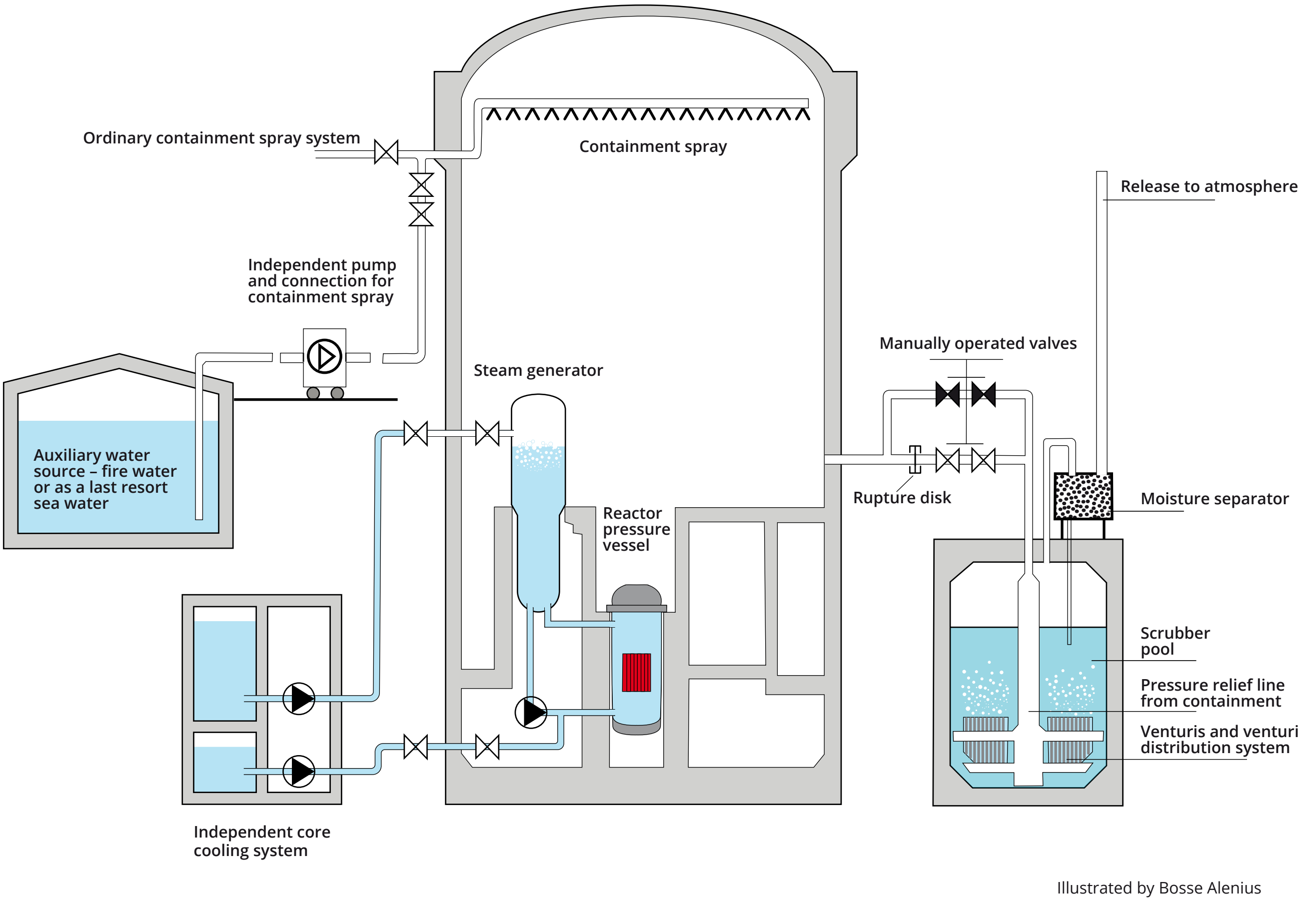

Figure 25. Schematic view of the independent core cooling system and severe accident mitigation features installed in Swedish PWRs.

MW thermal power (corresponding to approximately 100 TBq Cs-137), provided that other nuclides 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 overpressurization,
- 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 SAM 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.A conceptual illustration of the overall severe accident mitigation concept for the BWRs and PWRs is presented in figure 24 and figure 25, respectively.

The major component is the scrubber system comprising 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.

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, even if a wide range of international research has been conducted on phenomena that are also applicable to Swedish plants. 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 run 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. 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 now 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, e.g., that a major interaction between concrete and core melt (MCCS) will most likely be avoided. Also, 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

Independent core cooling systems (ICCS) are in place at all reactors in operation, as described in section 6.2.1.

Forsmark NPP

A new ICCS was put into operation at the Forsmark plant in 2020. The new system is a consequence of the stress tests following the Fukushima accident and the SSM requirements for an independent core cooling system, designed to withstand extreme external hazards.

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 units 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 (FRISK). One important design condition is that the FRISK 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 the implementation 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 independent core cooling system ICCS was installed in Ringhals units 3 and 4 in 2020. 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 independent core cooling system 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 the existing steam-driven auxiliary feedwater pump 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. 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 ny referens. The water provided to the reactor coolant system is borated and demineralized, and the water for the steam generators and spent fuel pit is demineralized and deareated.

The main features of the Independent Core Cooling system 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.

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 electromagnetic 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 independent core cooling system 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 OKG, measures are being taken to establish feed-and-bleed for the spent fuel pools (SPF). The measures comprise feeding of the SFP with water 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 energize the battery-backed busbars after the initial 8 hours in order to retain RPS functionality. Residual heat is released through the multi-venturi scrubber system.

Implementation of the final design solution is completed, includning 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.

A good example of incorporation of proven technologies, including the assessment needed to ensure that the technology is proven, is the major upgrade to the digital instrumentation and control system (I&C), completed in Ringhals unit 2 as part of the TWICE project. The project involved installation of a completely new and modern control room.

Some of the requirements applied to the TWICE project were:

- Functional classification is to follow the intentions stated in IEC 1226, first edition.
- The cable separation shall, considering limitations posed by the existing buildings, to the largest extent possible fulfil the requirements stated in IEEE 384 –1992.
- The fire protection shall, considering limitations posed the existing buildings, to the largest extent possible fulfil requirements applicable to new nuclear power plants.
- Installations of cabinets and equipment which support safety-related system functions shall have seismic capabilities according to “Swedish earthquake spectra” with a probability of exceedance of 10–5 per year.
- The structure shall have a level of functional separation that allows I&C system failures without loss of major plant system functionality, and allows maintenance and modification work to be performed at a plant and on I&C system/function level without affecting any other major systems/functions .
- The structure shall have a sufficient degree of functional diversity for avoidance of software Common Cause Failures (CCF) that might affect functional safety or reliability.
- The structure shall not introduce any additional functional dependencies between plant systems/ functions.

A plant safety demonstration method was developed and iterated with the regulator. The objective of the method was to demonstrate that plant safety was improved or at least remained unchanged prior to the implementation in a defined number of areas. The method was applied to the main steps of the project, with a final demonstration of safety during start-up and operation. Additional analyses of the concept were performed based upon experiences from the “Forsmark event” that occurred in 2006, and resulted in implementation of additional possibilities for DC power supply by DC, and some additional UPSs. For more information, see Sweden’s seventh national report under the Convention on Nuclear Safety.

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 needed to be taken within 30 minutes after an initiating event involving the risk of a radioactive release must be automated. The rule is implemented in the BWRs, and with some exceptions in the PWRs.

SSM has requested that the licensees, starting with the PWR operators, to conduct an analysis as to whether the grace times are suitable for different incidents. Human factors have long been recognised as an important consideration in design matters, and are addressed in Section 5 of SSMFS 2008:1. 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.

Sweden also participates 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 control

The regulatory approach in Sweden is to retrofit 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 15 years to achieve this target, see Appendix 1. SSM conducts and will continue to carry out supervision of licensee implementation of safety improvements and measures taken to ensure compliance with current standards and regulations.

SSM's overall assessment is that the measures taken to comply with modern requirements contained in SSMFS 2008:17 have significantly improved the level of safety at all nuclear power reactors 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 nuclear power reactors and licensee monitoring of the barriers' surveillance have also been substantially improved by implementing new or upgraded control equipment.

All measures in the NAcP have been completed in accordance with the original given time schedule, meaning that all identified measures were fully implemented by the end of 2020, following the Independent Core Cooling System (ICCS) installations.

Detailed information regarding the Swedish NAcP can be found in section 6.2 and Appendix 2.

According to the regulation, any safety significant events or plant modifications must be reported to the Authority. A standing group of experts (see section 10.5.3) makes the first assessment of all notifications; it consists of experts representing all relevant disciplines, including human factors experts. Information on regulatory review and control activities in relation to operation and human factors is provided in sections 12 and 19.

18.4. Implemetation Vienna Declaration on Nuclear Safety

This section, in reference to Article 18, describes how Sweden implements relevant improvements concerning principles of the Vienna Declaration on Nuclear Safety regarding the design of power plants.

As reported in the previous national reports, all Swedish reactors 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 nuclear power plants are, however, dedicated to one unit only.

In 2014, SSM decided that the licensees are required to implement an independent core cooling system at 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, as presented in section 18.2.1.6.

Implementation of particular design measures to maintain the integrity of the physical containment and to basically avoid a severe accident with potential long-term off-site contamination are examples of VDNS principles' fulfilment.

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 of developments since the previous report

During the current review period, the following developments are of relevance with regard to the obligations of Article 19:

- The total number of licensee event reports (category 2 LERs) has decreased from 210 to 150 per year over the past three years, due to fewer reactors in operation.
- Since mid-2017, efforts are ongoing to produce specific procedures for extraordinary situations at Swedish NPPs. These will give better support to the organisation in the case of similar events. A part of the work is improvement and adaptation to international guidelines in the area of SAMG.

19.1. Development of new regulations

SSM has developed new regulations which enter into force 1 March 2022, i.e., after the current reporting period. The main changes in the future regulations, are described in the respective subsections below.

19.2. Initial authorization

19.2.1. Regulatory requirements

Chapter 2, Section 1 of SSMFS 2018:1 requires that events and conditions important to safety (or 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 security) requirements.

As mentioned in section 14.1, a comprehensive deterministic and probabilistic safety analysis is required by SSMFS 2008:1, Chapter 4, Sections 1 and 2, prior to constructing and commissioning a plant. These analyses shall subsequently be kept up to date. To show how the plant is built, analysed, verified, and the safety requirements are met, a Preliminary Safety Analysis Report (PSAR) shall be supplemented to provide a pre-operational Safety Analysis Report, which justifies the finalised detailed design of the plant and demonstrates its safety. The final report (SAR) incorporates any necessary revisions to the pre-operational Safety Analysis Report following the commissioning and licensing process for the first entry into routine operation of the as-built nuclear power plant.

19.2.2. Development of new regulations

New regulations, entering into force 1 March 2022, are as follows. The regulations SSMFS 2008:1 are superceeded by requirements in SSMFS 2021:4, SSMFS 2021:5 and SSMFS 2021:6.

Chapter 4 of SSMFS 2021:4 more clearly specifies the events and conditions important to safety that shall be considered in design and construction of a nuclear power plant, and also specifies the main safety/security functions that have to be fulfilled and criteria for their fulfillment. In the new regulation, requirements on deterministic and probabilistic safety analysis in Chapters 3 and 4 of SSMFS 2021:5, are given in more detail than was the case of SSMFS 2008:1. Also, the relationship between these analysis, SAR and the safety assessment as a whole, are more clearly described. Requirements on PSAR are now 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 security).

