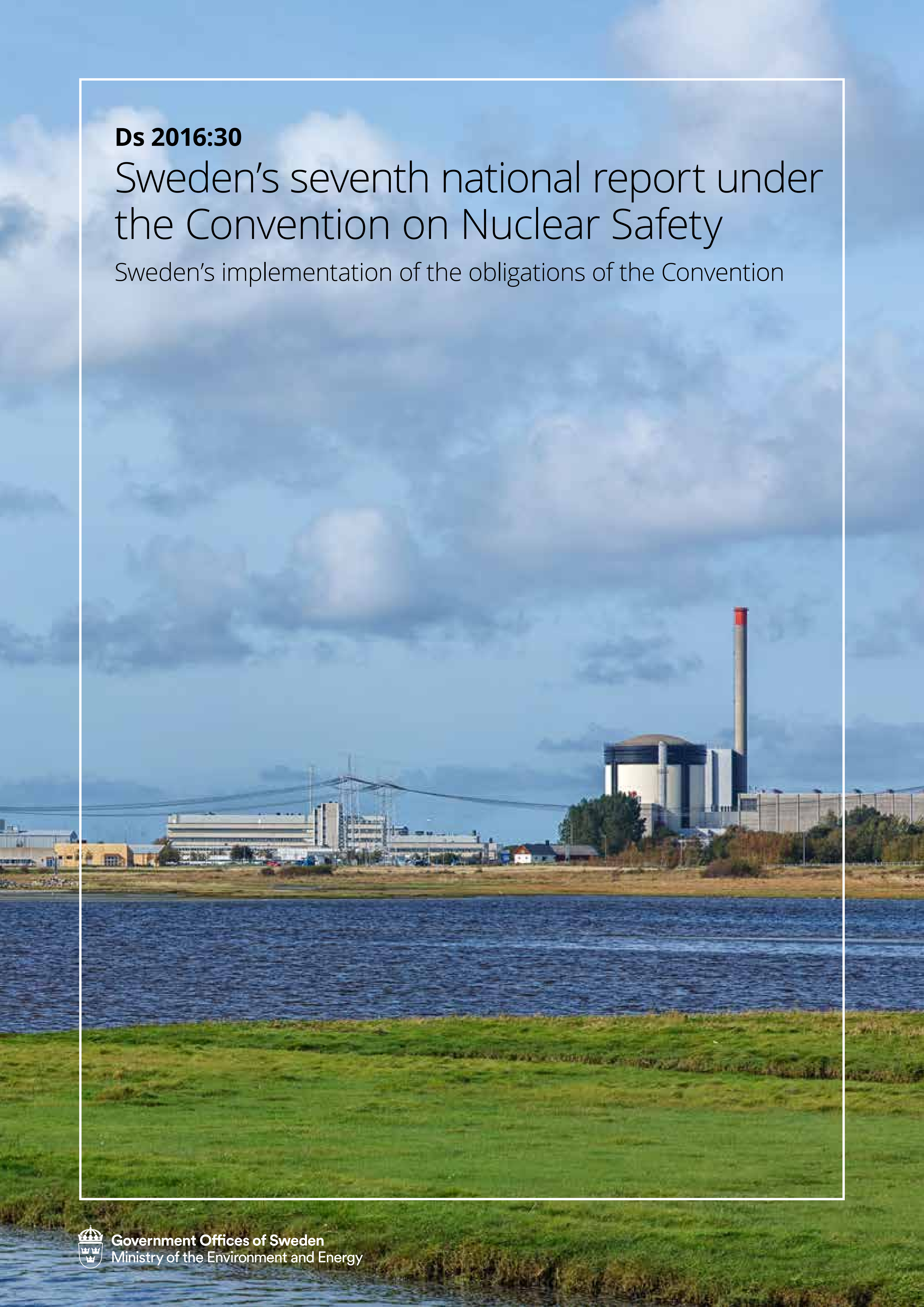
Ds 2016:30

Sweden's seventh 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 and Energy

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Sweden's implementation of the obligations of the Convention

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Foreword

This report is issued according to Article 5 of the Convention on Nuclear Safety. Sweden signed the Convention on 20 September 1994. The Convention was ratified about a year later, on 11 September 1995, and it entered into force on 24 October 1996.

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

A summary of highlights and issues raised about Sweden during the sixth review meeting held 24 March–4 April 2014 can be found in Chapter A. This section also includes an overview of the issues Sweden was asked to report on in its seventh national report.

The Swedish Radiation Safety Authority was assigned the task to co-ordinate the work to compile and produce the seventh national report on behalf of the Government. A six persons working group with four representatives of the regulatory body, the Swedish Radiation Safety Authority, and one representative of each of the reactor owners, Vattenfall AB (further Vattenfall) and Sydkraft Nuclear Power AB (further Sydkraft NP), produced the report.

The present report is structured in the same manner as the previous Swedish national reports. Chapter A includes basic facts and information about the Swedish nuclear programme to provide the reader with a frame of reference. Chapter B includes facts and information to substantiate compliance with the obligations of the Convention. Each Article under Chapter B corresponds to one Article of the Convention. Articles 6–8 are structured to allow for information, in accordance with the Articles, to be provided in a clear and reviewable manner. Articles 9–16 and 19 have a similar basic structure where information is provided about the regulatory requirements related to the corresponding Article and measures taken by the licence holders to comply with the regulatory requirements. These Articles also includes information about the licensees own safety initiatives as well as on regulatory oversight/supervision. Articles 17 and 18 are structured considering the templates provided by the special working group of experts. They contain the same information but the structure may differ from the other Articles. Altogether, this information will provide evidence for meeting the obligations of the Convention.

Recommendations on the report structure issued as guidelines INFCIRC 572 Rev. 5 have been taken into account. In addition a template has been used which was developed by a group of experts to support the Contracting Parties by providing suggestions to be considered during the preparation of their reporting on Articles 17 and 18.

The sixth 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 seventh review meeting. The agreed topics are reflected and the results presented in the report.

As a result of the Diplomatic Conference to Consider a Proposal by Switzerland to Amend the CNS, the Vienna Declaration on Nuclear Safety was adopted by consensus by the Contracting Parties, on 9 February 2015. It contains three principles to guide the Contracting Parties, in the implementation of the objective of the CNS. These principles are reflected in this national report with special focus on Article 18 as well as other relevant Articles, including 6, 7, 14, 17 and 19.

The general conclusions on Swedish compliance with the obligations of the Convention are reported in the executive summary.

List of 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
CCF	Common Cause Failure
Clab	Central Interim Storage Facility for Spent Nuclear Fuel
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
I&C	Instrumentation and Control
IEEE	Institute of Electrical and Electronics Engineers
INES	International Nuclear Event Scale
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 Center)
KTH	Kungliga Tekniska Högskolan (Royal Institute of Technology)
LER	Licensee Event Report
LILW	Low and Intermediate Level Waste

LOCA	Loss of Coolant Accident
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
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
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
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)
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
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
UPS	Uninterruptible Power Supply
USNRC	US Nuclear Regulatory Commission
VTT	Finnish Technical Research Centre
WANO	World Association of Nuclear Operators
WENRA	Western European Nuclear Regulators' Association

EXECUTIVE SUMMARY: GENERAL CONCLUSIONS

The national reports for the review meetings according to Article 5 of the Convention call for a self-assessment of each Contracting Party with regard to compliance with the obligations of the Convention. For Sweden, this self-assessment has demonstrated compliance with all the obligations of the Convention, as shown in Chapter B of this national report.

The extensive modernization programs introduced in 2005 and the power uprating programmes for Swedish NPPs have now been completed and major investments have been made by the industry in the ten operating reactors to improve safety and prepare for long-term operation. However, during 2015 decisions have been taken by the plants owners on a phase-out of the four oldest nuclear power reactors during the period 2017 - 2020. The decisions were based on the overall business and energy market situation and other circumstances in the past few years.

There have been no events during the review period with serious consequences for safety at Swedish NPPs. However, some events occurred during the review period which have importance in respect of the intergrity of the safety barriers. For example, one event was the corrosion in the bottom part of the containment liner of Ringhals unit 2 indicated during a regular integrated containment air test.

Following the severe accident at the Fukushima Dai-ichi nuclear power plant in 2011 and the EU stress tests in 2012, a Swedish national action plan covering all Swedish NPPs has been developed to implement lessons learned from the accident and to deal with the conclusions from the second extraordinary meeting under the Convention on Nuclear Safety in 2012 and the regular Review Meeting in 2014. Actions to be taken by the licensees to strengthen the plants protection against extreme external hazards were covered by the EU Stress Test National Action Plan (NAcP). All actions included in the NAcP were completed during the review period and the final reporting from the licensees was presented to the regulator in December 2015. However, most of the actions in the NAcP required further evaluations and the results from these evaluations aimed at identifying reasonably achievable technical and administrative measures to further strengthen the safety at the plants. Technical and administrative measures related to the NAcP are now under implementation and all measures are expected to be completed by the end of 2020.

Further information on the actions taken in Sweden in relation to the Fukushima Dai-ichi accident is presented in Chapter A and in sections B6, B16, B17 and B18. The Swedish Radiation Safety Authority (SSM) continuously reviews and follows up on licensee implementation of safety improvement measures. The focus is on ensuring that requirements are fulfilled and that the implementation follows agreed timetables.

On February 9 2015, a Diplomatic Conference of the CNS was held in Vienna at the headquarters of IAEA, to consider a proposal by Switzerland to amend Article 18 of the CNS. No amendment was accepted, on the other hand, a declaration on nuclear safety was adopted by consensus by the Contracting Parties to the CNS. This Vienna Declaration on Nuclear Safety includes principles for the implementation of the objectives of the CNS to prevent accidents and mitigate radiological consequences. The Contracting Parties further decided that the fulfilment of the principles and implementation of the Declaration should be considered in the preparation of national reports for the seventh review meeting. Thus, each principle of the Declaration is shortly discussed in Chapter A and is further described in sections B6, 7, 14, 17, 18 and 19 of this report.

A full-scope IAEA IRRS mission to Sweden was performed during the period 6–17 February 2012. The purpose was to review the effectiveness of the Swedish regulatory framework for safety within the competence of SSM. In February 2014 the Government requested SSM to arrange a follow-up of the 2012 IRRS mission. Arrangements were made with IAEA and in April 2016 a follow-up mission will take place. SSM looks forward to the follow-up IRRS-mission and the possibility to describe the actions taken on recommendations and suggestions and the further development of infrastructure, acts and regulations and the national oversight processes in Sweden. Two of 22 recommendations given by the IRRS team are deemed by Sweden to be open, since more work is needed to close these recommendations. These recommendations deal with issues related to provisions to maintain national competence for nuclear safety and radiation protection and systematic evaluation of operational experience from non-nuclear facilities and of radiation protection events and activities, including dissemination of all significant operating experience.

SSM is currently revising regulations 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 for SSM in its supervisory activities. The need for a consistent and more comprehensive set of regulations and general advice was also highlighted during the IRRS mission in 2012. Another reason for the ongoing revision was that the Swedish Government in 2012 ordered SSM to develop regulations for potential new nuclear power reactors. A major review of existing Codes and Statutes began in 2013.

In parallel with the SSM regulatory review, the Swedish Acts on nuclear activities and radiation protection are reviewed to ensure that the latest Euratom Directives in the area of nuclear safety and radiation protection are appropriately implemented in Swedish legislation. In this regard, as requested by the Government, SSM has presented proposals for a new Radiation Protection Act and changes to the Act on Nuclear Activities. These proposals are undergoing extensive consultations and potential changes will be made in accordance with the time schedule for implementation, as defined by each Directive.

SSM has received additional staff resources for strengthening its regulatory supervision and developing safety regulations for new nuclear power plants. An application was submitted by Vattenfall AB (further Vattenfall) in July 2012 for permission to replace old nuclear power reactors with new ones. This required SSM to further expand its human resources. In late 2014, Vattenfall informed SSM that all work related to this application had been put on hold. As a consequence, SSM decided on staff reduction. Furthermore, decisions have been taken by the owner of the Swedish NPPs to phase-out the oldest NPPs. This requires SSM to strengthening its regulatory activities in the area of decommissioning and assess availability of further necessary competence. The human resources situation at SSM has improved during the review period, but SSM still strives to find and recruit personal with suitable skills.

IAEA OSART missions, focusing on operational safety, were performed at all Swedish NPPs during the period 2008-2010, and subsequent follow-up missions were conducted between 2010 and 2012. IAEA SALTO peer reviews activities, focusing on ageing management and long-term operation, have been initiated at all Swedish NPPs during the review period. WANO peer reviews and subsequent development work continues at all plants. The areas identified for improvements and the subsequent implementation of measures, resulting from all the above peer reviews, form a basis for continued safe operation.

In the beginning of the review period both Ringhals AB (RAB) and OKG Aktiebolag (OKG) were under so called “special supervision”, which is applied when SSM is dissatisfied with the safety performance of the licensee. SSM concluded in 2013 that the special supervision of RAB was no longer necessary and the program was terminated. SSM has concluded that there are still some open issues that needs to be resolved at OKG and subsequently the special supervision of OKG will continue. In response to the owners decision to permanently shut down two reactors at each of the Ringhals and Oskarshamn sites, measures have been taken by SSM to strengthen supervision of the licensees RAB and OKG, in order to ensure that the safety at the NPPs is maintained, for both the reactors under operation and the reactors in decommissioning.