Chapter 3 of SSMFS 2021:4 now include new requirements on management of design and construction work, including requirements on plans for commissioning, demonstrating that the installation, as constructed, is consistent with design and safety (and security) requirements.

19.2.3. Compliance by licensees and actions taken

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 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 later an FSAR; and through extensive operational testing, to verify both the function of the different individual systems and their shared 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 and technical specifications had been accepted.

The main changes and modifications in the SAR were related to plant modifications due to power uprates. Also, 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 be reflected in a regular update.

19.2.4. Regulatory control

SSM reviews safety analysis reports as a result of updates made due to applications for power uprates, or notifications related to (for example) plant modifications or analysis updates. Reviews by SSM have the aim of verifying that the SAR reflects the facility as it is built, analysed and verified, as well as its demonstrating how current requirements for design, function, organisation and activities are met.

19.3. Operational limits and conditions

19.3.1. Regulatory requirements

As stated by the regulation SSMFS 2008:1, Chapter 5, Section 1, documented and up-to-date Operational Limits and Conditions (OLCs), known in Sweden as STF, are required containing the necessary limits and conditions, as further specified in a separate annex to the regulations.

The OLC shall, together with the operational procedures, ensure that the conditions postulated in the safety analysis report are maintained during operation of the facility (Chapter 5, Section 1 of SSMFS 2008:1). The OLC is subjected to a twofold safety review by the licensee and submitted to SSM for approval. SSM is to be notified by the licensee about any changes that must also be subjected to a safety review.

19.3.2. Development of new regulations

New regulations, entering into force 1 March 2022, are as follows. Chapter 5, Sections 3 and 4 of SSMFS 2021:5 requires a set of OLCs to be specified (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 are identified for all areas, spaces, structures, systems and components contributing in the fulfillment of the main safety 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.

19.3.3. Compliance by licensees and actions taken

The operational limits and conditions for a reactor units stated in Annex 3 to SSMFS 2008:1 are included in an operational document named “STF” in Sweden (Säkerhetstekniska driftförutsättningar). This document is considered as one of the cornerstones in the governance and regulation of the operations of Swedish plants. 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 occurred, is described. However, several revisions have been made in all STFs 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 to the STF are subjected to a twofold 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). The STF documents are now part of the SAR documentation upon which STFs are based. 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. Integral 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 integral test is performed.

19.3.4. Regulatory control

SSM is regularly notified by a licensee when changes are made in the STF (OLC), or when temporary exemptions are needed. These notifications on changes in STFs and exemptions from STFs are reviewed as described in section 14.3. In total, SSM receives 10 to 20 notifications from the licensees each year.

19.4. Procedures for operation, maintenance, inspection and testing

19.4.1. Regulatory requirements

Suitable, verified and documented procedures according to Chapter 5, Section 2 of SSMFS 2018:1 shall be established by the licensee and are required for all plant states, including accidents. Chapter 5, Section 2 of SSMFS 2008:1 requires that symptom-based procedures shall be in place for a nuclear power reactor in order to re-establish or compensate for lost safety functions and to avoid core damage. Also, management guidelines are required to control and mitigate consequences of beyond design basis accidents. These guidelines should be developed to the extent possible and reasonable with regard to the need for protection of the public and the environment. The guidelines should be well coordinated with emergency procedures. Required instructions also cover events and conditions affecting several facilities at the same site.

The procedures for operability verification, as well as procedures and guidelines used in plant modes other than normal operation shall be subjected to a twofold safety review by the licensee. A full scale simulator should be used if possible and to a suitable extent for verification of operational procedures. Procedures for maintenance that are important for safety are also included in the requirement. Programmes for ageing management, maintenance, surveillece and in-service inspection are to be documented and up to date, and methods used shall be validated for their purpose. The regulations of SSMFS 2008:13 state that inspection and testing of mechanical components shall be carried out in accordance with qualified methods and verified procedures.

19.4.2. Development of new regulations

New regulations, entering into force 1 March 2022, are as follows. The current regulations SSMFS 2008:1 will be superceeded by requirements in SSMFS 2021:4, SSMFS 2021:5 and SSMFS 2021:6.

While Chapter 3, Sections 4 and 5 of SSMFS 2018:1 requires that all activities important to safety (or security) follow written procedures, new requirements in Chapter 2, Section 4 of SSMFS 2021:6 specifies that all procedures at a nuclear power plant 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 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 accidents. Also Chapter 3 of SSMFS 2021:4 requires that associated procedures, as far as resonably 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 requires a systematic coordination of plans and procedures in the implementation of progammes for maintenance, surveillance and in-service inspection. Since Chapter 6 of SSMFS 2021:6 inlude all requirements related to maintaining plant dependability, the chapter also specifies requirements on programmes for chemistry, verification of equipment qualification and aeging management, housekeeping and foreign material management.

19.4.3. Compliance by licensees

All activities that directly affect the operation of the plants are governed by procedures of different kinds. Normal operation, abnormal operation, emergency operation and functional tests are included in this category. 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 step by step, 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 SSMFS 2008:17 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 Safety Analysis Report (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. Optimization is also carried out in order to achieve an appropriate balance between maintenance and equipment modification.

Signing of steps' fulfillment, 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 ownership 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 (Övergripande störningsinstruktioner, ÖSI). ÖSI 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. The structure of procedures is illustrated by figure 26.

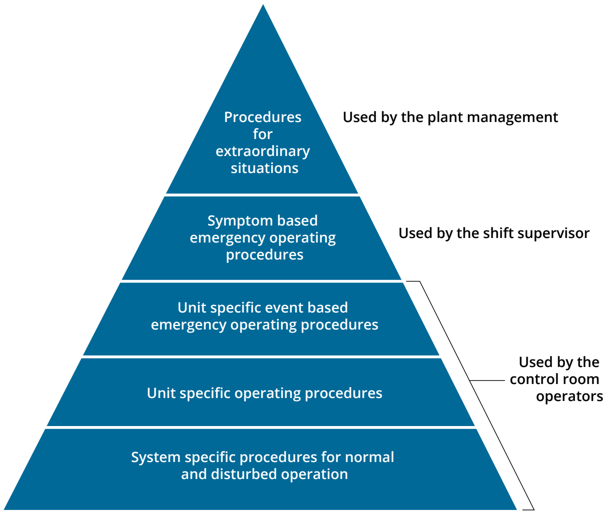

Figure 26. Overview of the main procedures applied during emergency situations.

Other documents are available that reference to the main procedures. The level of detail and number of procedures decrease in pace 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 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 dealing with situations including loss of all AC power and depressurization by means of the system for filtered ventilation of the containment.

Due to experience from the Fukushima event, an ongoing project is being carried out since mid-2017 to create procedures for extraordinary situations at Swedish NPPs. The purpose of the work is to develop procedures to better facilitate the organisation during similar events. The goal of this update is to improve the procedures and adapt them to international guidelines in the area of SAMG. Completion of the project is planned for late 2020. Moreover, this work will enhance procedures and guides for dealing with accidents affecting more than one unit at a site (when each facility will be staffed to manage its own situation and the plant's emergency and command centre is staffed and has the ultimate responsibility for making fundamental decisions that have an impact on more than the individual facility).

19.4.4. Regulatory control

Procedures are usually reviewed during supervision. When conducting an event investigation, SSM requests that procedures be submitted relating to the event in question. In these cases, SSM performs scrutiny in order to ascertain whether the procedure gives the prerequisite 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. SSM requested broadening of the scope of prepared strategies for managing severe accidents, in addition to a specific reassessment of the interface between the preventive and mitigatory domains. SSM had also identified a need for improvement of the documented support for decision-making, and for extended verification and validation of the procedures. The licensees were also asked to evaluate their training programmes for both BWRs and PWRs, and to report to SSM each year until 2020 about the outcome of their evaluations and reassessments.

The licensees work at Forsmark and Oskarshamn NPPs has resulted in the implementation of new SAMG:s inspired by IAEA Safety Guide NS-G-2.15 and Specific Safety Guide SSG-54. These SAMGs are currently under review. In addition, SSM issued new orders in March 2021 to Ringhals NPP to update the SAMGs for their PWRs unit 3 and 4. The licensee has submitted a plan to follow the current work of PWROGs development of a new generic SAMG and subsequent plant specific customization and implementation of the new guidelines.

19.5. Engineering and technical support

19.5.1. Regulatory requirements

Chapter 3, Sections 4 and 5 of SSMFS 2018:1 requires that all activities important to safety (or 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 ionizing radiation or shall have the economic, administrative and personnel resources neccisary to fulfill the requirements set by these acts. Chapter 3, Section 10 of SSMFS 2018:1 also more in detail specifies requirements that adequate personnel are available having 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 to an applicable extent. 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 requesting, managing and evaluating work important for safety that is carried out by contractors.

19.5.2. Development of new regulations

New regulations, entering into force 1 March 2022, are as follows. In addition to the current 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 security) related activities at a nuclear power plant, 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 specificly requires that engineering and technical support is available within the emergence response organization.

19.5.3. Compliance by licensees and actions taken

The nuclear power plants have personnel whose role is to specifically 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 still must be used, the plants have in-house expertise and the capability to evaluate the results of analyses, calculations, etc. that have been performed.

The former engineering group (VPC) within Vattenfall functioned previously as consultants. The group has been incorporated as a line organisation function for some time now, and in 2019 it was reorganised in order to incorporate the Fuel business unit. This unit, which is responsible for Vattenfall's nuclear fuel supplies, is now named Fuel Engineering & Projects (FE&P).

In 2018, the concept of Competence Centres (CC) was introduced at Vattenfall. CCs comprise the joint resource management for FE&P, Ringhals, Forsmark, decommissioning and SKB. The purpose of the CC model is to ensure access to strategically important competence within agreed competence areas, which is a long-term need.

19.5.4. Regulatory 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 nuclear power plants. In connection with other inspections and reviews, the specialist staffing situation has occasionally been commented upon.

19.6. Reporting of incidents to SSM

19.6.1. Regulatory requirements

The requirements of SSMFS 2008:1, "The Swedish Radiation Safety Authority's Regulations concerning Safety in Nuclear Facilities", include a chapter containing provisions on reporting and an appendix specifying these requirements in relation to various types of events (SSMFS 2008:1, Chapter 7, Sections 1 and 2 and Appendix 4, respectively). The following is a brief summary:

- Reporting within one hour: alarm events, scram with complications, and events and conditions belonging to category 1 (see below)
- Reporting within 16 hours: INES events of Level 2 or higher
- Reporting within 7 days: a comprehensive investigation report on alarm events or events and conditions belonging to category 1
- Reporting within 30 days: a comprehensive investigation report on events and conditions belonging to category 2, INES events of Level 1, and scram reports.

Additional requirements include daily reporting of operational state, power level and occurrence of any abnormal events or disturbances, such as scrams, and requirements for a comprehensive annual report summarizing all experiences that are important for plant safety. Specifications are provided on the content of the different reports and further interpretation of the reporting requirements given in the general advice.

One of the fundamental paragraphs contained in SSMFS 2008:1 regulates actions to be taken by licensees in cases of deficiencies in barriers or in the defence in depth. These actions include the first assessment and classification, adjustment of the operational state, implementation of necessary measures, performance of safety reviews, and reporting to SSM. A graded approach is allowed here. Appendix 1 of the SSMFS 2008:1 regulation specifies events and conditions that require different responses depending on the category of event they belong to. The three categories below are defined in this appendix:

Category 1
A severe deficiency observed in one or more barriers or in the defence in depth system, 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 defence in depth system 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 defence in depth system that arises when an event or situation is rectified and which, without measures, 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 measures 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 reporting to SSM. It is sufficient to make a compilation of these events 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 the plant has a disturbance in its operations, or in cases where it is difficult to determine the significance of an identified deficiency.

Section 10 of SSMFS 2008:23 requires that abnormally large concentrations of radioactive substances found in the surrounding environment of a nuclear facility shall be reported to SSM. Section 28 of the same regulations, also require that incidents leading to increased discharges of radioactive substances from nuclear facilities, shall be reported to SSM. Sections 36 and 37 of SSMFS 2008:26 include requirements on reporting internal contamination and exceeded dose limits for workers at the facility.

19.6.2. Development of new regulations

New regulations, entering into force 1 March 2022, are as follows. Requirements on reporting to SSM in the regulations SSMFS 2008:1, SSMFS 2008:23 and SSMFS 2008:26 will be superceeded by requirements SSMFS 2021:6.

In the new regulations SSMFS 2021:6, requirements on identification, categorization and management of incidents in Chapter 2, Sections 16–19 are similar to the previous requirements in SSMFS 2008:1, still using the categories 1, 2 and 3. However, all previous requirements on reporting incidents to SSM from SSMFS 2008:1, SSMFS 2008:23 and SSMFS 2008:26 have now been merged into a single Section, Chapter 9, Section 1, with Annex 3 describing different reporting procedures for different types of incidents. Also, requirements on reporting incidents related to radiation protection, discharges of radioactive substances and abnormal radioactive substances in the surrounding environment have been clarified.

19.6.3. Compliance by licensees and actions taken: incident reporting

Incidents of safety significance, including unintended reactor shutdowns, are reported in accordance with the non-routine reporting requirements in the STFs. There are two types of licensee event report (LER). The more severe one, called category 1, requires plant personnel to notify SSM within one hour. An extensive report is to be submitted within seven days from the point in time of the event, and the full analysis of the event and appropriate measures to prevent recurrence must be approved by SSM before restarting the reactor. Only a very limited number of events of this category have occurred at Swedish plants over the years. These events are also typically of a magnitude warranting prompt reporting (Level 2 or higher) according to the INES scale. During the period 2016–18, three reported events were rated as Level 1 on the INES scale. The rest of the reported events were rated as 0 or below the scale.

The other type of LER, called category 2, is used for less severe events. This type of event is mentioned in the daily report that is submitted to the regulatory body; this is followed up by a final report within 30 days.

Events that have resulted in reactor shutdown are analysed by the operations department and reviewed independently by the safety department and, 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
– Planned/decided measures
– 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 in accordance with the STF if the permitted levels of activity release from the plant are exceeded, or in the event of unusually high radiation exposure to individuals at the plant.

19.6.4. Regulatory control and actions taken

Over the past three years, the number of licensee event reports (category 2 LERs) has been approximately 20 per year and operating reactor and the total number has been between 120 and 140 LERs each year. Licensee reporting provides in most cases the necessary information, together with SSM verifications on-site, for making needed regulatory decisions.

For more serious incidents, SSM has a procedure in place for conducting on-site rapid investigations in the form of surveilance inspection (see 8.8). This procedure has been used in a few cases over the past few years.

19.7. Operating experience

19.7.1. 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 security), Chapter 3, Sections 18 and 19 of SSMFS 2018:1 also require that events of importance to safety (or 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 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. The results of the investigations related to incidents shall, under Chapter 5, Section 4 of SSMFS 2008:1, be disseminated within the organisation and have the purpose of contributing to the development of safety work at the facility. Moreover, the results of investigations must also be reported to SSM (see above). SSM ensures that significant events are reported to international organisations as appropriate (IAEA IRS) and other regulatory bodies, as well as to other suitable organisations.

19.7.2. Development of new regulations

New regulations, entering into force 1 March 2022, are as follows. Requirements on systematic feedback of operating experience in the current regulations SSMFS 2008:1 will be superceeded by requirements in SSMFS 2021:6.

In the new regulations, Chapter 2, Section 5 and 20 of SSMFS 2021:6, now requires an implemented operating experience programme, to compile experiences significant to safety or security, follow scientific and technological development, assess and prioritize experiences and to mediate these to relevant personnel and parties, such as i.e. international bodies, other operating organisations and SSM.

19.7.3. Compliance by licensees and actions taken

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 in one's 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, causes and root causes are to be identified, and the consequences clarified and the measures defined to prevent recurrence. MTO analysis is used when root causes and in-depth analysis are deemed relevant. MTO 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 imply recommendations (REK) directed towards Swedish and Finnish operators.

The procedure for operating experience feedback (OEF, termed "ERF" in Swedish) 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 out 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, including final repository and its settlement. 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 operators who have direct access and can use it for specific purposes.

Plants 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 with the Finnish plant, TVO and the German plant, Gundremmingen; the Oskarshamn NPP cooperates with other Uniper SE plants). Participation in owners' groups is considered valuable, although it is a more demanding task 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 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 systemic process.

Corrective Action Programme (CAP)

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 manager is responsible for encouraging reporting of deviations (e.g. observations and near-misses) from expected conditions (status, quality, etc.) and ensuring that the process of screening, analyses, corrective action and follow-ups is effective.

CAP is carried out at the distributed sub-locations of Operations, Maintenance and Health & Physics, and they all provide input for the internal OPEX by addressing relevant observations to the central OPEX group.

Internal OPEX

Each department is responsible for managing OPEX within their sub-organisation, including screening and corrective actions. Screening and addressing are managing by the central OPEX group. The result is brought upstream to the central OPEX group meeting. This group is staffed by appointed representatives from the OPEX group and two or three from the line organisation.

Industrial experience, an analytical approach and credibility in the organisation are considered valuable qualities for this role. Input for the central OPEX group consists of screened observations that might be of interest to share and act upon across the organisation, along with OPEX information from Norderf.

External OPEX

The production unit's safety board (SPS) meets three or four times per year and constitutes the decision-making body for external experience feedback. The SPS appoints members to the external OPEX group based upon

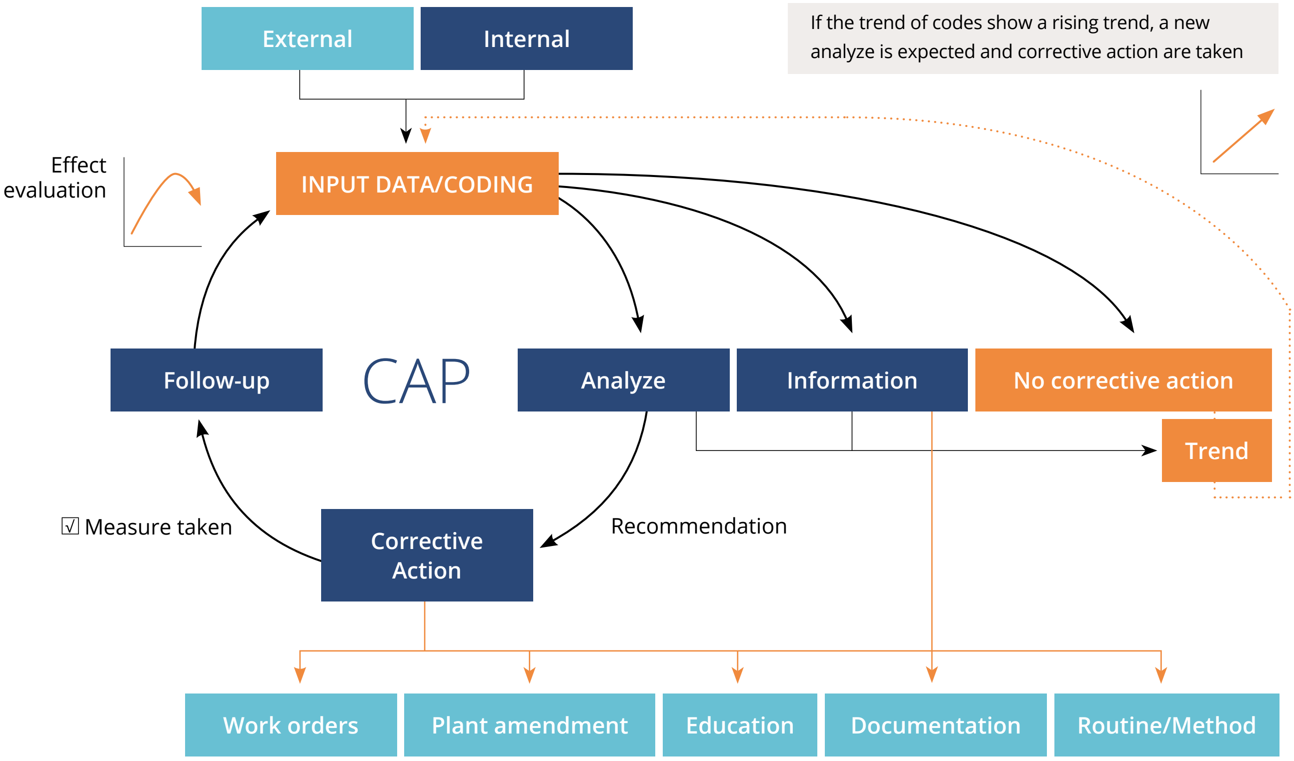

Figure 27. Vattenfall's CAP.

technical skills and organisational position. The overall objective is to enhance reactor safety by making use of external events/lessons learned.

Selected technical issues with a possible impact on nuclear safety are investigated within the organisation and then evaluated by a multidisciplinary technical group composed of 10 persons. The group meets eleven times per year. The SPS decides upon recommendations and whether or not actions are to be taken.

Forsmark NPP

The OEF function at Forsmark is organised in the Engineering Department. The OEF function is composed of two groups: Internal/External Operating Experience and MTO Investigation.

Internal and External OE

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 (see figure 27). In order to assist in handling and processing of OE reports, all main departments at FKA have OE coordinators who are responsible for ensuring that matters are dealt with as specified by the CAP process. The OEF department has four OE coordinators: one for the maintenance unit and project, which is the planning and outage management unit, one coordinator for plant operations units 1, 2 and 3, one coordinator for the engineering unit, and one coordinator for the safety, quality and environment unit.

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.

MTO investigation group

The 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 MTO.

Oskarshamn NPP

All departments and sections at the Oskarshamn plant are responsible for applying experience feedback in daily work within their own operations. This means that departments and sections at OKG:

- 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 OKG also obtain experience feedback from the quality department and from OKG's ERF (operational experience feedback) 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 operations assessment meetings, where the production managers require a broad illustration and cause analysis of the issues being dealt with.