The licensees’ staffing and competence planning have been strengthened during the review period. 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 recruiting has been assessed. The decisions to permanently shut down four reactor units made the competence and staffing plans even more important. Activities regarding competence planning have therefore been intensified and the plans are now more detailed. The goal is to secure competences during the entire decommissioning process and to support a good transition process when the sites are transferring from having several reactors in operation to only having one or two at each site. The amount of training days has decreased the last few years since all modernisation measures are now completed and the earlier needs for additional training due to changes in the plants are no longer necessary. However, the needs for special training in relation to decommissioning activities will influence the training activities in the future. In addition, the human performance area and safety culture have received increasing attention in recent years. This has, for example, resulted in more resources, training programs and seminar series.

Radiation protection education and training has continuously been reviewed and strengthened. Also, the efforts to reduce releases of radioactive substances to air and water have been effective and the activity amounts, as well as the corresponding calculated doses, have decreased or remained largerly unchanged. Work will continue with the aim to further decrease the releases of radioactive substances and to keep them as low as reasonably achievable.

New regulations on on-site emergency preparedness and response entered into force in January 2015. Amongst others, the regulations have new provisions on endurance of the on-site emergency response organization and on off-site logistical centres. In addition, a national contingency plan for dealing with a nuclear accident was compiled in 2014–15. The plan describes basic conditions such as legislation, organizations involved, responsibilities and coordination in the event of a nuclear or radiological emergency. Furthermore, monitoring stations and function have been increased and a number of new on-line stations will be taken into operation in late 2016.

In summary, the following strengths of the Swedish Nuclear Safety framework can be highlighted:

- The Swedish legal framework is well developed and the responsibility for nuclear and radiation safety is well defined. The legislation provides for public insight into the activities of the licensees and the authority. Legislation and regulations are recurrently reviewed to ensure sufficient and up-to-date requirements (including Euratom Directives).
- There is an open and constructive dialogue between the regulatory body and the licensees.
- The owner companies are well established and demonstrate a commitment to maintain a high level of safety in their nuclear power plants and to take strong measures to correct deficiencies regardless of the plants' operating mode.
- Both collective and individual radiation doses at the nuclear power plants remained stable or have decreased during the review period.
- The design of the nuclear power reactors has developed over the years as a response to development of regulations and safety standards. Large-scale modernisation programmes have been completed and the current designs are in line with modern safety standards. The NAcP has been completed and further technical and administrative measures to increase the safety of the plants are under implementation and are to be finalized by 2020.

However, there is still room for improvements and the following areas should be given special attention in relation to the obligations under the Convention:

- The success of the safety work, both at the utilities and at the regulatory body, depends on continued access to human resources and necessary expertise on the national level. The efforts to strengthen education, facilitate generational shifts and attract young people to the nuclear power and nuclear safety sectors must continue. The situation in terms of expertise and human resources must be monitored continuously and, when required, the necessary actions must be taken.
- It will be necessary to ensure safe long-term operation of existing nuclear power plants. This may require additional safety measures, and that the licensees are applying effective ageing management.

Further development in these areas will be reported in Sweden's eighth national report under the Convention on Nuclear Safety.

A. INTRODUCTION

Current role of nuclear power in Swedish power production

In 2013 total annual production in Sweden was 149.5 TWh, a significant reduction compared with 2012, when over 162 TWh was produced. Wind power and nuclear power increased production while other sources decreased. Hydropower reached nearly 61 TWh in annual production (41 percent of total) compared with the normal average production of 65 TWh. Wind power reached production record of 10 TWh (7 percent) compared with 7 TWh the year before. Nuclear power increased production to nearly 64 TWh (43 percent), even though some issues related to the commissioning of the upgraded power plants occurred. The other power sources decreased slightly to just over 15 TWh (10 percent).

Electric power generation in 2014 was about 151 TWh, which is slightly higher than in 2013. Hydropower accounted for the largest part (about 42 percent) of electricity produced during 2014, slightly below the average. Nuclear power came somewhat behind at 41 percent of electricity production, while other sources of thermal power accounted for 9 percent and wind power for 8 percent. Nuclear power decreased its production from 64 TWh in 2013 to 62.2 TWh in 2014. This level of production is lower than normal.

Electricity production in 2015 increased to 158 TWh, which is the second highest annual production ever in Sweden. Hydropower was the largest source accounting for 47 percent of Sweden's electricity production during the year, i.e., about 74 TWh. This was due to high precipitation and good availability of water. The hydropower output was 10 TWh higher than in 2014, which illustrates potential natural differences that may occur between the years. Wind power also reached a new production record of 16.6 TWh, accounting for 10 percent of total electricity generation. This is almost 45 percent higher than in 2014, and illustrates the ongoing and significant increase in production capacity in recent year. The fosile fuel-based electricity production was just above 13 TWh, slightly higher than the year before. Nuclear power produced 54 TWh in 2015, 13 percent lower than in 2014. The reason is that several reactors had extended outages during the year. Nuclear power thus accounted for only 34 percent of Sweden's electricity production.

The Swedish electrical 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.

In 2015 the total use of electricity, including losses in transmission, was 136 TWh. This is the second lowest annual electricity consumption in the 2000s, and only slightly higher than in 2014. Consequently, and for the fifth consecutive year, there was a net export of electricity from Sweden in 2015. Because of the high electricity production and low electricity consumption, net exports totalled 22.6 TWh, which is the largest ever, representing the equivalent of 14 percent of total electricity production and 17 percent of consumption in the country during the year. The previous record was 19.6 TWh of net exports in 2012.

Development of nuclear power in Sweden

In Sweden, nuclear engineering was launched in 1947, when AB Atomenergi was established to realise a development programme resolved 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, located in a rock cavern in a suburb of Stockholm. The Ågesta reactor was mainly used for district heating and was in operation between 1964 and 1974. It was permanently shut down in 1974. The first commercial nuclear power plant, Oskarshamn unit 1, was commissioned in 1972 and was followed by another eleven units sited at Barsebäck, Oskarshamn, Ringhals and Forsmark up until 1985. The twelve commercial reactors constructed in Sweden comprise nine BWRs (ASEA-Atom design) and three PWRs (Westinghouse design). As a result of political decisions, the twin BWR units Barsebäck 1 and 2 were shut down permanently in 1999 and 2005, respectively.

In 2004, Studsvik Nuclear AB decided to shut down two research reactors (R2 and R2-0) on the Studsvik site. They were closed in June 2005 and are currently undergoing decommissioning.

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 the SSM in July 2012. At the time the applicant, Vattenfall, considered to replace the two oldest units in Ringhals with one or two new units. However, in late 2014 Vattenfall informed SSM that all on-going work related to plans for new build of nuclear reactors had been put on hold and there is currently no intention to resume the project.

During autumn 2015, at the extraordinary shareholders' meetings of RAB and OKG, decision in principal have been taken on phase-out of the reactors Ringhals unit 1, unit 2 and Oskarshamn unit 1 and unit 2. The decisions were taken in respect to the overall business and energy market situation, existing taxes, and SSM's safety requirements regarding operation beyond 2020.

The owners of OKG decided to stop and cancel implementation of the ongoing safety modernization of Oskarshamn unit 2. This unit was in long term outage for modernization since 2013 and it was decided not to restart the unit. OKG have also decided that Oskarshamn unit 1 will continue operation until the annual outage in 2017. After the outage 2017 Oskarshamn unit 1 will go into decommissioning phase as well. The new mission for the utility is safe and effective decommissioning of these two units. OKGs largest reactor, unit 3, is planned to be in operation with a planned lifespan until 2045.

The owners of RAB have decided that operation of Ringhals unit 2 will end in 2019 and that operation of Ringhals unit 1 in 2020. As a consequence, all major investments for these units have been cancelled, but all necessary measures to maintain safety will be taken until they are taken out of operation. In parallel, planning for safe and efficient decommissioning is ongoing.

For Forsmark units 1, 2, 3 and Ringhals units 3 and 4 the safety development programmes continue as planned with expected lifetime up to 60 years.

Political development of the Nuclear Power Issue

In January 2011 amendments were made to the Act on Nuclear Activities (1984:3) and the Environmental Code to make it possible, under certain preconditions, to gradually replace existing nuclear power reactors with new ones. One precondition for obtaining permission to construct new reactors in Sweden is that the new reactor will replace one of the older reactors that have been permanently shut down. Another precondition is that the new reactors may only be constructed at one of the sites where one of the present reactors are in operation. This legislation is to enable controlled generational shifts in Swedish nuclear power. Also, the Nuclear Power Phase-Out Act (1997:1320) was abolished and the prohibitions in the Act on Nuclear Activities (1984:3) on construction of new nuclear power reactors removed.

Furthermore, already in 2010 Parliament passed a new Act on Liability and Compensation in the event of Radiological Accidents (2010:950) which replaced Nuclear Liability Act (1968:45). The Act imposes unlimited liability on the owner of a facility for radiological damage and regulates the extent to which the operator of a facility must provide financial guarantees for compensation to those affected by a radiological accident.

After the 2014 election, in the new Government Declaration, it was stated that the Government prepared an invitation to some of the parties in Parliament to participate in a special energy commission. It was also stated that a starting point for the commission's discussions was to be the replacement of nuclear power by renewable energy and greater energy efficiency. The commission was established in the beginning of 2015 with the aim to reach an energy agreement that would be sustainable over the long term.

Nuclear power installations in Sweden

In March 2016, there are ten nuclear power reactors with operational licence in Sweden, as specified in Table 1. Three nuclear power reactors have been permanently shut down, namely Ågesta, Barsebäck unit 1 and Barsebäck unit 2.

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 Kraft AB	1970	1975-1999
Barsebäck 2	1800	615	BWR		1972	1977-2005
Forsmark 1	2928	984	BWR	Forsmarks Kraftgrupp AB	1971	1980
Forsmark 2	3253	1120	BWR		1975	1981
Forsmark 3	3300	1167	BWR		1978	1985
Oskarshamn 1	1375	492	BWR	OKG Aktiebolag	1966	1972
Oskarshamn 2	1800	661	BWR		1969	1975
Oskarshamn 3	3900	1450	BWR		1980	1985
Ringhals 1	2540	910	BWR	Ringhals AB	1968	1976
Ringhals 2	2660	847	PWR		1969	1975
Ringhals 3	3144	1117	PWR		1972	1981
Ringhals 4	2783	1181	PWR		1973	1983

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

Figure 1 shows the geographical location of Swedish nuclear facilities, all of them situated in the southern part of Sweden.

All Swedish BWRs were designed by the domestic vendor ASEA-Atom (later ABB Atom, now Westinghouse Electric Sweden AB) and all Swedish PWRs, excepting Ågesta, by Westinghouse USA.

Eight of the power reactors (including Barsebäck units 1 and 2) have been uprated during between 6% and 38% from the original licensed power levels. An overview of the current situation is given in section B6.3. The main data for nuclear power installations in Sweden are shown in Table 1.

[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.

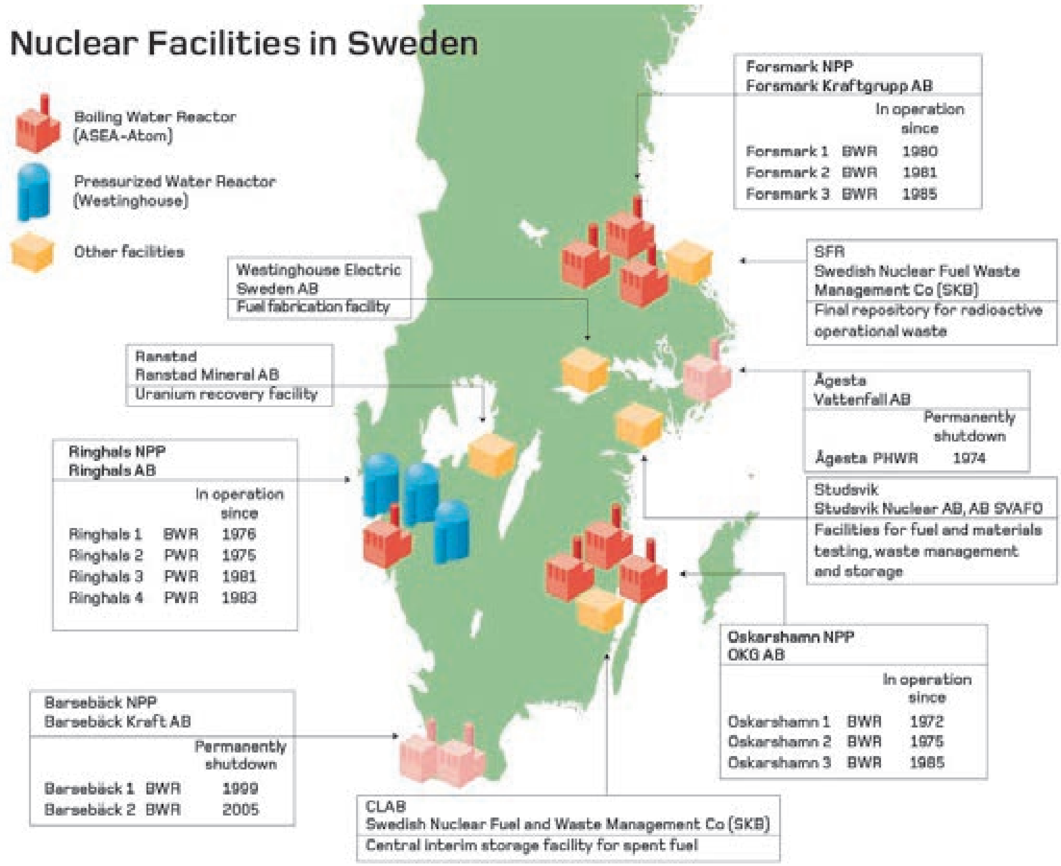

Figure 1. Location of the nuclear facilities in Sweden

Ownership, organisation and staffing

Ownership of the Swedish nuclear power plants is to a large extent characterised by cross ownership as shown in Figure 2. The Swedish state owns 100% of the shares of the utility Vattenfall. In 2008 and 2009, conditions for the present cross ownership were analysed by a group of government officials. In 2010, after discussions with all involved parties, it was concluded that there was no need to further regulate the ownership.