CAP-process workflow

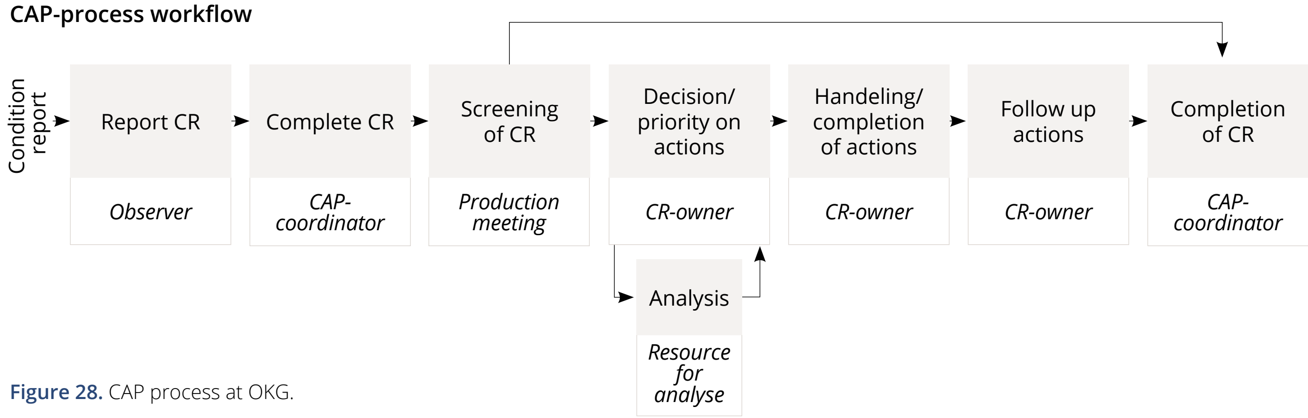

Figure 28. CAP process at OKG.

Depending on the nature and complexity of the event, MTO 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 OKG. 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.

Corrective action programme (CAP)
OKG works with a CAP for management of events, nonconformities and suggested improvements, see figure 28. 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 OKG 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 visualizes the drive for continuous improvements and defines setting of priorities.

19.8. Regulatory control

A procedure called "ASK" in Swedish, which deals with analysis of disturbances on electricity-generating nuclear power plants, 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 2008:1, and an international part which is reporting activity through the IAEA reporting system, IRS.

All reports from licensees are screened each week by a SSM team of four to five persons from the organisation. 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 ("ASKEN"). 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 (WBIRS).

19.9. Radioactive waste

19.9.1. Regulatory requirements

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 with different characteristics are separated from each other. Chapter 5 of SSMFS 2018:1 also include further general requirements on documentation of radioactive waste and annual reports to SSM, describing i.e. amount, contents, placement of and responsibilities related to the radioactive waste.

As of 1 November 2012, requirements are in effect regarding handling, processing and storage of radioactive waste. These requirements are stipulated by regulation SSMFS 2008:1. The regulations of SSM include requirements for the following:

- Measures for safe on-site handling, storage or disposal of radioactive waste and spent nuclear fuel shall be described in the safety analysis report of the facility. The measures for on-site handling shall consider the requirements implied by continued handling, transport and disposal of the radioactive material.
- Legally binding requirements to minimize radioactive waste to a reasonable extent.

– When designing and operating a facility concerning space for storage, the need to inspect the stored radioactive waste and spent nuclear fuel must be met as well as the need for extra space for moving radioactive materials.
– Plans for the management, including disposal, of all radioactive material present at the facility, which is likely to arise at the facility or is brought to the facility in some way. The plans shall for example take into account amounts of different categories of the radioactive material, estimated nuclide-specific content, and sorting, treatment and interim storage of the radioactive material. The plans are to be included in the safety analysis report before the facility is taken into operation.
– Only packages approved by SSM may be transported to a geological repository (such as the SFR facility) for disposal. Such approval presupposes the waste packages complying with conditions stated in the safety analysis report of the repository.
– An up-to-date inventory of on-site radioactive waste. The inventory of nuclear materials including spent nuclear fuel is regulated by SSMFS 2008:3.
– Waste acceptance criteria must be derived based on the properties of the radioactive material that can be received for storage, disposal or some other management. These criteria must, to the extent that is feasible and possible, be formulated while taking into account safety and radiation protection throughout all stages of the ongoing management. The waste acceptance criteria are to form part of the safety Procedures must also be in place for management of radioactive material that does not meet the waste acceptance criteria in that it is returned to the consignor, or by taking measures to rectify identified deviations.

For shallow land burial facilities, waste acceptance criteria are stated in the licence conditions.

19.9.2. Development of new regulations

New regulations, entering into force 1 March 2022, are as follows. Several reuirements of SSMFS 2008:1, related to radioactive waste, will be superceeded by the new and clarified requirements of SSMFS 2021:7.

Chapter 4, Section 5 of SSMFS 2021:4 requires that the the fulfillment of the main safety functions for a nuclear power plant, as far as reasonably achievable, shall strive to minimize exposure of workers, members of the public and the environment to ionizing radiation. This includes both actions to minimize discharges and radioactive waste. Also, Chaper 5, Section 1 of SSMFS 2021:4 requires that balanced choices shall be made in the design and construction of a nuclear power plant, so that amounts of radioactive waste will be minimized to the extent practicable. Similar considerations are also required in the preparation of work at the power plant, as stated by Chapter 2, Section 6 of SSMFS 2021:6. Chapter 5, Section 15 of SSMFS 2021:6 also requires that core management ensures operation, so that used nuclear fuel have appropriate characteristics to be managed according to the plan for radioactive waste.

19.9.3. Compliance by licensees

19.9.3.1. Spent fuel

Spent fuel is stored in fuel pools at Swedish nuclear power plants, usually for an average of two years while awaiting transport. In the cases of the Forsmark and Ringhals NPPs, transports are carried out 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 nuclear power plant. 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.

19.9.3.2. General objectives of waste management

The general objectives of waste management at the locations of the nuclear power plants are:

– Minimizing 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 minimization is in certain cases substituted by optimization of waste generation, in which consideration is given to radiation doses and costs. Minimization 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. Radioactive wastes generated at Swedish nuclear power plants belong to different categories; consequently, they are treated, stored and disposed of in various ways as described briefly below.

19.9.3.3. 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 immobilizes 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.

19.9.3.4. 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 shallow land burial sites at the nuclear power plants. To minimize 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 Studsvik, where it is incinerated in a special facility. The ash is collected in steel drums, which in turn are grouted with concrete in overpacks of steel.

19.9.3.5. Registration, storage and disposal of waste

Registration and documentation are required for all waste management at the sites. Examples of data concerning the waste that is documented and registered in a database include:

- Identity
- Type of package
- Date of production
- Category of waste
- Weight
- Activity content, nuclide composition and dose rate at the surface or at a distance of 1 m
- Position during intermediate storage.

Production and storage of radioactive waste at the plants are reported annually to SSM and SKB.

Intermediate and low-level waste at the nuclear power plants is stored temporarily in rock caverns or storage buildings while awaiting transport to the SFR repository. SFR is located near the Forsmark nuclear power plant. The use of waste packages of different types and their application for storage of various radioactive waste must have approval of SSM.

19.9.4. Regulatory control and actions taken

Inspection of on-site management of radioactive waste is carried out by SSM's inspectors. SSM also inspects radiation protection aspects of waste handling. A major effort undertaken by specialists at SSM is to review and approve the types of waste packages produced at the nuclear power plants, prior to their use for disposal in SFR.

19.10. Vienna Declaration on Nuclear Safety

This section, in reference to Article 19, accounts for Sweden's implementation of relevant improvements concerning principles of the Vienna Declaration on Nuclear Safety regarding safe operation of nuclear power plants.

Swedish PWRs use EOPs 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 depressurization through the system for filtered ventilation of the containment, etc.

New procedures for extraordinary situations at Swedish NPPs are in place at all sites. Due to the experience from the Fukushima event, the work will also enhance procedures and guides are now applicable for accidents affecting more than one unit at a site. They are also improved to adapt to 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 Standard Institute
BAT	Best Available Technique
BSS	The Basic Safety Standards Directive of the 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
BDBA	Beyond Design Basis Accident
EDG	Emergency Diesel Generator
ENISS	European Nuclear Installations Safety Standards
ENSREG	European Nuclear Safety Regulators Group
EPRI	Electric Power Research Institute
EU	European Union
EUR	European Utility Requirements
FKA	Forsmarks Kraftgrupp AB (licence holder of Forsmark NPP)
FSAR	Final Safety Analysis Report
IAEA	International Atomic Energy Agency
ICCS	Independent Core Cooling System
I&C	Instrumentation and Control
IEEE	Institute of Electrical and Electronics Engineers
INES	International Nuclear Event Scale
IRS	IAEA International Reporting System for Operating Experience
INPO	Institute of Nuclear Power Operations
IRRS	IAEA Integrated Regulatory Review Service
KPI	Key Performance Indicator
KSKG	Kärnkraftssäkerhetskoordineringsgrupp (Nuclear Safety Coordination Group of the Swedish licensees)
KSU	Kärnkraftsäkerhet och Utbildning AB (the Swedish Nuclear Training and Safety Centre)
LOCA	Loss of Coolant Accident
LTO	Long Term Operation
KTH	Kungliga Tekniska Högskolan (Royal Institute of Technology)
LER	Licensee Event Report
LILW	Low and Intermediate Level Waste
MSB	Myndigheten för samhällsskydd och beredskap (Swedish Civil Contingencies Agency)
MTO	Interaction between Man, Technology and Organisation

MVSS	Multi Venturi Scrubber System
NAcP	EU stress test National Action Plan
NORM	Naturally occurring radioactive material
NDT	Non Destructive Testing
NKS	Nordic Nuclear Safety Research
Norderf	Swedish-Finnish Group for Operating Experience Feedback
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
OKG	OKG Aktiebolag (licence holder of Oskarshamn NPP)
OLC	Operational Limits and Conditions
OSART	Operational Safety Review Team (a review service of the IAEA)
PSA	Probabilistic Safety Analysis (or Assessment)
PSAR	Preliminary Safety Analysis Report
PSR	Periodic Safety Review
PWR	Pressurized Water Reactor
PHWR	Pressurized Heavy Water Reactor
R&D	Research and Development
RAB	Ringhals AB (licence holder of Ringhals NPP)
RPS	Reactor Protection System
SALTO	Safe Long Term Operation (a review service of the IAEA)
SAMG	Severe Accident Management Guideline
SAR	Safety Analysis Report
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)
SOER	Significant Operating Experience Report
SQC	Swedish Qualification Centre (NDT qualification
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
TMI	Three Mile Island NPP
USNRC	US Nuclear Regulatory Commission
VDNS	Vienna Declaration on Nuclear Safety
	Finnish Technical Research Centre
VTT	Finnish Technical Research Centre
WANO	World Association of Nuclear Operators
WENRA	Western European Nuclear Regulators' Association

Appendix 1

Major past and currently implemented modifications at Swedish NPPs

1. Measures implemented during the reporting period 2019–2021

1.1. Oskarshamn NPP

1.1.1. Oskarshamn unit 1 and unit 2

– No significant measures are implemented since decision have been taken to permanently shut down unit 1 and 2 (Today not in operation).

1.1.2. Oskarshamn unit 3

– Enhanced and simplified connection of the on-site existing gas-turbine plant to the busbars on unit 3. In order to get a robust and powerful (40 MW) diversified power source.
– The amount of availavable water for make-up to the primary system and creating a feed-and-bleed possibility for the spent fuel pools is increased to 120 000 m^3 by installation of new pumps and valves to bypass to operational water treatment facility. The latter is also a part of the final solution of the ICCS function.
– A shut-off valve in the storm water well in the yard in order to prevent back-flow from the baltic sea in case of water levels exceeding the 10-7/year probability.
– Reinforced capability to cool the condensation pool with two out of the four available trains of the condensation pool cooling system and the corresponding diesel generator engines.
– New permanent diesel generator set to the emergency Command Centre location
– An external break-point about 50 km from the site, where we in a safe way can exchange staff to and from the site in case of a severe accident. The break-point has monitors and showers as well as a storehouse and, of course, personnel that supports the teams and runs the place.
– Exchange of electrical motors to a new design in most of the process systems, no spare parts to the original motors are available anymore.
– Exchange of fire extinguishing piping due to corrosion.
– Installation of protection against discrepancies beween the terminals in the three-phase connections to the external grid.
– Inspection and repair measures in the sea water cooling channels
– Installation of additional logic to run-back of the main feedwater pumps in case of an ATWS event, in order to protect the cladding from high temperatures.
– Installation of additional logic regarding the pressure control valves in the safety relief valve system, in order to better preserve the Reactor Pressure Vessels water inventory.
– Installation of new relay protections in the operational 10 kV busbars in order to protect the electrical motors

connected to the busbars from asymmetric errors (phase errors).
- Replacement of all 10 kV breakers.
- Measures in accordance with Severe Accident Management Program
- Increased battery capacity from 2 to 8 hours to better meet ELAP scenario
- Installation of new systems for Independent Core Cooling
- Replacement of one out of four Emergency Diesels Generators. This follows a plan for replacement of all EDGs.

1.2. Forsmark NPP

Forsmark unit 1 and 2

- Replacement of reactivity measuring channels in the mail chimney and in the reactor hall.
- Replacement of excitation equipment.
- Replacement of power transformers.
- Installation of Surge protection device.
- Replacement of containment electrical penetration assemblies.
- Replacement of cables in the containment.
- Installation of ICCS
- Installation of independent water supply to the spent fuel pool.
- Replacement of anchor plates.
- Improvment of fire protection in mail transformer booths – Fire extinguisher grille.

Forsmark unit 3

- Replacement of reactivity measuring channels in the mail chimney and in the reactor hall.
- Installation of ICCS.
- Installation of Surge protection device.
- Replacement of anchor plates.
- Installation of independent water supply to the spent fuel pool.
- Replacement of rectifiers.
- Improvment of fire protection in mail transformer booths – Fire extinguisher grille.

1.3. Ringhals NPP

Ringhals unit 1–4

- Improvements of the Emergency preparedness to comply with new regulations SSMFS 2014:2 (including new logistics centre outside the site, sysstem to oversee the evacuation of the site) (2016-2018)

Ringhals unit 1 and unit 2

- Installation of protection features against Open Phase Conditions in the Electric Power Systems (2017)
- Installation of temperature controlled ventialtion dampers to avoid steam intrusion to electrical rooms (only unit 2) (2016)

Ringhals unit 3and unit 4

- Independent core cooling function (2020)
- RCP passive thermal shutdown seal (As a post Fukushima action the reactor coolant pumps of Unit 3 and 4 were equipped with low leakage seals.) (2018–2020)
- Independent make-up for feed-and-boil of the spent fuel pit including rugged WR-level measurement (part of the independent core cooling function) (2020)
- Separation measures for the spent fuel pool cooling system (2020)
- Seismic reinforcemnt of Spent fuel storage racks (2020)
- Reinforcement of the Diesel Generator building to cope with earthquake and severe weather (2020)
- Seismic reinforcement of Diesel Generator room cooling equipment, 6kV switchgear and 6kV/500V transformers (2020)
- Installation of automatic air waste gate valves for the Diesel Generators to improve the tolerance for low outside temperatures (2019–2020)
- Emergency Diesel Generators modernization, power increase and major overhaul of diesel generators (2016–2020)
- Environmental qualification uppgrades (2016–2020)
- Installation of protection features against Open Phase conditions and Sustained Degraded Voltage conditions in the Electric Power Systems (2018–2019)
- Replacement of non safety related 6kV switchgear (2020–2022)
- Replacement of electrical pump motors of the Charging, Containment Spray and Residual Heat Removal pumps (only unit 3) (2018–2020)
- Replacement of electrical pump motors of the Auxiliary Feedwater pumps (2020–2021)
- Upgrade of the Core Exit Thermocoples (2020–2021)
- Replacement of Instrument Air compressors (2019–2020)
- Replacement of cables inside containment (2020–2021)
- Installation of ultrasonic flowmeter to reduce the uncertainty of the measured feedwater flow (2019–2020)
- Replacement of filters in the salt water system (2019–2020)

2. Modifications implemented 1995–2018

2.1. Oskarshamn NPP

Oskarshamn unit 3
Major safety modifications have been implemented at Oskarshamn unit 3. The PULS (Power Uprate with Licensed Safety) project included a power uprate, modifications to comply with SSMFS 2008:17 as well as replacement of critical components in order to achieve a 60-year operating life. The power uprate of Oskarshamn unit 3 to 3900 MWth and 1450 MWe gross is now complete (the plant is still in test operations). This corresponds to 129% of the original design (3020 MWth). The uprated plant is planned for operation until 2045 (60-year lifetime). The main part of the work was performed during the 2009 outage.

A great number of modifications were made in order to improve safety. For example, nuclide-specific on-line measurement was installed in the turbine offgas system with the purpose of achieving early detection of fuel failures. Experience from the events at Forsmark unit 1 on 25 July 2006 resulted in the redesign of the auto switching automatics for the diesel bus bars at voltages of less than 85%.

Some other examples of the modifications implemented during PULS are listed below:

– Replacement of internal parts in the RPV
– Replacement of main steam isolation valves
– Installation of new aggregate and station transformers
– Installation of a new generator
– Replacement of high-pressure turbine and all low-pressure turbines
– Installation of two new scram modules in system for hydraulic SCRAM
– Replacement of all main circulation pumps
– Replacement of all main cool water-pumps
– Installation of new logic chains in the reactor protection computer system
– Installation of new diversified cooling chains.
– Component diversity in the RPV level measurement created by using different brands of level transmitters (differential pressure) in two different measurement ranges.

The following modifications were performed after the finalisation of the PULS project until 2013.

– Changed turbine bearings
– Increased manoeuvrability and instrumentation of the reactor protection functions in the emergency control room
– Replacement of 400kV switchgear
– Replaced internal parts of the reactor pressure vessel (shroud head, steam separators and steam dryers).
– Fire hazards analysis (2010–13)
– Update of the environmental qualification inside the containment, including measures if necessary (2014)

2.2. Forsmark NPP

The first comprehensive modernization programme for the Forsmark NPP, Program 2000, started in 1995, and was completed in 2000. Another strategy and modernization plan was then adopted, Program P40+, that contained modernization items, of which 70% are aimed at maintaining technical status, 20% for safety upgrades and 10% for dose reduction and environmental improvements.

The following major measures have been completed:

– removal of the core spray nozzles in the reactor pressure vessel after analyses showing that all safety requirements are met with injection only. The advantages are: less non-destructive testing will be required in the future, releasing resources for other safety work; avoiding the risk for costly repairs; and lower doses to the personnel
– replacement of equipment in the main circulation pumps to reduce transients on the fuel at loss of external power
– prevention of oxy-hydrogen in steam systems
– diversified reactor vessel level measurement
– new equipment for physical protection
– improved fire safety and security systems
– strengthening of auxiliary buildings to withstand external hazards.
– exchange of moderator tank lid

- exchange of moisture separator
- exchange of steam separator
- a new diversified reactor shutdown system
- robustness measure to prevent pipe-break
- measures on new I&C in the Emergency Control Room
- earthquake measures
- diversification of sensors and actuation of RPS
- ventilation measures in electrical building to segregate fire compartments
- new hook-on devices for the containment for external mobile decay heat cooling units.

Forsmark unit 1 and unit 2

- core grids and other reactor internals have been replaced in units (unit 1 and 2)
- replacement of 6 kV switchboards (units 1 and 2).

Forsmark unit 1

- Independent water supply to the spent fuel pool
- Forward pumping of high pressure drainage
- Upgrade of alarm signal system (non-safety system)
- Change of production platform for control systems (non-safety system)
- Installation of protection device regarding degraded voltage conditions at the EDG busbars
- Improvement of the RPS regarding trip conditions
- Modernization of instrumentation for activity measurement in the off-gas system. These modifications comprise detectors as well as electronics.
- Measures to deal with slowly decreasing voltage in the external grid. Relay protection modification to disconnect the external grid if the voltage decreases to less than 85% for 10 second.
- Improved capacity and physical separation of cooling chains to the condensation pool. These cooling chains are now divided in four sub divisions.
- Partial scram upgraded. Modification comprises design as well as conditions for the activation of partial scram.
- Installation of cyclone filters in the feed water system inside the containment. The purpose of these filters is to collect debris that could cause fuel damage.
- Redesign of the sequence for control rod screw activation in order to fulfil requirements on diversity.
- Replacement of the power range monitoring system. The new system contains protection against power oscillations.
- Improved fire protection of safety functions by additional spray nozzles in culverts containing power and i&c cables.
- New high voltage switchgear for connection of unit 1 to the 400kv grid.
- Alteration of the reactor's auxiliary cooling circuits, separation of power supplies and increase in capacity
- New low pressure turbines.

Forsmark unit 2

- Independent water supply to the spent fuel pool
- Upgrade of alarm signal system (non-safety system)
- Installation of protection device regarding degraded voltage conditions at the EDG busbars
- Replacement of Step-up and Auxiliary Transformers
- Improvement of the RPS regarding trip conditions
- Partial scram upgraded. Modification comprises design as well as conditions for the activation of partial scram.
- Replacement of the power range monitor system. The new system contains protection against power oscillations
- Modernization of instrumentation for activity measurement in the off-gas system. These modifications comprise detectors as well as electronics.
- Measures to handle slow decreasing voltage in the outside grid. Relay protection modification to disconnect the external grid if the voltage decreases to less than 85% for 10 second.
- Improved fire protection of safety functions by additional spray nozzles in culverts containing power and I&C cables
- New RPV-internals. Moderator vessel head, steam and moisture separators installed.
- Diversified reactivity control implemented. Automatization of the initiation of the boron injection system
- New main steam inboard isolation valves installed
- Reconstruction of the sequence for control rod screw activation in order to fulfil requirements on diversity
- New high voltage switchgear for connection of unit 2 to the 400kV grid
- New high pressure turbines
- replacement of electrical control boards in the main control room (unit 2)
- modification of the reactor pressure vessel head sprinkler
- modernization of the power measurement system
- modification of the cooling chain for increased capacity and separation of power supply connections
- new low pressure turbines.

Forsmark unit 3

- Independent water supply to the spent fuel pool
- Installation of protection device regarding degraded voltage conditions at the EDG busbars
- Replacement of containment electrical penetration assemblies
- Replacement of wide range neutron monitor
- Measures to handle slow decreasing voltage in outside grid. Relay protection modification to disconnect the outside grid if the voltage decreases to less than 85% for 10 second.
- Diversified source for emergency feed water to the RPV
- Partial scram upgraded. Modification comprises design as well as conditions for the activation of partial scram
- New nuclide-specific on-line measurement equipment in the stack

– Separation of operational and safety functions in the power system with battery back-up
– A new diversified reactor shutdown system
– Separation of safety classified electrical equipment from non safety
– Measures to diversify the residual heat removal
– Security measures
– Robustness measure against pipe-break
– new automatic stop of reactor building ventilation in case of loss of heating system for the building
– new low pressure turbines (2004)
– Analysis of the requirement on two different parameters to identify the need of initiation of the reactor protection system, including necessary plant modifications (2013)

2.3. Ringhals NPP

The renewal programme for the Ringhals plant was initiated in 1997, and the following major measures have been completed.