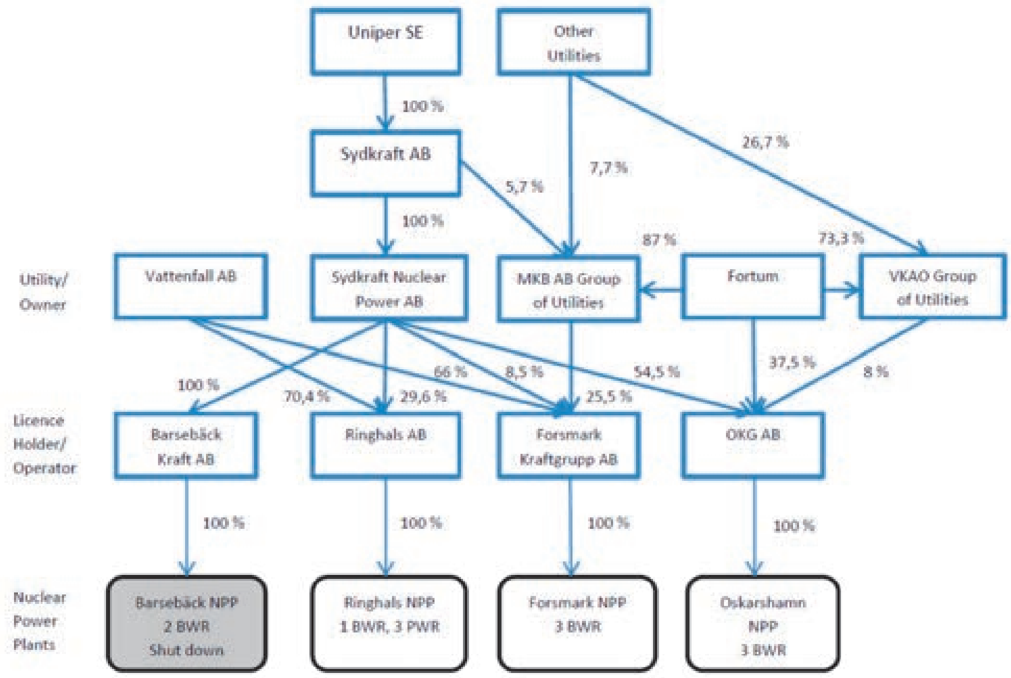

Figure 2: Utility and ownership structure 2016.

The numbers of employees at the different sites are shown in Table 2. Numbers of employees at Swedish nuclear power plants in 2015 compared with the years since 2012.

Nuclear power plant	2015	2014	2013	2012
Barsebäck	48	51	54	40
Forsmark	1154	1186	1154	970
Oskarshamn	957	923	896	900
Ringhals	1627	1657	1619	1600

Table 2: Numbers of employees at Swedish nuclear power plants, 2012–15.

The owners and licensees support organisations and cooperation

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

- 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 (former ERFATOM): a group for cooperation between Swedish and Finnish NPP operators, KSU and SKB to carry out experience feedback 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) in Oskarshamn and the final repository for short-lived radioactive waste (SFR) in 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 the canister laboratory in Oskarshamn.

Other commercial services in the nuclear power field

In recent years, 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 Toshiba under the name Westinghouse Electric Sweden AB. Other active vendors on the Swedish market are Areva, Westinghouse USA, General Electric, Siemens, and Alstom Power.

Studsvik Nuclear AB is a contractor for materials testing and nuclear fuel investigations. Its materials testing reactors are closed but the company cooperates with the Halden reactor in Norway. Studsvik Nuclear AB maintains operation of its own hot-cell laboratory for fuel investigations. The company also provides decommissioning and waste treatment services.

Over the past few years, Swedish nuclear power plant licensees have noticed that fewer companies are bidding on qualified technical projects and services. This reflects the concentration of vendors and service companies on the market and also the increasing demand as a result of the extensive upgrading of Swedish reactors and the nuclear construction project in the neighboring country, Finland.

Under Swedish law, a licence holder needs a permit from the Government or from SSM in order to contract out a major proportion of nuclear activity. For minor proportions, it is sufficient under certain conditions to notify SSM that a contract has been awarded. SSM requires the licensees to make the necessary check of quality and competence of a contractor and to take full responsibility for the work done by the contractor.

Nuclear waste

Operational radioactive waste is generated by nuclear reactors and fuel cycle facilities, such as Studsvik AB facilities and the Westinghouse Electric Sweden AB fuel fabrication plant located in Västerås. Radioactive waste also originates from medical and research institutions, industry and consumer products. Past research activities also generated some waste, which is either stored or has already been disposed of. In total, the Swedish nuclear power programme will generate approximately 20,000 m^3 (12,600 tonnes) of spent fuel (counted as uranium), 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 (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). Total annual production of LILW at the nuclear facilities is usually around 1,000–1,500 m^3.

In addition to waste management practices at the NPPs, the national waste program includes the waste treatment facilities at Studsvik, the repository for short-lived radioactive waste at Forsmark site (SFR), the shallow land burials, the 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.

SFR is a repository for short-lived LILW resulting from operations of the Swedish nuclear programme. In addition to this, small amounts of radioactive waste from hospitals, research institutions and industry are disposed of in SFR. SFR consists of four rock caverns and a silo. The facility is situated close to the Forsmark site on the Baltic Sea coast at a depth of 50 m in the bedrock. Construction started in 1983 and SFR was taken into operation in 1988. Its total capacity is 63,000 m^3 and about 42,000 m^3 had been used by 31 December 2013.

In December 2014 SKB submitted a license application for an extension of SFR for disposal of LILW from decommissioning of Swedish reactors and nuclear fuel cycle facilities and for disposal of nine boiling-water reactor vessels. SKB also applied for storage of long-lived waste, including core components, in the extended SFR until the final disposal in a dedicated future diposal facility. The maximum permitted volume of LILW to be accommodated in SFR, including SKB's application for the extension, amounts to 171,000 m^3. SSM is currently reviewing SKB's licence application for SFR. A final review statement is expected in 2018. SKB plans to start operation of the extended part in 2023. Including the extension, the final repository will have a waste disposal capacity of 200,000 m^3.

The nuclear power plants at Ringhals, Forsmark and Oskarshamn as well as the Studsvik site, have shallow land burials for short-lived very low-level waste. The licence conditions for the power plants' burials imply time limits for authorized disposal between the years 2060 and 2075 and limitations on the waste volumes between 10,000 m^3 and 17,000 m3. Each of these burials is licensed for a maximum total activity of 100–200 GBq (maximum concentration of alpha-emitters a factor of one thousand lower) with the exception of Ringhals, the site with PWR reactors, for which 1100 GBq is allowed, accounting for up to 900 GBq of Ni-63 in the wastes.

Spent nuclear fuel from all Swedish nuclear power reactors is stored in the Clab facility, which is situated next to the Oskarshamn nuclear power plant site. The fuel is stored in water in storage pools in bedrock caverns with a rock cover of about 25 m. Construction started in 1980. The facility was taken into operation in 1985 with a storage capacity of 5,000 tonnes of spent fuel. Clab has been expanded in the form of a second rock cavern with storage pools. Its current total storage capacity is approximately 8,000 tonnes of spent fuel (with nearly 6000 tonnes in storage to date), though SSM is currently reviewing an application from SKB to increase the storage capacity to 11 000 tonnes.

In March 2011, SKB submitted licence applications under the Act on Nuclear Activities and the Environmental code for construction of an encapsulation plant at Oskarshamn and a final repository for spent nuclear fuel at Forsmark. The regulatory review of the applications under the Act on Nuclear Activities (1984:3) is being coordinated with the land and environmental court's review of the application under the Environmental Code. SSM is currently finalising its regulatory review and will submit a preliminary statement on SKB's applications to the land and environmental court in 2016 for its main hearings. SSM's final statement with a recommendation for a Government decision will be submitted to the Government in 2017. The Government will make a decision on SKB's applications after having consulted with the involved municipalities (municipal veto).

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

In addition to the existing waste management facilities, four major waste 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 and an extension of the SFR facility for waste from decommissioning. Additional land burials may also be constructed.

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. The three Swedish nuclear power plants and Westinghouse Electric Sweden jointly support these three universities through the Swedish Centre of Nuclear Technology (SKC), an organization for sponsoring and coordination that has been in existence since 1992. SKC supports undergraduate education, graduate schools as well as research.

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 regulatory authority faced similar challenges in competence development in general and staff renewal in particular. The situation during the early days of SKC is similar to that of the present situation with the planned shutdown of four reactors (see A2) out of the ten in operation in Sweden. It will introduce new challenges regarding maintaining sufficient competence within the country. The present SKC contract ends in 2016, but the ongoing negotiations regard a continuation involving the same partners.

In the past, the industry, previous regulator and its' successor, SSM, jointly financed education and research at universities, but this ended in 2013 due to the possible new-build plans from Vattenfall. SSM has chosen to discontinue shared funding with nuclear operators due to assessment of a new-build application. SSM found it unsuitable to have joint activities with the same industry that is the subject of an extensive licensing process. However, SSM continued providing support to the same universities, and has an observer's status in SKC to obtain and provide information on the respective funding for different purposes.

Swedish nuclear power plants have also provided jointly funding for a new Bachelor's degree programme on nuclear power at Uppsala University (UU). 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.

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

In addition to the industry support to the universities, SSM supports basic and applied research as well as development of methods and processes (usually not products), see section B8.4.

Also, a large project on joint research and education programme was established in 2011. Within this project, 15 Swedish PhD students spend a significant part of their study period at French laboratories. The project also includes training sessions at research reactor, located at the Saclay Nuclear Research Centre, outside Paris.

National cooperation

The joint industry initiative KSKG (Kärnkraftssäkerhetskoordineringsgrupp) was taken in 2013 to coordinate critical nuclear safety and security issues (primarily following the Fukushima Dai-ichi accident); stress tests and 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 and SKB and the owners of the nuclear facilities i.e. Vattenfall, Sydkraft NP and Fortum.

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

The regulatory body

Sweden is, through SSM, involved in about 140 international working groups. The majority of groups are related to nuclear safety and radiation protection issues. The cooperation mainly takes place within the frameworks of the IAEA, OECD/NEA and EU, and also in connection with the international conventions ratified by Sweden and in non-governmental organizations such as the Western European Nuclear Regulator's Association (WENRA), Heads of European Radiation Control Authorities (HERCA), and the International Nuclear Regulator's Association (INRA).

In addition to multilateral collaboration, SSM has bilateral agreements with twelve regulatory bodies in various countries on exchanging information and cooperating on agreed areas (e.g. nuclear safety, emergency preparedness, occupational exposure, environmental radiological protection and radioactive waste management). These are Australia, Canada, France, Finland, Germany, Japan, South Korea, Lithuania, Russia, Ukraine, the United Kingdom, and the United States. Additionally Sweden has special agreements with the Nordic countries (Denmark, Finland, Iceland and Norway) regarding emergency preparedness and information exchange.

SSM plays an active role in WENRA, not least because of its vice-chair position but also through active participation in WENRA's working groups. SSM has contributed to the review and development of the updated WENRA Safety Reference Levels for Existing Reactors[2] and participate in the ongoing WENRA's benchmarking project which makes a systematic comparison of national reactor safety requirements and their implementation against jointly agreed reference levels.

SSM participates in ENSREG (European Nuclear Safety Regulators Group), an expert advisory group to the European Commission. It 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 28 Member States in the European Union and representatives of the European Commission. SSM representative is also chairing the ENSREG Working Group on Waste Management.

Following the severe accident at the Fukushima Dai-ichi NPP that began on 11 March 2011, the European Council requested that a comprehensive safety and risk assessment be performed on all EU nuclear power plants. The request included 'stress tests' to be performed at national level, supplemented by a European peer review. SSM participated in this process as a member of ENSREG's stress test peer review board.

SSM contributes to the work performed within 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 has taken active part in the development

[2] The WENRA Safety Reference Levels for Existing Reactors from September 2014 are available at: www.wenra.org.

of new international safety standards for protection against harmful effects of ionising radiation through the development of EU Basic safety standards and the development of the IAEA International Basic Safety Standards.

Apart from regulatory issues, SSM is engaged in a number of international research projects, mostly within the cooperation of the Nordic countries, the EU research programme, NEA and the IAEA. Sweden is also active in networks for research and cooperation in radiobiology, radioecology and biological dosimetry. Furthermore, SSM staff has been involved in many international expert missions, for example as experts in the IAEA review service teams IRRS, OSART and SALTO.