Ringhals units 1–4

– Improvements of the Emergency preparedness to comply with new regulations SSMFS 2014:2 (including new logistics centre outside the site, sysstem to oversee the evacuation of the site)
– Improvements in fire protection systems
– Fire system modernizations
– Upgrading and modernizing Ringhals NPP's Command Centre
– Strategy for long-term cooling of a severely damaged core, including necessary plant modifications
– Update of the environmental qualification outside the containment, including necessary plant modifications

Ringhals unit 1 and unit 2

– Installation of protection features against Open Phase Conditions in the Electric Power Systems
– Installation of temperature controlled ventialtion dampers to avoid steam intrusion to electrical rooms (only unit 2)

Ringhals unit 1 and unit 4

– Analysis of earthquake, including necessary plant modifications

Ringhals unit 2 and unit 4

– Interconnection of RH and SP systems

Ringhals units 2–4

– improvements of the safety valves of the pressurizer
– modernization of the radiation monitoring system
– measures to cope with containment sump blockage during design basis accidents
– improved battery capacity during station black-out
– securing of piping for the pressurizer

Ringhals units 3 and 4

– Extended battery capacity on Class 1E electrical systems (at least 8 hours)
– Mobile diesel generators (primarily to charge batteries) with separate connection points to the electric power systems
– Installation of protection features against Open Phase conditions and Sustained Degraded Voltage conditions the Electric Power Systems
– Environmental qualification uppgrades
– Replacement of safe ends and spool pieces on pressurizer (only unit 3)
– Installation of filters in the salt water system piping upstream the emergency diesels
– Installation of manual waste gate valves to improve the tolerance for low outside temperatures
– Automatic disconnection of the pressurizer backup heater upon active SI-signal to decrease the Emergency Diesel Generator load
– Emergency Diesel Generators modernization, power increase and major overhaul of diesel generators
– Analysis of verify Long Term Operation of the plant
– Time Limited Ageing Analyses of important structures, systems and components
– Introduction of a risk monitoring tool
– Requalification of the containment sump strainers (including reducing the amount och fibre isolation in the containment) to resolve GSI-191
– modernization of the safety injection pumps including vibration monitoring
– upgrading with redundant cooling of the charging pumps at shut-down
– modernization of vibration measurement/monitoring of the reactor coolant pumps
– introduction of cavitation alarms on the residual heat removal pumps
– reactor pressure vessel heads replaced
– pressurizer relief valves replaced/modified
– new emergency core cooling strainers fitted in the bottom of the containments
– diesel back up power supply to the spent fuel pool cooling systems installed
– passive autocatalytic re-combiners installed in the containment
– upgraded capacity in the heat exchangers for the spent fuel pool cooling systems
– power operated relief valves of the pressurizer qualified to withstand water blowing
– improved fire protection in the relay and cable spreading rooms
– environmental qualification of components in the turbine and auxillary building
– Diversified Protection System
– redundant check valves
– PORV qualification for containing liquid
– steam line break protection

- NICE – Modernization of turbine and generators' I&C
- replacement of Kerotest valves
- replacement of control room roof
- modernization emergency control room
- measures to meet the seismic requirements of the facility.
- Analysis of the emergency control post, including necessary plant modifications
- Analysis of local loads, including necessary plant modifications
- Analysis of natural phenomena, including necessary plant modifications
- Measures regarding dependency of miniature circuit breakers
- Emergency Diesel Generators modernization, power increase and major overhaul of diesel generators

Ringhals unit 1

- separation of electric power supply of core cooling systems
- introduction of alarm for core instability
- exchange of control rod indication and manoeuvring system
- verification and improvement of piping supports
- the SPRINT project (replacement of primary system piping)
- part two of fire protection modernization programme completed.
- diversified source for feed water to the core spray system installed.
- modernization project RPS/SP2 completed. The main purpose of these modifications is to increase the level of separation in order to strengthen protection against fire and to mitigate common cause failures, i.e. to improve diversity in safety functions. Major modifications consist of modernization of the reactor protection system and improvement of the residual heat removal systems.
- measures on RPS (isolation logic train blockage during tests enhanced)
- robustness measures on electrical systems (from Forsmark event of 25 July 2006)
- a new diversified reactor shutdown system
- security measures
- Post-Accident measure system
- a new main fire water ring installed for the site of units 1 and 2.
- Separation of operation and safety systems within the switchgear
- Change to two phase flow relief valves
- Measures to vent incondensable gases from the reactor vessel
- Improvement of the back panels in the control room

Ringhals unit 2

- completions for the Twice-project, replacement I & C equipment including the main control room
- a fourth level measurement channel installed in the steam generators
- modernization of 110 V DC systems with new switchboards
- replacement of toroid plates
- pressurizer relief valves replaced/modified
- replacements and improvement in the electrical supply systems for improved separation and safety
- Passive autocatalytic recombiners installed in the containment
- Implementation of the TWICE-project. I&C equipment replaced with new technology. Modifications include new main control room (MCR), all I&C and cables connected to MCR together with sensors and measuring apparatus in the plant.
- Separation of RPS
- Diverse actuation system
- New severe accident monitoring systems
- a new main fire water ring installed for the site of units 1 and 2.
- Measures to make the auxiliary feed-water system independent, including a new water supply
- Physical separation within the ventilation system in the auxiliary systems building
- Analysis of the physical separation within the power system in the auxiliary systems building and the containment, including necessary plant modifications
- Separation within component cooling system
- Supports for several containment isolation valves
- Fire hazards analysis, including necessary plant modifications
- Incore and Flux measurement

Ringhals unit 3

- Modernization of turbine
- The GREAT power uprate project completed, thermal power increased to 3144 MW.

Ringhals unit 4

- Steam generator and pressurizer replacement.

Appendix 2

Progress of National Action Plan

Foreword

The Swedish NAcP was first issued in December 2012 and was reviewed and revised in December 2014, December 2017 and March 2020. This Appendix describes the final update of the Swedish NAcP including the status of all actions in the plan.

Following the severe accidents which started in the Fukushima Dai-ichi nuclear power plant, the European Council of 24/25 March 2011 requested stress tests to be performed on all European nuclear power plants. The Swedish national action plan is part of these stress tests and was developed with the aim to manage all plant weaknesses identified by the EU stress tests as well as by other forums such as the second extraordinary meeting under the Convention on Nuclear Safety.

All measures in the NAcP have been completed in accordance with the original given time schedule, meaning that all identified measures were fully implemented by the end of 2020, following the Independent Core Cooling System (ICCS) installations. The ICCS is a major safety enhancing technical measure that was required to be in place by the end of 2020 at all Swedish NPPs that continued operation after 2020. The ICCS provides core cooling that is completely independent from previously existing CC systems in terms of power supply and water source. It is also significantly more robust and built to handle extended loss of power supply and ultimate heat sink.

The installation of the ICCS is the most extensive single measure in the Swedish NAcP. As it necessarily required a relatively long time for design and implementation, SSM also decided on transitional measures to be implemented by 31 December 2017. These measures were completed for all NPPs in accordance with the decisions, with solutions that primarily focused on actions that provided, with limited modification and without fulfilling robustness requirements, a substantial increase of the safety level.

In general, the Swedish NAcP required investigations to be performed with the aim to identify necessary technical and administrative measures, how they should be implemented as well as appropriate time schedules for the implementation of these measures. All actions resulting from these investigations were fully implemented by the end of 2020.

SSM has continuously performed reviews and follow-up on the licensee actions concerning the Swedish NAcP. Due to the high degree of complexity, the majority of the necessary technical and administrative measures identified by the investigations included in the Swedish NAcP were implemented after 2015.

Finally, it is worth stressing as another important success factor the comprehensive safety modernisation carried out at Swedish NPPs between 2006 and 2014 as a result of the updated design regulation SSMFS 2008:17. The main areas for the safety modernization was to reinforce independence, to increase diversification, to increase separation, and measures performed to fulfil the requirement to withstand extreme external events. This created a good basis for meeting many of the requirements linked to the experience after the nuclear accident in Fukushima. Hence, the completion of the then still ongoing safety modernization programme was a top priority in parallel with the completion of the stress test activities.

1. Implementation of technical and administrative measures

In the following sections the progress on the measures included in the Swedish NAcP are described. Further technical and administrative measures identified and considered as needed by the completed investigations are also described.

1.1. Implementation of the Independent Core Cooling

The most important measure in the Swedish NAcP is the implementation of the Independent Core Cooling system (ICCS). Other important technical measures are the implementation of more robust cooling of spent fuel pools and more robust supply of emergency power. The ICCS was not an explicit part of the first version of the Swedish NAcP , but was foreseen as a consequence of the results of the analyses, studies and investigations requested in the Swedish NAcP 2013. The ICCS will provide alternative core cooling if the normal safety systems are unavailable in a situation with design extension conditions. In December 2014 SSM issued an injunction requiring the installation of the ICCS, as a condition for operation after 2020. This condition applies to six reactors, since four of the Swedish reactors have been permanently shut down in the period between 2014 and 2020.

The main basic design requirements for ICCS are the ability to handle:

- Extended Loss of AC Power, ELAP (for 72 hours)
- Loss of Ultimate Heat Sink, LUHS (for 72 hours).

The ELAP and LUHS events are assumed to coincide with, or be the consequence of, severe external events (beyond the ordinary design base), including various electrical disturbances. These events should have an exceedance frequency of 10-6 per annum, and the ICCS should operate without the need for manual action the first 8 hours. The system have been in operation since late 2020 at all reactors, in accordance with the injunction from 2014.

Forsmark NPP
ICCSs have been installed for Forsmark 1, 2 and 3. For Forsmark 1 and 2, the ICCS has been placed in a new building with its own water source adjacent to the reactor building of Forsmark 1. The power supply is galvanically separated from the plant's normal electrical power system via a motor-generator set. The water source is sufficient for 24 hours of operation for Forsmark 1 and 2 or for 72 hours for one of the units. 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. Forsmark 3 has its own new building designed according to the same principles. Decay heat will be removed from the containment after about 8 hours of ICCS operation, by transporting steam to the multi-venturi scrubber.

If needed, there is an additional possibility to utilize mobile equipment to supply more water, and thereby use the ICCS for a longer period than 72 hours.

Ringhals NPP
ICCSs have been installed for Ringhals 3 and 4. All features of the ICCS, including supportive functions, are housed in a separate building, one for each unit. The main features of the Independent Core Cooling system are as follows:

- Providing feedwater to the steam generators (normal operation)
- Providing boron and make-up water to the closed reactor coolant system (normal operation)
- Providing borated make-up for feed-and-bleed for an open reactor coolant system (shutdown mode)

The ICCS building has a separate electrical power supply system, galvanically, functionally and physically separated from the normal electrical power system. The galvanic separation is achieved by a motor-generator set. The electromagnetic design of the building structure and shielding of cables ensure that no electrical disturbances (conductive or radiative) can affect the ICCS.

Oskarshamn NPP
ICCS has been installed for Oskarshamn 3. The ICCS function comprises a new low pressure make-up system with a diesel-driven pump, also giving electrical support.

The primary water source is the central fuel 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. The ICCS has its own diesel generator set that can recharge the dedicated batteries for the ICCS and energize the battery-backed busbars after the initial 8 hours. Residual heat is released through the multi-venturi scrubber system.

1.2. Natural hazards

1.2.1. Actions performed by the licensees

In this section, the status for each measure related to natural hazards performed by the Swedish licensees (LA) is given. Further technical and administrative measures needed are also described.