SSM is a member of the OECD/NEA Multinational Design Evaluation Programme (MDEP) launched by regulatory authorities to foster cooperation on the safety of new reactors.

International development and cooperation programmes

Sweden is, through SSM, involved in 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 its control in the region. The cooperation projects are mainly with Russia and Ukraine but there are also some projects with Georgia and Moldova. In 2015, SSM together with Finish and Norwegian authorities have had initial contacts with Belorussian authority to establish cooperation in areas of nuclear and radiation safety, mainly related to the construction of two nuclear reactors.

The programmes are based on Government decisions and are financed by the Ministry for Foreign Affairs, the Ministry of the Environment and Energy and Sweden's International Development Cooperation Agency. The total budget is on the order of 35 million Swedish kronor per year.

Utilities

The utilities in Sweden have traditionally been quite active in international cooperation to enhance nuclear safety by sharing experience, contributing to work on international regulation and guidelines and participating in safety assessments and peer reviews. This is today primarily accomplished through memberships in WANO, in owner's group associations of the major European and US vendors, and by participation in the Foratom initiative European Nuclear Installations Safety Standards, the European Utilities Requirements project, IAEA activities, and various task forces representing most of the disciplines of nuclear facilities. Both Vattenfall and Sydkraft NP have direct membership in WANO.

Swedish utilities and authorities have for a long time cooperated in international projects and research organizations. Particular examples are the Nordic Safety

Research Project (NKS)[3] – ongoing since 1977, and programmes and projects within EPRI and the NRC in the US and OECD and the EU in Europe.

ISOE (Information System on Occupational Exposure) is an example in the field of radiation protection, where Sweden is a member and an active participant from the perspectives of both utility and regulator.

European Nuclear Installations Safety Standards

Representing all Swedish nuclear licensees, Vattenfall was an active participant in 2005 when the European nuclear industry formed, under the Foratom organisation, the European Nuclear Installations Safety Standards, ENISS. ENISS has representation from all of the 17 European countries that have commercial nuclear power plants in operation.

The primary objective of ENISS was to create a forum for the European nuclear operators to prepare their position in interaction with WENRA. The aim of the initiative is to bring together decision makers and specialists from the industry with the regulators in an effort to establish safety targets, safety rules and measures and to achieve a set of common and harmonized European safety standards.

In addition ENISS reviews new or revised IAEA Requirements and Guidelines, TECDOCs and Safety Glossary. ENISS has in this aspect taken 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 normally the case before.

ENISS was also active in the review of the WENRA study "Safety Objectives for New Power Reactors" and the review of the 2014-update of WENRA Safety Reference Levels as well as Guidance Documents related to that update; i.e., WENRA Guidance Documents on Design Extension Conditions (Issue F) and Natural Hazards (Issue T).

European Utility Requirements

Vattenfall has been a member of the European Utility Requirements (EUR) group since 1996. EUR requirements have been used for assessing several new reactor designs and have also been used as technical specifications for several new build projects. They have also been reviewed by vendors and used by regulators.

The EUR group is currently going through some organisational changes and the need to modernize EUR requirements has been recognized. As a result of the Fukushima Dai-ichi accident, German, Italian and Swiss utilities recently put their participation on hold due the evolution of their respective national nuclear policies. On the other hand utilities with nuclear new-build programs have joined the organisation.

A first new revision of the EUR requirements, rev. D, was issued in 2012. Work on the next step started in 2013 and will be completed this year. The major changes in the new version will be a new safety chapter based on the European licensing environment, IAEA SSR 2-1 and the WENRA safety requirements. The new version will also include lessons learned from Fukushima Dai-ichi accident.

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[3] NKS (Nordic Nuclear Safety Research) is a forum for Nordic cooperation and competence in nuclear safety, including emergency preparedness, serving as an umbrella for Nordic initiatives and interests. It runs joint activities of interest to financing organisations and other end users producing seminars, exercises, scientific articles, technical reports and other types of reference material. The work is financed and supported by Nordic authorities, companies and other organisations.

Safety improvements in Swedish NPP

Measures to increase the level of safety at Swedish nuclear power facilities have gradually been taken in accordance with new knowledge and experience. New knowledge and experience have emerged from lessons learned from incidents and accidents, from research, from safety analyses and from new reactor designs. International accidents/ incidents such as the TMI nuclear power plant 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.

PSR were introduced in Sweden in the early 1980s 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. Another example is the Swedish regulations on design and construction of nuclear power reactors which were issued in 2005 (SSMFS 2008:17). They have resulted in extensive back-fitting and modernization programmes for all Swedish NPPs. Following the accident at Fukushima Dai-ichi in 2011, insights from the European stress tests have identified further areas of improvement that will be implemented in the upcoming years to strengthen the robustness of Swedish nuclear power reactors.

When the regulations in SSMFS 2008:17 (see Appendix 1), previously SKIFS 2004:2, entered into force in 2005, the transitional provisions provided the basis for the regulator's decision concerning reactor-specific modernization programmes, including a timetable for implementation of these programmes. For power plants commissioned in the 1970s extensive measures had to be taken in order to fulfill several requirements. At some plants the entire reactor protection systems have been replaced. At some plants redundant safety trains are being introduced in new buildings, strengthening residual heat removal and auxiliary power supply. Improved separation to strengthen protection against internal fire and flooding has also been one of the major activites at the older reactors.

In 2015, the modernization programs were completed at all reactors except of Oskarshamn unit 2. This unit is not foreseen to be restarted after being in long-term shutdown mode since 2013 (see Chapter A). The major safety improvements implemented in Swedish NPP between 1995 and 2015 are listed in Appendix 2.

In parallel with the modernization programs, during the period 2005–15 power uprates have been conducted or planned at seven out of the ten Swedish nuclear power reactors in operation.

In addition to safety improvements, the licensees have implemented extensive measures to comply with the regulations on security and physical protection (SSMFS 2008:12) issued in 2005. These measures are not described in this report.

Summary of actions taken following the Fukushima Dai-ichi nuclear power plant accident

Since the accident at Fukushima Dai-ichi NPP, a number of technical and administrative measures to increase the level of safety have been taken at Swedish nuclear power plants. These measures were mainly identified during the EU stress tests and in connection with investigative work linked to the licensees' international forum, WANO.

More than 60 measures have been completed so far. The measures implemented at each NPP site are relatively straightforward and feasible to take in the short term to prevent serious accidents and reinforcing the severe accident management including the emergency response organizations. No large-scale constructions work or organizational changes have so far been carried out as a result of the EU stress tests at any NPP. All reasonable and achievable/practicable technical and administrative measures identified following the EU stress tests shall be completed at the end of 2020.

- The following are examples of measures that have been taken at the NPP sites:
- Inspections, testing and verification
- Preparing documentation for impending technical updates
- Purchase of basic mobile equipment
    - Mobile illumination
    - Mobile battery chargers
    - Mobile air compressors
    - Head torches for control rooms
    - Construction fans
- Updates of procedures, routines and training programmes
- Updates of analyses
- Reinforcement of consequence-mitigating systems
- Reinforcement of firefighting services' capability to provide assistance in connection with severe accidents
- Agreements concluded with businesses and associations

In addition to the measures described, all licensees take part in and monitor ongoing international work and research in different areas related to the accident at Fukushima Dai-ichi NPP.

Furthermore, in 2014, SSM required that all Swedish nuclear power reactors operating after 2020 must have an additional and fully independent system for cooling of the reactor core in place before 2021. It was also required that any Swedish nuclear power reactor operating after 2017, must implement measures to reinforce the independence of the existing core-cooling function before 2018. The introduction of an independent core-cooling function strengthens the reactor's ability to prevent core damage for extreme events previously not included in the design basis. The independent core cooling function protects the plant against the events leading to the extended loss of normal auxiliary core cooling function.

These events consist mainly of failure of all the AC voltage and common cause failures in auxiliary core cooling function, which may arise due to extreme external influence.

The major safety improvements implemented in Swedish NPP between 1995 and 2015 are listed in Appendix 2.

EU stress tests

In 2011, the European member states preformed reassessments of the plant robustness and protection against extreme natural phenomena at all European nuclear power plants according to a specifications developed by the European Nuclear Safety Regulators Group, (ENSREG), the so called EU Stress test.

The result from the Swedish reassessments indicated the importance of completion of the modernization programs based on the requirements of SSMFS 2008:17, which at the time were still on-going. The assessments also clearly showed that the filters installed on the Swedish nuclear power plants in the 1980´s have a vital function in reduction of risk of radioactive releases following extreme natural phenomena. The results from the EU stress tests were used as a basis for developing a National Action Plans, and the Swedish National Action Plan (NAcP) was submitted to ENSREG in 2012. An updated NAcP, which describes the progress of the decided analysis and measures, was reported to the ENSREG in December 2014. The EU countries' updated action plans have been presented and reviewed at a workshop in Brussels in April 2015. In the observers' final report from this review, Sweden received favourable statements for having in place accident filters function; for having implemented the safety upgrading and for having documented a set of requirements for the introduction of the independent core-cooling function.

The NAcP contained actions to be completed by 2016. Licensees reported to SSM, on their completion of the NAcP, in December 2015. In 2015, SSM carried out plant-specific inspections in respect of the stress tests' National Action Plan.

Many of the measures listed in the NAcP highlights the need for further evaluations and reassessments. According to the NAcP, the outcome of these evaluations and reassessments is to result in reasonably practicable technical and/or administrative measures and licensees must report on the time schedule and implementation of such measures. SSM requires all technical and administrative measures related to the NAcP to be completed by 2020.

During the first half of 2016 the licensees submitted plant-specific implementation plans for reasonably practicable technical and administrative measures to be taken as a result of the item for action presented in the NAcP. Within the framework of the National Action Plan, SSM has also decided that the licensees shall report on implementation plans for the strengthened core cooling and safety measures that should be implemented by 2017, as well as for the permanent independent core cooling system to be introduced in 2020 at the latest.

As a result of the NAcP, all licensees have strengthened their emergency preparedness to deal with situations where several reactors at a site are affected simultaneously. Emergency organizations have been reinforced by internal resources and agreements with external actors. Additionally, the ability to handle situations that are protracted in time has been analysed for loss of external power supply up to three days after an extreme external event. To ensure electric power supply for these more prolonged courses of events, new mobile devices have been acquired, for example diesel generators that allow charging of batteries to ensure accident filter function also over the long-term.

Other enhancements that have been introduced include connection points to allow water supply from fire trucks and other mobile pumps. Exercises are carried out regularly on dealing with event scenarios, e.g. connection of new mobile equipment to be used for a prolonged extreme situation that might challenge reactor safety. Since Swedish reactor sites are located on the coast line, all licensees have strengthened the sites' resistance to extreme sea-water levels as well as extreme rainfall.

Implementation of the Vienna Declaration on Nuclear Safety

In respect of the principles to be followed as stated in the Vienna Declaration on Nuclear Safety (see Appendix 3) further information about the measures taken and fulfilment of the principles is available in sections B6, 7, 14, 17, 18 and 19.

Principles one and two

In order to prevent accidents, Swedish nuclear power reactors are designed and operated in accordance to the defence-in-depth principle, and in consideration of the approach to Design Extension Conditions. See further information in section B18.1.2.

All Swedish nuclear power reactors have filtered venting systems installed to mitigate releases of radionuclides causing long-term off site contamination and to avoid early radioactive releases or radioactive releases large enough to require long-term protective measures and actions. For further information see section B18.1.4.

Comprehensive and systematic safety assessments are carried out at least every ten years for existing installations throughout their lifetime, referred to as Periodic Safety Reviews (PSR). A PSR aims at ensuring compliance with the current design basis and current (modern) requirements, as well as identifying further safety improvements by taking into account developments in science and technology. Reasonably practicable safety improvements must be implemented in order to maintain the level of safety and to ensure that older facilities can achieve a level of safety that is as far as reasonably achievable and comparable to that of new nuclear facilities. See further information contained in section B7.1.2.2, B14.2.5 and B14.3.2.

In addition to the PSR, in order to maintain the level of safety and to ensure that older facilities can achieve a level of safety that is as far as reasonably achievable and comparable to that of new nuclear facilities, safety improvements are identified through analysis of operational experience (see further information contained in section B19.2.8), research and development, new knowledge and through the use of probabilistic safety analyses, PSAs. Sweden applies the concept of "Living PSA" which means that the PSAs are continuously used in enhancing and understanding plant safety status. A PSA is updated or modified when necessary to reflect any physical (resulting from plant modifications, etc.), operational (resulting from enhanced procedures, etc.) or organizational changes. It is documented in such a way that each aspect of the model can be directly related to existing plant information, plant documentation or the analysts' assumptions in the absence of such information. For further information regarding PSAs see section B14.2.3 and B14.3.1.

Principle three

Swedish national requirements are developed in consideration of relevant IAEA Safety Standards, EU legislation, WENRA reference levels, as appropriate, and other good practices. See also section B7.