T1.LA.1 – Seismic plant analyses

Completed for all NPPs. Further studies regarding the structural integrity of the reactor containments, scrubber buildings and fuel storage pools have been performed. The analyses showed that those structures can withstand an earthquake significantly stronger than the "Swedish E-5-earthquake". For the ICCS installed by 2020 earthquakes with the exceedance frequency of 10-6 per annum shall be considered for the design.

T1.LA.2 – Investigation regarding secondary effects of an earthquake

Completed for all NPPs. A more detailed analysis of earthquake induced flooding has been included in the analyses regarding secondary effects. In addition, seismic induced fires have been analysed. Minor weaknesses have been addressed.

T1.LA.3 – Review of seismic monitoring

Completed for all NPPs. Seismic monitoring systems are installed at all Swedish sites. The licensees have reviewed the procedures and training program for seismic monitoring and implemented the revised procedures and programs.

T1.LA.4 – Investigation of extreme weather conditions

Completed for all NPPs. The analyses, and in some cases corresponding administrative and physical improvements, shows that the NPPs can handle extreme weather with the exceedance frequency of 10-5 per annum. For the ICCS installed by 2020 extreme weather with the exceedance frequency of 10-6 per annum shall be considered for the design.

T1.LA.5 – Investigation of the frequency of extreme water levels

Completed for all NPPs. The analyses and in some cases corresponding administrative and physical improvements shows that the NPPs can handle extreme water levels with the exceedance frequency of 10-5 per annum. For the ICCS installed by 2020 extreme water levels with the exceedance frequency of 10-6 per annum shall be considered for the design.

T1.LA.6 – Flooding margin assessments

Completed for all NPPs. Analyses of incrementally increased flooding levels beyond the design basis and identification of potential improvements have been performed. These analyses included capability to mitigate internal and external flooding events. Weaknesses have been addressed and physical measures have been taken at some plants. For the ICCS installed 2020, flooding margins with the exceedance frequency of 10-6 per annum is considered for the design.

T1.LA.7 – Evaluation of the protected volume approach

Completed for all NPPs. Based on performed stress tests, measures have been taken at some plants.

T1.LA.8 – Investigation of an improved early warning notification

Completed for all NPPs. The licensees have introduced instructions for the control room staff to check the weather forecast with the Swedish Metrological and Hydrological Institute (SMHI) once per shift. The instructions include a check regarding possible effects of extreme weather conditions at the NPPs and the consideration of suitable mitigating measures.

T1.LA.9 – Investigation of external hazard margins

Completed for all NPPs. The analyses and in some cases the corresponding administrative and physical improvements show that the NPPs can handle external hazard with the exceedance frequency of 10-5 per annum. For the ICCS installed by 2020 extreme external hazards with the exceedance frequency of 10-6 per annum shall be considered for the design.

T1.LA.10 – Develop standards to address qualified plant walk-downs

Completed for all NPPs. Extensive efforts have been undertaken to manage resistance to earthquakes and other external events. As part of this, a walk-down methodology has been defined and documented, and walk-downs have been performed. The licensees use the deterministic method represented by SMA (Seismic Margin Assessment), based on guidelines in the EPRI NP-6041 SL

1.2.2. Actions to be performed by the regulators

The following section describes the status for each measure related to natural hazards performed by the Swedish regulatory body (RA).

T1.RA.1 – Research project regarding the influence of paleoseismological data

Completed. Results presented in SSM technical report 2017:35.

T1.RA.2 – Estimation of extreme weather conditions

A study to better estimate extreme weather conditions has been performed as a research project by the licensees The resulting extreme weather conditions have been used as design conditions for the construction of the ICCS.

1.3. Design issues

1.3.1. Actions to be performed by the licensees

The following section describes the status for each measure related to Design issues performed by the Swedish licensees (LA). Further technical and administrative measures needed are also described.

T2.LA.1 – Implementation of the demonstrations of design basis in SAR

Completed for all NPPs. Included in the Safety Analysis Reports for all Swedish NPPs

T2.LA.2 – Define design basis for alternate cooling and alternate residual heat removal

Completed for all NPPs. The ICCS decision states that Loss of Ultimate Heat Sink (LUHS) 72 hours is a design basis. The licensees have also performed strengthening of existing alternate cooling and alternate residual heat removal. In some cases, the strengthening will be a part of the ICCS solutions.

T2.LA.3 – Primary and alternative AC power supplies and AC power distribution systems

Completed for all NPPs. The ICCS decision states that Extended Loss of AC Power (ELAP) for 72 hours is a design basis. All licensees have already performed strengthening of the electrical power supply. In some cases, the strengthening will be a part of the ICCS solutions.

T2.LA.4 – Reassess DC power supplies and DC power distribution system Completed for all NPPs. The licensees have analysed the actual battery capacity available with existing loads. The analyses shows that there are considerable margins of the batteries at some of the plants. For the remaining plants, measures have been taken to expand the battery capacity in existing battery systems. Alternatively an application of load shedding or a combination thereof have been installed.

T2.LA.5 – Reassess the integrity of the primary system

Completed for all NPPs. For the PWRs the integrity of the primary system has been further evaluated and reassessed for prolonged extreme situations resulting from natural phenomena and other events. This included reassessment of the primary pumps seals, which have been replaced.

T2.LA.6 – Reassess the operability and habitability of the Main and Emergency Control Rooms as well as emergency control centre

Completed for all NPPs. Operability and habitability of both the main and the emergency control rooms as well as of the emergency control centre have been further evaluated. Some weak points have been identified and addressed. For example, the inner roofs in the control rooms have been strengthened to withstand strong earthquakes.

T2.LA.7 – Reassess the instrumentation and monitoring

Completed for all NPPs. For dose monitoring, see T3. LA.4. For core cooling and residual heat removal, see T3. LA2. For spent fuel pools see, T2.LA.8, and T3.LA.3.

T2.LA.8 – Reassess the integrity of the spent fuel pools

Completed for all NPPs. The integrity and robustness of the spent fuel pools during prolonged extreme situations have been further evaluated and reassessed. The assessments have defined technical and administrative measures to be addressed, e.g. regarding strengthening of the instrumentation and of the water supply to the fuel pools.

T2.LA.9 – Evaluate the need for mobile equipment

Completed for all NPPs. New mobile equipment has been identified as necessary for all plants for prolonged extreme situations. The needed mobile equipment is in place. As part of the ICCS decision, SSM decided on transitional measures to be implemented before 31 December 2017. The transitional measures were completed for all NPPs in accordance with the decisions.

T2.LA.10 – Reassess and update equipment inspection programs

Completed for all NPPs. Plans have been developed to ensure that the procedures for inspection and maintenance are incorporated in ordinary activities, both for equipment that existed before the Fukushima accident and equipment acquired as a result of the stress tests.

T2.LA.11 – Reassess and update training programs

Completed for all NPPs. Training programs were reassessed when new equipment and new administrative measures were in place.

T2.LA.12 – Evaluate the need for consumables

Completed for all NPPs. The licensees have evaluated and assessed the technical and administrative measures needed to ensure adequate accessibility during all potential situations.

The conclusions drawn were that the review carried out by all facilities for fuel supplies and consumables do fulfil the requirement.

T2.LA.13 – Evaluate the need for resources

Completed for all NPPs. This issue is handled within the framework of actions in response to the requirements of the new emergency regulations, SSMFS 2014: 2

T2.LA.14 – Evaluate the accessibility of important areas

Completed for all NPPs. The licensees have conducted a review of existing emergency operating procedures with bearing on accessibility of important areas. This has resulted in an updating of the instructions in the Emergency Operating Procedures.

T2.LA.15 – Investigate the effects of simultaneous events affecting all reactors at the site

Completed for all NPPs. The licensees have conducted a review of existing operating procedures with focus on weather and other events that can simultaneously affect all reactors at the site. This has resulted in an update of the instructions in SAR and Operating Procedures.

T2.LA.16 – Reassess the use of severe accident mitigation systems

This is a part of the solutions for ICCS for the BWRs, which uses the severe accident mitigation systems as an ultimate heat sink. Analyses or/and technical improvements showing that this does not affect the system's primary function as a severe accident mitigation system have been performed.

T2.LA.17 – Reassess the procedures and operational training

Completed for all NPPs. Procedures and operational training are reassessed when new equipment and new administrative measures are in place.

T2.LA.18 - Evaluate the need for external support

Completed for all NPPs. The licensees have implemented and evaluated external recourses that will be needed in prolonged extreme situations.

T2.LA.19 – Reassess the risk of criticality and/or re-criticality

Completed for all NPPs. For the Ringhals PWRs re-criticality must be considered in the long-term scenario. Measures have been identified and addressed and were considered in the ICCS project. Boron is included in the ICCS water and new pump seals have been installed.

The overall probability for re-criticality that endangers the containment integrity is judged very low for the BWRs based on research performed within the long term Swedish program APRI (Accident Phenomena of Risk Importance).

1.3.2. Actions to be performed by the regulators

No specific actions to be performed by the Swedish regulatory body (RA) have been identified.

1.4. Severe accident management and recovery (On-site)

1.4.1. Actions to be performed by the licensees

The following section describes the final status of each measure related to severe accident management performed by the Swedish licensees (LA). Further technical and administrative measures needed are also described.

T3.LA.1 – Consider improvements of the capability to cool the spent fuel pool

The licensees have in a common project developed a ”Position Paper” that defines requirements that are adopted and improvements are introduced as a part of the installation of the ICCS.

T3.LA.2 – Define the design basis for an independent core cooling system

The licensees have in a common project developed a ”Position Paper” that defines requirements that are adopted and used in the design process.

T3.LA.3 – Investigate instrumentation of spent fuel pool

Completed for all NPPs. This has been addressed by introducing necessary instrumentation to monitor temperature and water level in the fuel pools in connection with the introduction of an alternative function for cooling the fuel in the fuel storage pools. See Action T3.LA.1.

T3.LA.4 – Investigate the need for measuring radiation levels

Completed for all NPPs. Recommendations on more dose rate monitors in the reactor building to support accident management have been addressed at all utilities. New monitors have been installed at the NPPs.

T3.LA.5 – Develop a plan to handle more than one affected unit

Completed for all NPPs. As a direct measure after the Stress tests, the licensees have developed training scenarios and emergency exercises in which more than one reactor at each site is involved.

T3.LA.6 – Improve the strategies for managing re-criticality

Completed for all NPPs. The licensees have conducted a review of existing emergency operating procedures with bearing on re-criticality. This has resulted in updating of the instructions in the Emergency Operating Procedures.

T3.LA.7 – Develop the strategies for managing loss of containment integrity Completed for all NPPs.

The licensees have investigated possible strategies on the loss of containment function and approaches to assess the containment damage extent. The outcome of the investigations have been incorporated in the Emergency Operating Instructions.

T3.LA.8 – Evaluate accident management programmes

Completed for all NPPs. A review of the instructions have been carried out for all utilities. Some changes have been implemented based on the findings. As the emergency preparedness organisation develops, further mobile equipment are introduced and analyses carried out. The emergency procedures are continuously developed.

T3.LA.9 – Consider an extended scope of training and drills

Completed for all NPPs. As a direct measure after the Stress tests, the licensees developed training scenarios and emergency exercises in which more than one plant at each site is involved.

T3.LA.10 – Investigate the need for a new call-in system

Completed for all NPPs. The licensees have in some cases decided to introduce enhanced call-in-systems.