Highlights and issues in the discussion about Sweden at the 6th review meeting held in 2014

The following observations and aspects were highlighted and documented by the rapporteur during the discussion about the Swedish national report:

- New legislation allows for replacement of existing reactors
- The review of the legislation on nuclear and radiation safety has been completed
- A complete review of SSM's regulations is ongoing
- The IAEA completed a full-scope IRRS mission at SSM's premises in February 2012, resulting recommendations have been addressed by SSM in an action plan
- Modernization and safety upgrades of the reactors are being continued
- Efforts to reduce radioactive releases to air and water continue; activity amounts as well as the resulting doses are relatively low

It was agreed that Sweden complied with the obligations of the Convention. The following item was highlighted as a good practice:

- Pre-defined criteria have been developed for automatic countermeasures in the acute phase of an emergency. In addition, Sweden and the other four Nordic countries have agreed upon what is referred to as "the Nordic Flag Book".

The following were mentioned as challenges for Sweden in the years to come:

- Completion of NPP modernization programmes
- Reviewing SSM's regulatory framework, i.e. regulations and general advice, for nuclear and radiation safety
- Implementation of the Swedish National Action Plan aiming to improve robustness and safety, including an update of dimensioning values related to external hazards and an additional independent core cooling system
- Ensuring safe long-term operation of Swedish NPPs requires additional safety improvements and licensee applying effective ageing management

Based on the presentation of its national report and the ensuing discussions Sweden received the following suggestion:

- Ensure that the Regulatory Body gets a legal basis for performing vendor inspections.

The suggestion has been reported to the Government. SSM has proposed to the Government that an amendment be made to the Act on Nuclear Activities (SFS 1984:3) so that it will include a requirement on the licensee to have agreements and other means in place, which will ensure that SSM will be able to conduct supervision of a licensee's quality assurance of design and manufacturing activities at suppliers' and manufacturers' sites (see section B7.1.2.7).

B. COMPLIANCE WITH ARTICLES 4 TO 19

4. 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 are discussed in this report.

5. 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 seventh Swedish report issued in compliance with Article 5.

6. 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.

Summary of developments since the last national report

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

- The extensive modernisation programmes introduced in 2005 for all Swedish NPP have been completed. The programmes were implemented in accordance with the requirements of regulations SSMFS 2008:17.
- The licensees finalized power uprating programmes of seven reactors and a minor uprating of one reactor. The uprate programmes added some 600 MWe to nuclear power capacity in Sweden.

6.1 Overview of major events since the last national report

Regarding the current review period it can be pointed out, that no events occurred indicating a serious degradation of safety and radiation protection at Swedish nuclear power plants. In total, one event was classified as Level 1 on the International Nuclear Event Scale (INES) during the period (see section B19.2). An overview of the most significant events during the period 2013–15 is provided below.

6.1.1 Emergency Diesel Generator failed to start after undetected loss of two phases on 400 kV incoming offsite supply

In June 2013, Forsmark NPP unit 3 was in a refuelling state with the reactor vessel head removed and spent fuel pool gates open. The unit is equipped with a 400 kV connection, with two parallel unit breakers, to the national grid, and a regional 70 kV backup grid. Due to maintenance, the 70 kV grid and one of the two unit breakers were disconnected.

There are four (4) safety trains in Forsmark unit 3. Trains A and B were verified for operation; trains C and D were operable but maintenance was ongoing. Relay protection testing was in progress for the main generator's excitation equipment. The testing device was attached incorrectly and an unintentional signal to open the 400 kV unit breaker was sent.

When the breaker went open only two phases opened and the third remained closed due to loose wiring. The safety bus bars were not disconnected so the phase failure could affect the safety bus bars on lower voltage levels. No undervoltage protection was activated because >65% voltage was still available but unbalanced, and the bus bars do not have phase unbalance protection, hence no signal to disconnect the safety bus bars and start the Emergency Diesel Generator (EDG) was activated.

The phase failure fed the unit and the components phase unbalance relay protection disconnected 146 components (safety and non-safety). Also, some non-safety motors were overheated and failed. Components vital for heat removal from the spent fuel pool and for cooling the EDGs tripped.

After approx. 16 min., EDG train B was manually started and the breaker from 10 kV ordinary grid and 10 kV EDG backup grid was manually opened. Thereafter, the sequence for energizing the bus bar worked as intended.

After that, consecutive manual start of EDGs and opening of breakers and local resetting of prioritized safety objects, e.g. cooling systems for EDG and residual heat removal systems, were fulfilled after approx. 35 min. The faulty unit breaker in the 400 kV switchyard was reconnected after 43 min. Local resetting of other objects was finished after approx. 90 min.

6.1.2 Reactor scram and containment isolation caused by seawater leakage into the reactor building

During the 10th and 11th of January 2015, there was a storm with a peak wind speed of 38 m/s on the west coast of Sweden. The westerly wind caused high seawater levels in the area where the Ringhals NPP is located. The highest measured sea level was about 140 cm above the normal level. The water flowing through the bedrock to the Ringhals unit 1 drainage system surrounding the reactor building increased. Strainers in drain lines between two drain systems were clogged by sediment, consequently the water level outside the reactor building's basement floor rose to 2.5 meters. A flooding hatch opened and the water flowed into the reactor building, which caused automatically actuated scram and containment isolation. All safety functions worked as designed. The event shows the importance of re-evaluating risks from often neglected peripheral systems, especially infrastructure systems, as the plant and organization shows their age.

Ageing problems might not only be technically related but also linked to challenges regarding knowledge management.

6.1.3 Corrosion in the bottom part of containment liner

In October 2014, a Containment Air Test (CAT) was performed at Ringhals unit 2. Increased leakage was identified during the CAT. The leak rate was 29.2 litres/hour. The leaking water was identified as coming from the lime water that Ringhals unit 2 has between the floor in the containment and the steel bottom liner. The leakage point was identified as a mechanical defect through the plate in one of the leakage measurement channels. The defect was assumed to be from repair of the toroid plates in 2005. Sediment from drilling was believed to have sealed the deficiency in the channel, and the pressure during the CAT might have cleared out the hole. The damaged area was the first site for drilling in the concrete during the repairs that took place in 2005. No routine for best practice was available and the steel plate in this position was directly underneath the concrete. The damage was repaired and a new CAT showed that the repairs were successful. During this work, some spots of corrosion were detected and further investigations were launched.

In December 2014, about 31 m^2 of the concrete were opened for inspection. Defects were found, most of them were less than 1 mm deep and the worst defect was 3.9 mm deep (the plate is 5 mm thick). In January 2015, another 148 m^2 of the concrete floor were opened for inspection and repair. . It has been a time-consuming effort to uncover the steel plate. In all approximately 45% of the bottom steel liner has been inspected. Damaged steel plate has been repaired and leak tested. Subsequently, re-casting of the concrete floor of the reactor containment has been carried out.

Investigations, analyses and discussions are still ongoing in early 2016. The mechanisms behind the corrosion as well as evidence of a leak tight seal are still not determined to the regulators satisfaction. The schedule for restart of Ringhals unit 2 is in September 2016, according to the utility, but decisions still depend on the results from the ongoing analysis.

6.2 Ongoing and planned safety improvement programmes for Swedish nuclear power reactors

The extensive modernization programmes introduced in 2005 for all Swedish NPPs have now been completed, with the exception of Oskarshamn unit 2 (see Chapter A). Oskarshamn unit 2 will be permanently shut down having been in long-term shutdown mode since 2013.

In summary, the safety measures that have been implemented as a result of the modernization programmes, mainly cover enhanced capability to control conditions that may 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 through the introduction of new and/or upgraded instrumentation and control equipment.

Measures planned to be implemented to increase protection against external hazards (earthquakes, flooding, etc.) were reassessed following the accident at

Fukushima Dai-ichi, within the EU's stress test exercise performed in 2012. Therefore, actions to be taken by the licensees to strengthen the plants protection against extreme external hazards are now covered by the EU stress test National Action Plan (NacP), see Chapter A, sections B17, B18. The NAcP is completed and measures to further strengthen the safety of the plants, identified by the evaluations and analysis covered by the NAcP, are required to be completed by 2020.

In 2015 licensees completed all necessary analyses covered by the NAcP. During the first quarter of 2016 licensees submitted to SSM plant-specific implementation plans for reasonably practicable measures identified by the evaluations and analysis covered by the NAcP.

Important measures identified by the NAcP include those for meeting the requirements for functionally independent core cooling. The purpose of such measures is to increase the reliability of the core cooling in a NPP by introducing a new and alternate independent function. Discussions regarding the introduction of functionally independent core cooling functions started already in the early of the 2000s. The need was later confirmed by the EU stress tests. Within the framework of the NAcP, SSM has decided that the licensees must report on detailed implementation plans for independent core cooling for the temporary safety measures that should be implemented by 2017, and for the final solution to be introduced in 2020.

The introduction of functionally independent core cooling functions strengthens reactor capabilities to prevent core damage during a number of extreme events that were, previously not covered by the safety analyses. The functionally independent core cooling functions 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 both may arise due to extreme external influence.

Comprehensive overviews of plant modifications performed in the past and implemented during current reporting period are presented in Appendix 2.

6.2.1 Regulatory control

SSM conducts, and will continuously conduct, supervision of licensees' implementation of safety improvements in the plants. This is to ensure that requirements are met and that the efforts to strengthen plant safety will maintain a continuous process.

6.3 Uprating programmes of Swedish nuclear power reactors

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

The power uprate programmes in Sweden included major power uprates of seven reactors and a minor power uprate of one reactor. The current power levels are shown in Table 3.

Reactor	Original power level		Current power level		State of operation
	Thermal	Electrical gross output	Thermal	Electrical gross output	
F1	2711	900	2928	984	Routine operation
F2	2711	900	3253	1120	Test operation
F3	3020	1100	3300	1167	Routine operation
O1	1375	460	1375	492	Routine operation
O2	1700	580	1800	661	See Chapter A
O3	3020	1100	3900	1450	Test operation
R1	2270	750	2540	910	Test operation[4]
R2	2440	785	2660	847	Routine operation
R3	2783	915	3144	1117	Routine operation
R4	2783	915	3300	1181	Test operation
Total	**24813**	**8405**	**28216**	**10079**	

Table 3: Power levels of operating Swedish reactors.
F = Forsmark, O = Oskarshamn, R = Ringhals.

A power increase can affect the facility in a number of different ways and to a varying degree, depending on the size of the increase. Conditions and parameters that might affect safety must therefore be identified and analysed in order to show that the safety requirements are met. A number of components and systems in the nuclear power plant must be verified as having a capacity corresponding to the higher power level. Planning as well as reviewing an uprating case are therefore important aspects that needs special attention to ensure that the safety of the plants is not influenced.

In its regulatory review of a power uprate application, SSM checks that the licensee is in compliance with all applicable safety requirements. An application for a power uprate is, in this sense, an opportunity to revise and verify the entire safety case. The Swedish licensing process is described in section B7.

Since the last report, the on-going power uprate processes have developed as follow:

- Forsmark unit 2 is still in test operation (since 2013) at the new power level. The licensee has performed the test program and the plant has continued operation with a steady state test period at the new maximum

[4] R1 is in test operation due to a plant modernization with major modifications. The application for routine operation after a small power uprate was reviewed and approved in 2010.

power level. The utility applied for routine operation in 2015. This application is currently under review by the regulator.

- The planned power uprate Oskarshamn unit 2 will not take place, because Oskarshamn unit 2 will be closed down, see Chapter A for further information.
- Oskarshamn unit 3 operates at the new power level and test operation is ongoing.
- Ringhals unit 4 started test operation in 2015 at the new power level.

6.4 Conclusion

Sweden complies with the obligations of Article 6.

7. Article 7: LEGISLATIVE AND REGULATORY FRAMEWORK

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

Summary of developments since the last national report

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

- A major review of SSM's regulations are under progress.
- SSM has issued new regulations concerning emergency preparedness at nuclear facilities SSMFS 2014:2 (replacing SSMFS 2008:15). SSM has also updated its regulations concerning safety in nuclear facilities SSMFS 2008:1 to comply with these new regulations.
- Sweden is currently transposing two EU directives in the area of nuclear safety and radiation protection into swedish legislation. SSM has presented to the Government its suggestions for national implementation of the revised nuclear safety directive and the new directive in the area of radiation protection. The Ministry of the Environment and Energy is preparing necessary legislative changes based on the proposals from SSM.

7.1 Nuclear safety legislation and the regulatory framework

7.1.1 Basic nuclear safety and radiation protection legislation

The following five acts constitute the basic nuclear safety and radiation protection legislation in Sweden:

- The Act on Nuclear Activities (1984:3),
- The Radiation Protection Act (1988:220),
- The Environmental Code (1998:808),
- The Act on the Financing of Management of Residual Products from Nuclear Activities (2006:647), and
- The Nuclear Liability Act (1968:45).

All acts are 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 is mainly concerned with issues of safety and security, while the Environmental Code regulates general aspects of the environment and the possible impacts of "environmentally hazardous activities", to which nuclear activities are defined as belonging.

The objective of the Radiation Protection Act is to protect people, animals and the environment from the harmful effects of radiation. The Act applies to radiation protection in general and, in this context, it provides provisions regarding workers' protection, radioactive waste management, and the protection of the general public and the environment.

The Act on the Financing of Management 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 that purpose have to be available when needed.

The Nuclear Liability Act 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 (SFS 2000:1064) and the Act on Inspections According to International Agreements on Non-proliferation of Nuclear Weapons (SFS 2000:140). Emergency preparedness matters are regulated by the Civil Protection Act (2003:778) and Ordinance (2003:789).

On 18 December 1997 the Swedish Parliament adopted the Act on the Phasing-Out of Nuclear Power (SFS 1997:1320), which came into force on 1 January 1998. The Act was part of the inter-party agreement on guidelines for energy policy, which was initiated by the Swedish Government in 1995 to create conditions for the efficient use and cost-effective supply of energy. Based upon provisions in this Act, the two boiling water reactors at Barsebäck were shut-down in 1999 and 2005, respectively.

On 23 March 2010, two different bills were sent to the Swedish Parliament: 2009/10:172 on the preconditions for generational change of nuclear reactors, and 2009/10:173 on the issue of increased liability for owners of nuclear power reactors. Parliament passed these bills in mid-June 2010. The main content of the legislative changes adopted by the Parliament is as follows:

- Authorisation to build and operate a new nuclear power reactor can be granted if it replaces an existing reactor, is built on a site with existing nuclear reactors in operation, and the replaced reactor unit is permanently shut down when the new reactor is operational. The legislative amendments to allow for replacement of existing reactors entered into force on 1 January 2011.
- The Nuclear Phase-Out Act (1997:1320) was annulled.
- Certain tasks concerning inspection and enforcement under the Environmental Code relating to nuclear activities and activities using radiation were transferred to SSM.
- Requirements on periodic safety reviews of the nuclear safety and radiation protection at a nuclear facility became mandatory by law. They

were previously regulated by SSM's regulations concerning safety in nuclear facilities (SSMFS 2008:1).

- Sweden will accede to the 2004 amendments of the Paris Convention and the Supplementary Convention on Liability. It has been decided that the Nuclear Liability Act (SFS 1968:45) will be replaced by a new act concerning liability. When this act enters into force, the owner of a nuclear facility will have unlimited liability and the owner of a nuclear reactor will be required to provide financial guarantees amounting to up to 1,200 million euros. The owners of non-reactor facilities will be required to provide financial guarantees of a minimum of 700 million euros. The Parliament has given the Government the powers to decide when the new liability legislation will enter into force.

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 as well as to the handling of nuclear material and nuclear waste.

The Act does not contain provisions concerning radiation protection and general provisions on environmental protection. This is regulated in a separate act and a separate code, the Radiation Protection Act (see section B7.1.3) and the Environmental Code (see section B7.1.4). 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.

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

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.

7.1.2.1 Basic requirements on nuclear safety

According to the Act, nuclear activities shall be conducted so as to meet safety requirements and fulfil the obligations pursuant to Sweden's agreements for the purpose of preventing the proliferation of nuclear weapons and unauthorised dealing with nuclear material and spent nuclear fuel.

Nuclear activities can only be conducted in accordance with a licence issued under the Act. The licence holder is fully responsible for the safety of every aspect of the operation. All safety measures needed in order to prevent a radiological accident shall be taken. As well as having a general responsibility to maintain safety, the licence holder is responsible for ensuring the safe handling and final storage of nuclear waste arising from the activity and the safe shut-down and decommissioning of plants in which nuclear activities are no longer conducted.

Safety in nuclear activities shall be maintained by taking all measures required to prevent errors in, or defective functioning of, equipment, to prevent incorrect handling or any other circumstances that may result in a radiological accident, and to prevent unlawful dealings with nuclear material or nuclear waste.

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

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

The holder of a licence for a nuclear activity has to ensure that all necessary measures are taken in order to maintain safety. These general requirements are supplemented by more detailed regulations issued by SSM (see below) and, if needed, licence conditions that the authority may issue in individual cases. The licensing conditions are imposed when a licence is issued. Licensing conditions can also be imposed during the period of validity of a licence.

7.1.2.2 Periodic Safety Review

According to the Act, an overall assessment of a nuclear facility's safety and radiation protection shall be conducted at least every ten years. These assessments shall aim at ensuring compliance with the current design basis and identifies further safety improvements by taking into account developments in science and technology. Reasonably practicable safety improvements shall 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.

7.1.2.3 Public transparency

It is considered very important to give the public insight into and information on nuclear activities. In municipalities where major nuclear facilities are located (power reactors, research reactors, and facilities for manufacturing, handling, storage or disposal of nuclear material or nuclear waste) it is particularly important that the residents are given correct and reliable information. For this purpose, so-called local safety boards have been established in those municipalities hosting nuclear power plants.

The licence-holder for a major nuclear plant is required to give the local safety board insight into the safety and radiation protection work at the plant. The licence-holder shall, at the request of the board, give the board information on the facts available and allow the board to study relevant documents and have access to plants and sites.

The function of the boards is to obtain insight into safety and radiation protection matters and to inform the public about these. It is therefore important to point out that the board is not supposed to impose requirements on, or to prescribe safety-enhancing or other measures for, nuclear plants. These functions rest exclusively with the regulatory authorities.

7.1.2.4 Licensing

All activities with nuclear installations require a licence. The system for licensing is further described in section B7.3.

7.1.2.5 Prohibition and revocation

A licence to conduct nuclear activities may be revoked by the authority issuing the permit if:

- conditions have not been complied with in some essential respect;
- the licensee has not fulfilled its obligations concerning research and development work on waste management and decommissioning, and there are very specific reasons from the 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 a 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.

7.1.2.6 Regulatory inspection

Compliance with the Act on Nuclear Activities and of conditions or regulations imposed pursuant to the Act is supervised by a regulatory body assigned by the Government. That body is SSM. If requested by SSM a licence-holder shall:

- submit all information and documentation necessary to perform the supervision; and
- provide access to a nuclear installation, or site for nuclear activities, investigations and taking of samples to the extent necessary to exercise.

SSM may decide on any measures, conditions and prohibitions necessary in individual cases to implement the Act on Nuclear Activities, or regulations or conditions issued as a consequence of the Act.

7.1.2.7 Provisions on the use of Contractors in Nuclear Operations

All contractors whom the licence-holders plan to use in nuclear operations need approval – upon application – from SSM. On 1 July 2006, stricter requirements on the use of contractors for nuclear activities entered into force. According to the current wording of Section 5 of the Act on Nuclear Activities (1984:3), two contractors at most are allowed to be involved in a specific task. This means that it is not possible to run a system where one general contractor has several sub-contractors.

According to Article 6 in Council directive 2014/87/EURATOM of 8 July 2014, amending Directive 2009/71/Euratom, member States shall ensure that the national framework requires that: (a) the prime responsibility for the nuclear safety of a nuclear installation rests with the licence-holder. That responsibility cannot be delegated and includes responsibility for the activities of contractors and sub-contractors whose activities might affect the nuclear safety of a nuclear installation. Based on this clarification of the prime responsibility for the nuclear safety, SSM has proposed the government change the current provisions of the law on nuclear activities so that it is in better harmony with the requirements of the Directive.

7.1.2.8 Enforcement of regulations, terms of licences and sanctions

The authorities have extensive legal regulatory and enforcement power. A licence may be revoked for activities that do not fulfil the obligations set out in the legislation. If there is an on-going licenced activity that does not comply with regulations or terms of the licence, the supervisory authorities may issue any injunctions and prohibitions required in the specific case to ensure compliance.

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

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

Regulations on civil liability for radiological damage are contained in the Atomic Liability Act (1968:45). The act is largely based on the contents of the Paris Convention on Nuclear Third Party Liability from 1960 and the Brussels Supplementary Convention from 1963, which Sweden has acceded to.

7.1.3 The Radiation Protection Act and Ordinance

Requirements for radiation protection are set out the Radiation Protection Act (1988:220) and in the Radiation Protection Ordinance (1988:293). The Act and the Ordinance entered into force in 1988. The purpose of the legislation is to protect people, animals and the environment against the harmful effects of radiation. Persons engaged in activities involving radiation are obliged to take the requisite precautionary measures. They are also responsible for the proper handling and disposal of the radioactive waste produced, which includes covering the costs associated with both the handling and disposal of the waste.

The Ordinance on Radiation Protection 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.

The Act applies to all activities involving radiation and these are defined to include 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 products and NORM). As far as nuclear installations are concerned, the Act and the Act on Nuclear Activities are applied in close association with each other.

The Government or the mandated authority may, so far it does not conflict with the purpose of the act, prescribe exemptions fully or partially from the application of the act. An exception can also be combined with special conditions. Furthermore specific conditions can be stipulated on radioactive substances or technical devices capable of generating radiation that are not otherwise covered by the act.

7.1.3.1 Basic requirements for radiation protection

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

- *Justification*: No activity is to be introduced until it has been shown to provide greater advantages than disadvantages to society. The basic principle of justification with regard to the management of nuclear and non-nuclear radioactive waste cannot be questioned at this stage. The waste has been generated as a result of previous decisions.
- *Optimisation*: All radiation doses to individuals, the number of exposed individuals as well as the probability of receiving doses, must be kept as low as reasonably achievable, taking into account economic and social factors. This is often called the ALARA principle (As Low As Reasonably Achievable)
- *Dose limitation*: The individual exposure to radiation (dose) must not exceed the established limits for the particular circumstances. The dose limit or dose constraint can be seen as a limit for optimisation; thus, the individual doses must not exceed the established limits, even if the collective dose would be reduced as a result.

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

General obligations of licensees and licence conditions

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

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

The provision implies that all measures should be taken to improve radiation protection; it is not sufficient only to follow regulations or conditions issued by the responsible authority. The Government or the authority assigned by the Government may also issue any further regulations required for protection against, or control of, radiation in the respects specified in the act.

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

7.1.3.2 Safe management and disposal of radioactive waste

Anyone who conducts activities involving radiation is required to treat and where necessary, dispose of the radioactive waste which may arise in the activity.

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

7.1.3.3 Environmental impact assessment

The Government or an authority appointed by the Government may, in licensing cases, prescribe that the applicant prepares an EIA (Environmental Impact Assessment) before permission is given. Such EIA shall be made in accordance with the rules in the Environmental Code (see section B7.1.4).

7.1.3.4 Licensing

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

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

7.1.3.5 Prohibition and revocation

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

7.1.3.6 Regulatory inspection

The Government assigns a regulatory body to supervise compliance with the Radiation Protection Act and licences and conditions issued in accordance with the Act. This body is the SSM. The SSM may decide on all measures necessary and all conditions and prohibitions required in individual cases to implement the Act, or regulations or conditions issued as a consequence of the Act. See also section B 8.3.

At the request of SSM, anyone who conducts activities involving radiation shall submit the information and provide the documents required for its supervision.

SSM should also be given access to the installation or site where the activities are conducted, for investigations and sampling, to the extent required for its supervision.

7.1.3.7 Enforcement of regulations, terms of licences and sanctions

The authorities have extensive legal regulatory and enforcement power. A licence may be revoked for activities that do not fulfil the obligations set out in the legislation. If there is an on-going licensed activity that does not comply with regulations or terms of the licence, the supervisory authorities may issue any injunctions and prohibitions required in the specific case to ensure compliance.

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

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

Liability under the Act is not adjudged if responsibility for the offence may be assigned under the Penal Code or the Act on penalties for Smuggling (2000:1225). Nor is liability adjudged in the instance of a minor offence to be a trivial case. The police authority shall provide the necessary assistance for supervision.

7.1.3.8 Public information about radiation protection

One of the authority's missions is to inform society about radiation protection issues. An education centre was established in 2004, which teaches courses in the area of radiation protection.

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
- any use of land, buildings or structures that may be detrimental to the surroundings due to noise, vibration, light, ionising or non-ionising radiation or similar impact.

7.1.4.1 General rules of consideration

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

- The knowledge principle means that the implementer must possess the knowledge that is necessary regarding the nature and scope of the activity to protect human health and the environment against damage or detriment.
- The precautionary and BAT (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 available 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.

7.1.4.2 Licensing

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 B7.3.

7.1.4.3 Prohibition and revocation

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

7.1.4.4 Regulatory inspection

The purpose of supervision shall be to ensure compliance with the objectives of this Code and rules issued in pursuance thereof. For this purpose, the supervisory authority is to supervise compliance with the provisions of the Environmental

Code and rules, judgements and other decisions issued in pursuance thereof and take any measures that are necessary to ensure that faults are corrected. SSM supervises radiation safety matters under the Code.

By an amendment made on May 8, 2013 to the Ordinance on environmental inspection and enforcement under the Environmental Code, SSM is to provide regulatory guidance regarding supervision of pollution damage and other environmental damage caused by radioactive substances. The Swedish Environmental Protection Agency manages a national programme on remediation of contaminated land from past practices. Potentially contaminated areas are identified, investigated and classified. No area has yet been identified for remediation in respect of radioactive substances. However, the identification of potentially contaminated areas is an ongoing process. The amendment of the Ordinance should ensure that radiological impacts are given higher priority in the process of identifying contaminated sites for remediation.

7.1.4.5 Enforcement of regulations, terms of licences and sanctions

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

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

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

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, Chapter 2–3 in 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 in 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, the Swedish Radiation Safety Authority (SSM), issues legally binding safety and radiation protection regulations for nuclear facilities in its Code of Statutes SSMFS. SSM reissued all earlier regulations in the SSMFS series in 2008 when SSM was established and the Swedish Nuclear Power Inspectorate (SKI) and the Swedish Radiation Protection Institute (SSI) were merged into the new authority. All relevant regulations are listed and described in Appendix 1.