T3.LA.11 – Analyse the management of hydrogen

Completed for all NPPs. An investigation regarding the handling of hydrogen (oxyhydrogen) after a severe accident is handled in a joint licensee project. Some potential shortcomings in the handling of hydrogen gas after a severe accident have been identified and have been corrected by installing increased venting in identified potentially vulnerable locations.

T3.LA.12 – Investigate the need for means to manage large volumes of contaminated water

Completed for all NPPs. Plans on how to manage large volumes are in place.

T3.LA.13 – Reassess personal safety issues

Completed for all NPPs. This issue is handled within the framework of actions in response to the requirements of the new emergency regulations, SSMFS 2014: 2.

T3.LA.14 – Secure the accessibility of the emergency control centre

Completed for all NPPs. This issue is handled within the framework of actions in response to the requirements of the new emergency regulations, SSMFS 2014: 2.

T3.LA.15 – Set up action plans for support to local operators

Completed for all NPPs. This issue is handled within the framework of actions in response to the requirements of the new emergency regulations, SSMFS 2014: 2.

T3.LA.16 – Reassess the use of containment filtered venting system in the long-term

Completed for all NPPs. Investigations and assessments of the ability to manage a severe accident have been performed by the licensees with different suggested solutions. Implementation of the ICCS, which takes into account the filtered venting system for residual heat removal, also resulted in more detailed analyses.

T3.LA.17 – Investigate long-term handling of the containment chemistry

Completed for all NPPs. Investigations and assessments of the ability to manage a severe accident have been performed by the licensees. The conclusion of the study is that none of the studied phenomena are expected to provide substantial degradation of the containment and increase the emissions. Uncertainties remain for some plants regarding the risks of corrosion and degradation of polymeric materials. Current research in these areas is followed.

T3.LA.18 – Evaluate the need for common resources available at the site

Completed for all NPPs. The licensees have evaluated the existing shared resources on the site with different suggested solutions.

T3.LA.19 – Investigate the performance of the common system for filtered containment venting

Not applicable since Oskarshamn 1 and 2 are permanently shut down. No other plants have common containment venting.

1.4.2. Actions to be performed by the regulators

No specific actions to be performed by the Swedish regulatory body (RA) was identified.

1.5. National organisations

1.5.1. Actions to be performed by the operators or other national organisations

The following section describes the status for each measure related to the specified national organisation.

T4.NA.1 – Processing the result from the evaluations of the country-wide exercise focusing on a nuclear power plant accident – SAMÖ/KKÖ

The result has been processed.

T4.NA.2 – Processing the result from the evaluations of the performances of the national organisations throughout the first month of the accident at the Fukushima Dai-ichi NPP.

Findings related to responsibilities were handled within the framework of the Action Plan "The Swedish preparedness for radiological and nuclear accidents" (2015). Internal development projects have been initiated at the involved authorities to increase the ability to manage a nuclear event. During 2016-2017 a working model following guidelines for effective coordination (SOL) published by the Swedish Civil Contingencies Agency (MSB) has been implemented, exercised and evaluated with good results. During this period, three different exercises were conducted involving the County Administrative Boards that have the primary responsibility for protecting the public during a NPP accident.

T4.NA.3 – Evaluation of the Swedish Defense Research Agency's (FOI) role during a radiological or nuclear emergency

The role of the FOI has been evaluated as part of the evaluations mentioned above in T4.NA.2. The responsibilities of FOI during a radiological or nuclear emergency include field and laboratory measurements and analysis (for example within the framework of the national expert response organisation led by SSM). FOI also gives advice to the Government of Sweden and supports SSM with assessment and prognosis in radiological or nuclear emergencies.

T4.NA.4 – A country-wide exercise focusing on a nuclear power plant accident – Havsörn

The exercise included 33 organisations and was carried out in December 2013. The scenario included an event on the NPP Forsmark, in the County of Uppsala, that escalated to a discharge. The exercise included field measurements.

T4.NA.5 – The evaluation of the exercise finished with a final report from the evaluation team – Havsörn

The County Board of Uppsala has produced the final report evaluating the exercise.

T4.NA.6 – Processing the result from the evaluations of the country-wide exercise focusing on a nuclear power plant accident – Havsörn

Most findings are handled within the framework of the Action Plan “The Swedish preparedness for radiological and nuclear accidents” (2015). Various development projects have been initiated to increase the ability to manage a nuclear event. For example, a table top (Assar) was conducted in December 2014 as a follow-up to increase the ability to handle a nuclear accident.

1.6. Emergency preparedness and response and post-accident management (Off-site)

1.6.1. Actions to be performed by the licensees

The following section describes the status for each measure related to Emergency preparedness and response and post-accident management performed by the Swedish licensees (LA). Further technical and administrative measures needed are also described.

T5.LA.1 – Clarify the responsibility for decontamination stations outside the site for personnel during shift turnovers and how equipment is to be replaced

Handled within the update of the emergency plan.

T5.LA.2 – Investigate the course of action during a long-term need for personnel

Handled within the update of the emergency plan.

T5.LA.3 – An investigation is suggested to ascertain advantages and disadvantages in replacing the present substitute Command Centre with a suitable office outside the site

Handled within the update of the emergency plan.

T5.LA.4 – It shall be investigated whether some of the functions included in the emergency preparedness organisation staffing are sufficient, to sustain shifts around the clock

An investigation has been conducted and the number of persons to maintain permanent staffing around the clock in case of emergency has been established for the roles in the emergency response organisation. The results have been incorporated in the emergency plan.

T5.LA.5 – Presently calling in personnel depends on a functioning GSM/Telenet. An improvement in this area shall be investigated

Handled within the update of the emergency plan in 2014.

T5.LA.6 – Identify alternative evacuation routes.

Alternative collection sites shall be decided upon and incorporated in the licensee’s emergency plans These sites shall be communicated with the emergency planning at the county administration board. Handled within the framework of actions in response to the requirements of the new emergency preparedness regulations, SSMFS 2014: 2.

T5.LA.7 – The Command Centre shall be connected to its own auxiliary power supply that is independent of the regular power supply at the plant site.

Auxiliary power is now in place for all the Command Centres.

1.6.2. Actions to be performed by the regulators

The following section describes the status for each measure related to Emergency preparedness and response and post-accident management performed by the Swedish regulatory body (RA).

1.6.3. Actions identified in Sweden at a national level

T5.RA.1 - Up-dating and formalization of pre-defined criteria on countermeasures and the implementation of measurable operational intervention levels and routines for application of intervention levels

On 22 October 2015, the Government of Sweden commissioned the Swedish Radiation Safety Authority (SSM) to, in consultation with the Swedish Civil Contingencies Agency (MSB), relevant county administrative boards and other competent authorities and stakeholders, perform a review of emergency planning zones and emergency planning distances applying to activities involving ionising radiation. The review, presented to the Government of Sweden on 1 November 2017, encompasses overall objectives for the emergency planning, the types of emergency planning zones and emergency planning distances that should be established, reference levels that should serve as the basis for emergency planning, and dose criteria and intervention levels for different protective actions. The review considers events at, and emergency planning zones surrounding, the nuclear power plants, a fuel fabrication plant and the central interim storage facility for spent nuclear fuel in Sweden. In 2020, the Swedish Radiation Safety Authority (SSM) published a report on the planning basis for activities and acts in emergency preparedness category 4 (SSM 2020:15). The report covers pre-defined criteria on countermeasures and the implementation of measurable operational intervention levels and routines for application of intervention levels for nuclear or radiological emergencies. The report will be published in English during 2021. The reports complements earlier reports for facilities in emergency preparedness category I, II and III.

T5.RA.2 – SSM and the nuclear facilities are currently working towards establishing a system for electronic transmission of plant data from the Swedish nuclear power plants to SSM’s Emergency Response Centre.

The system is installed. T5.RA.3 - Implementation of the revised Swedish regulation SSMFS 2008:15,

SSM’s Regulations concerning Emergency Preparedness at Certain Nuclear

Facilities. The regulation has been implemented.

T5.RA.4 – The Nordic Flag Book

In the last quarter of 2013 the “Nordic Flagbook”, “Protective Measures in Early and Intermediate Phases of a Nuclear or Radiological Emergency, Nordic Guidelines and Recommendations”, was completed and approved by the Director Generals of the Nordic Radiation Safety Authorities. The “Nordic Flagbook” has been translated into Swedish during 2014.

1.7. International cooperation

1.7.1. Actions to be performed by the licensees

The following section describes the status for each measure related to International cooperation performed by the Swedish licensees (LA). Further technical and administrative measures needed are also described.

T6.LA.1 – Expanding the scope of WANO Peer Reviews Ongoing.

T6.LA.2 – Expanding the frequency of WANO Peer Reviews Ongoing.

T6.LA.3 – Developing a world-wide integrated event response strategy Ongoing.

1.7.2. Actions to be performed by the regulators

The following section describes the status for each measures related to International cooperation performed by the Swedish regulatory body (RA).

T6.RA.1 – Accede to the 2004 Protocol to amend the Paris and Brussels Conventions on Third Party Liability in the field of nuclear energy Ongoing.

T6.RA.2 – Assessment and improvement of international crisis communication and information dissemination. The Swedish emergency preparedness guidelines have been updated.

T6.RA.3 – IRRS recommendation to SSM to establish and implement guidance for dissemination of all significant operating experience and lessons learned to all relevant authorized parties. This is an ongoing process.

T6.RA.4 – Actively participate in information exchange after the Fukushima accident – International organisations Ongoing. Sweden participates in relevant meetings and information exchange.

T6.RA.5 – IRRS-recommendation: Better ensure compliance with relevant IAEA Standards

Completed, the internal guidelines are updated and have been checked against IAEA guides and standards. This has also been an important part of project to update the regulations related to operating NPP:s, which entered into force on 1 March 2022.

T6.RA.6 – More strategic coordination and follow-up of the work in the different IAEA Safety Standards Committees Ongoing.

T6.RA.7 – Fulfilment of WENRA reference levels (RLs)

New regulations enter into force in 1 March 2022.

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Kronologisk förteckning

1. Viktigt meddelande till allmänheten – en översyn av VMA-systemet. Ju.
2. Bättre konsekvensutredning i svensk statsförvaltning. Fi.
3. Garantitillägg i bostadstillägget. S.
4. Ökade möjligheter till användning av välfärdsteknik inom äldreomsorgen. S.
5. En effektivare upphandlingstillsyn. Fi.
6. Straff för deltagande i en terroristorganisation. Ju.
7. Ett försämrat säkerhetspolitiskt läge – konsekvenser för Sverige. UD.
8. Deterioration of the security environment – implications for Sweden. UD.
9. Ett utvidgat utreseförbud för barn. S.
10. Ett flexiblare karensvillkor i arbetslöshetsförsäkringen. A.
11. Arlanda flygplats – en plan för framtiden. I.
12. Vistelseförbud för barn. S.
13. Utökat informationsutbyte. Fi.
14. Ett hållbart mediestöd för hela landet. Ku.
15. Regler om privata sjukvårdsförsäkringar inom den offentligt finansierade hälso- och sjukvården. S.
16. Ledarhundar. S.
17. Inordnande av Statens medieråd i Myndigheten för press, radio och tv. Ku.
18. Straffansvar för pyskiskt våld. Ju.
19. Sweden's Ninth National Report under the Convention on Nuclear Safety. Sweden's Implementation of the Obligations of the Convention. M.

Departementsserien 2022

Systematisk förteckning

Government Offices of Sweden
Ministry of the Environment

Sweden’s Ninth National Report under the Convention on Nuclear Safety