In addition, general advice on the interpretation of most of the safety regulations is issued. The general advice is not legally binding per se, but cannot be ignored by the licensee without risking actions by the regulatory body. Measures should be taken according to the general advice or, alternatively, methods justified to be equal from the safety point of view should be implemented. The regulations and the general advice, listed and described in Appendix 1, all entered into force on February 1, 2009 or later.

SSM's regulations also implement binding EU legislation and international obligations. In preparing SSM's regulations, IAEA safety standards, international recommendations, industrial standards and norms, and the rule-making of other Swedish authorities are considered. The SSM regulations are issued according to an established management procedure which stipulates technical and legal reviews of the draft. In accordance with governmental rules, a review of the final draft by authorities, licensees, various stakeholders, and industrial and environmental organisations is performed.

7.2.2 Changes to the Code of Statutes SSMFS

In January 2015 new and revised regulations concerning emergency preparedness at nuclear facilities SSMFS 2014:2, entered into force. The new and revised regulations includes requirements regarding planning of emergency preparedness and radiation protection measures in case of an emergency or a threat of an emergency at nuclear facilities. An important motive for the new and revised regulations was to integrate some of the lessons learned from the 2011 Fukushima Dai-ichi accident, and to ensure consistency between the Swedish regulations on emergency preparedness at nuclear facilities and the IAEA safety standards as well as the European basic safety standards for protection against the dangers arising from exposure to ionising radiation (EU BSS).

The new regulations aim at improving the licensees' arrangements and provisions to cope with severe accidents, including improving the functionality of the onsite operational support centre (the site emergency control centre), provisions for communications with other parties involved, endurance during any long and protracted course of events, provisions for multi-unit events, as well as personal safety during severe conditions. As with previous regulations, these regulations also address alarm criteria and alerting, emergency facilities, evacuation plans, training and exercises and other issues related to emergency preparedness (e.g. iodine prophylaxis, personal protective equipment, monitoring, ventilation filters, meteorological data).

In addition to the new and revised regulations in SSMFS 2014:2, amendments were made in 2014 to the regulations concerning safety in nuclear facilities, SSMFS 2008:1. In the new revision of SSMFS 2008:1 requirements and general advice in Chapter 2, sections 12 to 13 are repealed by SSMFS 2014:2.

7.2.3 Major revision of the Authority's regulations

In 2013 SSM began a comprehensive and thorough review of its Code of Statutes. The main reasons for initiating this review were as follows:

- In June 2012, an application was submitted to SSM by Vattenfall for permission to replace old nuclear power reactors with new nuclear power reactors. Existing regulations are developed for operating NPPs and new nuclear power reactors were not being considered at the time when these regulations were developed and issued.
- SSM's own application experience has demonstrated the need to clarify and supplement the regulations in order to create more predictability for the licensees and improve the regulatory support for SSM in its supervisory activities. These clarifications and additions are necessary in a situation where continuing safety modernisation of the existing nuclear power plants will take place and where the plants now gradually enter into 'long-term operation' (LTO). The regulations also need to be revised to encompass experiences from the Fukushima Dai-ichi NPP accident and subsequent stress tests of Swedish nuclear power plants.
- The IRRS mission report to Sweden in spring 2012 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. This is now one important part of the SSM action plan to deal with recommendations and suggestions from the IRRS review.

The work is conducted in two projects; one focusing on the regulations on safety and security of nuclear facilities, one focusing on safety and security in the use of ionising and non-ionising radiation in other parts of society. The work also includes the formulation of basic safety and security rules that will be common to both nuclear installations other licensable activities with radiation.

The structure adopted for the new Code of Statutes means that the safety and security of nuclear installations will be regulated partly for different stages of a plant's life and partly for main types of specific radiation safety aspects. The regulation will also be made on the "three levels":

1. common to all activities involving ionising radiation
2. on plant level for nuclear installations
3. more specific safety and security aspects.

In this way there will be a gradual specification of the requirements, from generally kept at level 1 to more specific at level 3, in a similar way as IAEA and many other radiation safety agencies have built up their rule package.

Important starting points for the work are the applicable Swedish and European legislation in the field, the current SSM rules and lessons learned from application in licensing and supervision activities. Other important starting points are as far as possible to relate to the IAEA's "Fundamentals", "Requirements", "Safety Guides" and "Security Series". There are several reasons for this. One is that these standards are of high quality and are produced in a process in which many international experts in various disciplines are involved. This makes the standards well-founded. Another reason is that some of these standards are the basis for the so-called reference levels ("Reactor Safety Reference Levels") that have been developed through inter-agency cooperation within WENRA, and that SSM has undertaken to comply with.

The work to revise SSM's regulations will be an ongoing process for many years.

7.3 Licensing

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

New nuclear facilities and modifications that are subject to authorisation on the part of existing facilities 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 will process the matter under the Act on Nuclear Activities, and to the environmental court, which will process the case under the Environmental Code. Applications are to be accompanied by an environmental impact assessment under Chapter 6 of the Environmental Code. Figure 3 below shows a schematic illustration of the licensing process for the construction of a new nuclear facility and how related review and licensing tasks are assigned.

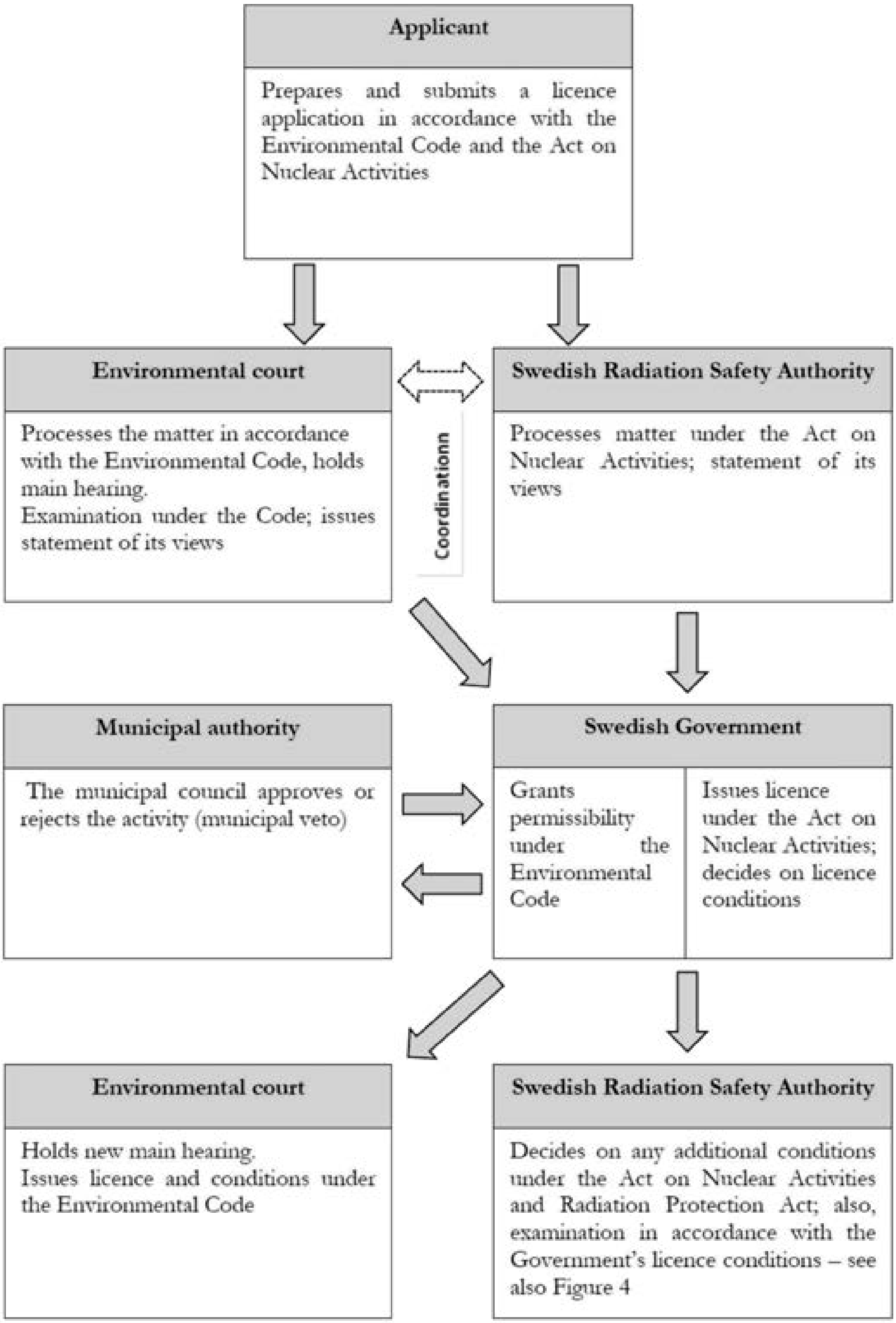

Figure 3: Schematic illustration of the licensing process for a new nuclear facility.

7.3.1 Environmental Impact Assessment (EIA)

During the licensing process, an important instrument is the Environmental Impact Assessment (EIA). Swedish EIA legislation is in accordance with the Council Directive 85/337/EEC of 27 June 1985, amended by Council Directive

97/11/EC of 3 March 1997 and by Directive 2003/35/EC of 26 May 2003, on the assessment of the effects of certain public and private projects on the environment. An EIA is to be submitted together with an application for a permit for environmentally hazardous activities. An EIA must also be submitted at the prospect of the decommissioning of nuclear facilities.

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

An environmental impact statement must have the following content:

- a description of the activity or measure including details of its location, design and scope;
- a description of the measures being planned with a view to avoiding, mitigating or remedying adverse effects, for example, action to prevent the activity or measure leading to an infringement of an environmental quality standard;
- the information that is needed to establish and assess the main impact on human health, the environment and management of land, water and other resources that the activity or measure is likely to have;
- a description of possible alternative sites and alternative designs, together with a statement of the reasons why a specific alternative was chosen and a description of the consequences if the activity or measure is not implemented; and
- a non-technical summary of the information.

In the EIA process, the implementer must consult with the county administrative board at an early stage. They shall also consult private individuals who are likely to be affected by the planned activity, and must do so in good time and to an appropriate extent before submitting an application for a permit and preparing the environmental impact statement. Prior to consultation, the implementer must submit information to the county administrative board and to any private individuals affected about the location, extent and nature of the planned activity and its anticipated environmental impact.

If the county administrative board decides that the activity or measure is likely to have a significant environmental impact, an environmental impact assessment procedure shall be performed. In such a procedure, the person who intends to undertake the activity or measure must consult with the other government agencies, the municipalities, the citizens and the organisations that are likely to be affected.

The consultation shall relate to the location, scope, design and environmental impact of the activity or measure and the content and structure of the environmental impact statement.

7.3.2 Consultation with other countries

If an activity is likely to have a significant environmental impact in another country, the responsible authority as designated by the Government shall inform the responsible authority in that country about the planned activity. This is 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. Such information shall also be supplied when another country that is likely to be exposed to a significant environmental impact so requests.

7.3.3 Permissibility

According to the Environmental Code, as a step licensing process, the Government is to consider the permissibility of certain activities such as facilities for nuclear activities under the Act on Nuclear Activities. An environmental impact statement must be submitted for the permissibility assessment. The Land and Environmental Court review an application on 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 activities may be located in the municipality (municipal veto).

7.3.4 Licensing approval

If the Government grants permissibility according to the Environmental Code, licensing approval needs to be issued for the nuclear activity according to the Act on Nuclear Activities and for the environmentally hazardous activity according to the Environmental Code. The Government (or the authority appointed by the Government) grants a licence in accordance with the Act on Nuclear Activities.

The application is reviewed by the regulatory authority assigned by the Government (SSM) and forwarded thereafter for a Government decision. A licence under the Radiation Protection Act is not required for activities covered by the Act on Nuclear Activities. Following a Government permissibility decision, the Land and Environmental Court grants a licence and issues conditions on environmentally hazardous activities under the Environmental Code. The Land and Environmental Court's judgement when granting a permit 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 Environmental Court. At that hearing, all interested parties may attend and comment, also too may the relevant authorities. The applicant must verbally describe all relevant aspects of its case. Questions can be submitted during the proceedings.

SSM may issue conditions under the Act on Nuclear Activities and the Radiation Protection Act in a step-wise authorisation process following a Government licensing decision.

7.3.5 Statements of views from public authorities and other organisations in Sweden

The Nuclear Activities Ordinance states that when the Swedish Radiation Safety Authority processes an application being considered by the Government, this shall involve the Authority obtaining the statements of views necessary, while providing its own statement, for the documents delivered in the matter to the Government. This means that such application, together with the environmental impact assessment and suitable reports summarising the application documents, are to be sent to the relevant Swedish authorities. Relevant authorities usually include the following:

- The relevant county administrative board
- Relevant municipal authorities
- The local safety board for the relevant facility (when the matter pertains to a nuclear facility)
- The Swedish Environmental Protection Agency
- Licensing work and examination of licence conditions as regards nuclear facilities and other complex installations where radiation is used
- The Swedish Civil Contingencies Agency (MSB)
- The Swedish Work Environment Authority
- The Swedish Board of Fisheries
- The relevant police authority
- Svenska Kraftnät (when the matter involves facilities producing power for the Swedish national grid)

7.3.6 Swedish Radiation Safety Authority's Review Opinion of an Application

Section 24 of the Nuclear Activities Ordinance stipulates that a licence application under Chapter 5 of the Act on Nuclear Activities must be made in writing and submitted to the Swedish Radiation Safety Authority.

The Swedish Radiation Safety Authority shall determine the matter in accordance with the Act on Nuclear Activities on the basis of the fundamental safety requirements under this Act, and the fundamental radiation protection requirements under the Radiation Protection Act, as well as the regulations describing these requirements in detail. An assessment also needs to be made on fulfilment of the general rules of consideration as per Chapter 2 of the Environmental Code. Underlying documentation to be assessed includes the environmental impact assessment submitted, in addition to an initial preliminary safety analysis report, together with technical and other reports concerning the planned facility and its operation that are to be attached to the application. During its preparation of the matter, the Authority needs to consider whether the activity is likely to be located, designed and conducted in a way fulfilling requirements imposed on safety as well as on radiation protection and physical protection. Also, the Authority needs to assess fulfilment of the general rules of consideration under the Environmental Code.

The legal preparatory work for the environmental legislation states that examination by the environmental court under the Environmental Code is presupposed to take place in parallel with licensing work by the Swedish Radiation Safety Authority under the Act on Nuclear Activities and that the expert authority's review from such consideration under the Act is available when considering matters under the Environmental Code.

Based on reviews of application documents, possible own investigations and analyses, in addition to statements of views received in a matter, the Swedish Radiation Safety Authority is to adopt a standpoint as to whether the activity can be located, designed and conducted in a way so that the requirements imposed on safety and radiation protection as well as the general rules of consideration can be fulfilled. This standpoint is subsequently documented as part of an assessment report and statement of views together with the justifications behind the Authority's final assessment. This statement must also include an opinion as to whether the environmental impact assessment conducted by an applicant fulfils the requirements imposed by Chapter 6 of the Swedish Environmental Code and whether the environmental impact assessment has been conducted in accordance with the procedures stipulated in the same chapter of the Code. The statement of views is also to include an opinion of the applicant's account of its fulfilment of the general rules of consideration. The statement must also contain a summary of the views of other organisations and the general public that have been received in the matter.

If the Swedish Radiation Safety Authority approves the application and proposes that the Government grant the licence under the Act on Nuclear Activities, the Authority 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 the Authority.
- The facility may not commence test operation prior to approval by the Authority.
- The facility may not commence regular operation prior to approval by the Authority.

This statement of views, together with the assessment report upon which this is based, are subsequently delivered to the Government via the Ministry of the Environment, enclosed with:

- the application and application documents,
- statements of views from authorities, other relevant organisations, the general public as well as the Commission in cases where the matter is subject to Article 37 of the Euratom Treaty.

7.3.7 Principles for step-wise review processes

When applying licence conditions a continued review, while constructing new facilities and during modifications of existing facilities subject to authorisation, will consist of the following main steps:

1. Review and decision-making in connection with approval of a more advanced preliminary safety analysis report (SAR) compared to the first report attached to the licence application as a basis for detailed design and construction of a new facility or a modification of an existing facility subject to authorisation. (See also section 6.2.) This review checks whether the Authority's regulations concerning safety, radiation protection and physical protection, and having a bearing on design and construction, can be fulfilled.
2. Review of organisational, human and administrative resources for procuring devices and carrying out facility work to the extent necessary and having the standard implied by the preliminary SAR approved by the Authority. This step also includes reviewing measures taken for physical protection during the construction phase and reviewing preliminary plans for future decommissioning of the facility. These reviews serve as the basis of the Authority's decision-making in terms of whether to grant approval to begin construction of a new facility. This is followed by continual follow-ups of facility work as part of the input for issues to be decided in the subsequent steps.
3. Review and decision-making in terms of whether to grant approval of an updated SAR reflecting the facility as it was constructed or modified and demonstrating how the requirements imposed have been fulfilled. This step also includes reviewing the Operational Limits and Conditions (OLCs) and procedures to guide the working staff as well as reviewing test operation programmes and reviewing training programmes for working staff. This includes reviewing plans for physical protection and emergency preparedness in the event of abnormal operation and accidents. These reviews serve as the basis of the Authority's decision-making in terms of whether to grant approval to begin a facility's test operation. This is followed by continual follow-ups of test operation as part of the input for issues to be decided in the subsequent steps.
4. Review and decision-making in terms of whether to grant approval of a SAR that has been supplemented with experience gained from test operation, and the first refuelling and maintenance outage in the event this is applicable. Other components include reviews of the OLCs and procedures supplemented by experience gained from test operation. These reviews serve as the basis of the Authority's decision-making in terms of whether to grant approval for regular operation.

This process is illustrated schematically in Figure 4.

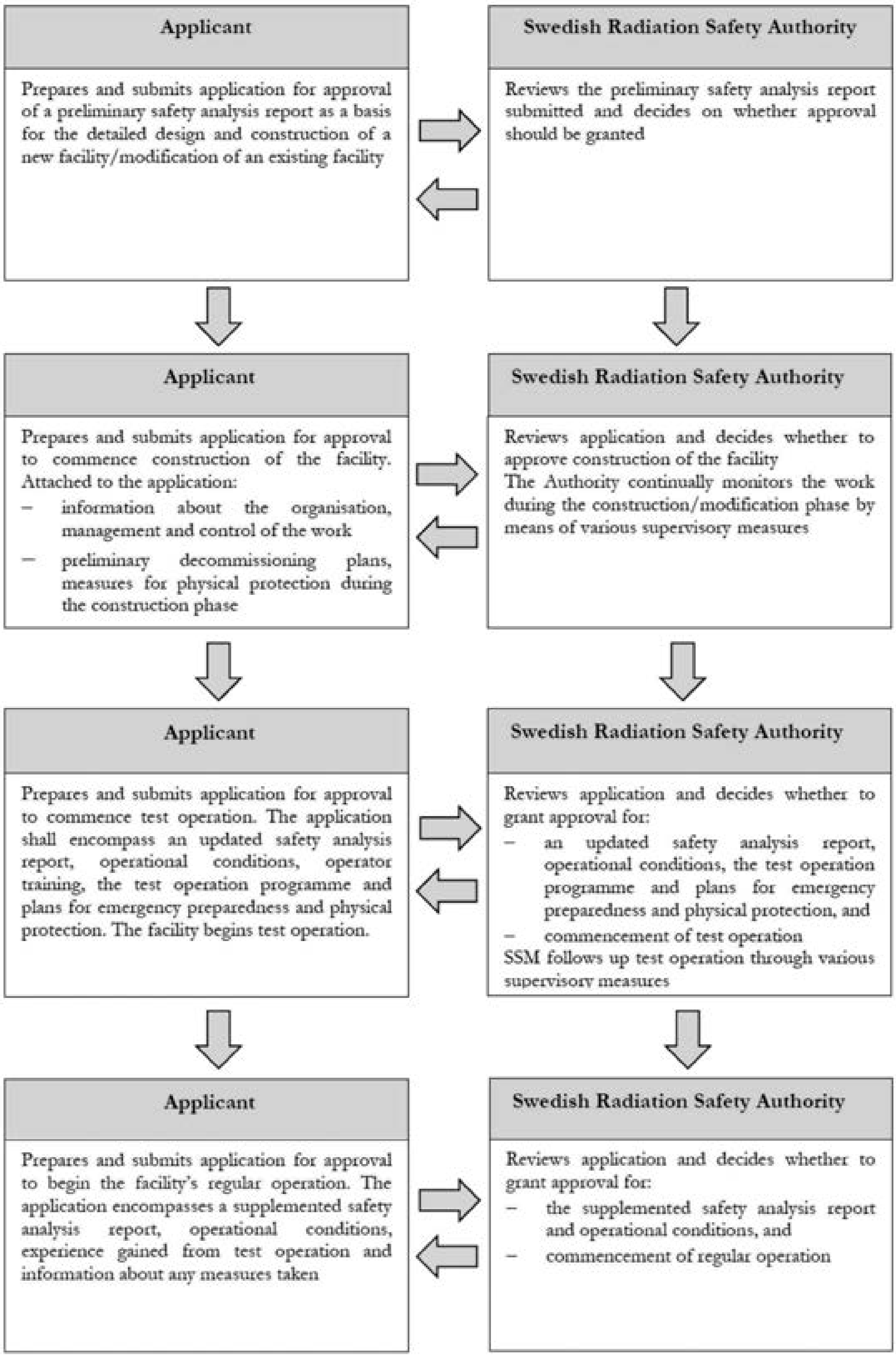

Figure 4 Schematic illustration of the step-wise review process.

7.4 EU legislation

7.4.1 The European Nuclear Safety Directive

On 25 June 2009 the 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 as well as addressing the safety of the entire lifecycle of nuclear installations (siting, design, construction, commissioning, operation and decommissioning of nuclear plants), including on-site emergency preparedness and response.

The amended directive further strengthens the independence and role of the national regulatory authorities, and enhances transparency on nuclear safety matters and the provisions on the information to be provided to the general public are more specific. As the consequences of a nuclear accident can go beyond 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 introduces a new concept for exchange of experiences through its provisions on topical peer reviews to be performed on the nuclear installations at least every six years, starting in 2017.

Sweden has transposed the Council Directive 2009/71/Euratom issued in 2009, into the national regulatory framework. A report on the implementation was submitted to the European Commission 22 July 2014. Implementation of the amended directive in the Swedish national regulatory framework is in progress. A report on the implementation of the amended directive is to be submitted to the European Commission by 22 July 2020.

7.4.1.1 Implementation of the amended directive in the national regulatory framework

On 13 November 2014 the government appointed the SSM to perform an analysis of the amended Council Directive 2014/87/Euratom to identify necessary amendments to the Swedish regulatory framework to ensure a consistent approach to implementation. SSM was also asked to assess the need for other potential measures necessary for the implementation of the directive.

On 26 November 2015 SSM published its proposals and submitted the report to the Government. In the proposals SSM suggests that the amended directive should be implemented in the Swedish regulatory framework by amendments to the Act on Nuclear Activities (1984:3) and to current regulations or alternatively in the new regulations that are under development. The Ministry of the Environment and Energy is preparing necessary legislative changes based on the proposals from SSM. Sweden intends to transpose the directive into Swedish legislation at latest August 2017, in line with the transposition requirements in the directive.

7.4.2 The European basic safety standards for protection against the dangers arising from exposure to ionising radiation

On 5 December 2013 the 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 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
- strengthened requirements on emergency preparedness and response incorporating lessons learnt from the Fukushima accident

The new directive incorporates the 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).

Implementation of the new directive in the Swedish national regulatory framework is in progress. According to the directive, EU member states have to implement the directive into their national regulatory framework by 6 February 2018.

7.4.2.1 Implementation of the new directive in the national regulatory framework

On 20 March 2014 the government appointed SSM to perform an analysis of the Council Directive 2013/59/Euratom to identify necessary amendments to the Swedish regulatory framework to ensure a consistent approach to implementation. SSM was also asked to assess the need for other potential measures necessary for the implementation of the directive.

On 28 January 2016 the government extended the scope for the SSM assessment to include a consultative process where SSM was asked to refer its proposals to authorities, agencies and organisations that may be affected by the proposals, and to report to the Government a summary of respondents' views. SSM will also respond to comments received during the consultation and clarify whether SSM considers that adjustments to its original proposals are justified.

On 12 February 2016 SSM published its proposals and initiated the consultation process. In the proposals SSM suggests that the new directive should be implemented in the Swedish regulatory framework by an amended Radiation Protection Act and new regulations. The Ministry of the Environment and Energy is preparing necessary legislative changes based on the proposals from SSM. Sweden intends to transpose the directive into Swedish legislation at latest February 2018, in line with the transposition requirements in the directive.

Furthermore, the new directive must not only be transposed in national legislation but also put into practise. The importance of practical implementation has been highlighted following the Fukushima Dai-ichi nuclear accident and over recent years international meetings have been arranged to analyse safety work where it has been concluded that rather than faltering in the formulation of the safety requirements it has been the practical implementation of these which has been lacking. Thus, there is broad international consensus on the importance of, over the next few years, focusing on the practical implementation of the new Basic Safety Standards rather than urgently amending or renewing them. This work will include establishing guidance on the implementation of the requirements at workplaces and facilities. To support the implementation SSM, as a national authority, will renew and establish practical advice on the policy behind the new requirements and their practical implementation.

7.5 Openness and transparency

In line with the Aarhus Convention Sweden has in its legal framework provisions on access to information, public participation in decision-making and access to justice.

According to the Swedish Constitution there are also provisions on public access to official records (see section 7.1.5. 8.1.1). This means that all (public) documents submitted to, sent out from or drawn up by the authorities are public. Anyone can ask the authority to gain access to these documents. However, some information in the documents could be confidential and hence will not be disclosed. In such cases, the authorities must state on what ground this information, it is confidential. The authority's decision not to disclose certain documents because of confidentiality can be appealed against in two ways, through the General Administrative Court (Kammarrätt) and the Supreme Administrative Court.

The public is also guaranteed, under EIA provisions, opportunities to access information and make comments on planned activities and facilities applied for. The provisions require consultation (in addition to municipalities and authorities) with the concerned public and environmental organisations.

Decisions by the Land and Environment Court or authorities in various cases can be appealed against by the party concerned and also by environmental non-governmental organisations (those that have existed for 3 years and have at least 100 members).

The Government's decision on permissibility under the Environmental Code (see section B7.1.4) and license under the Act on Nuclear Activities (see section B7.1.2) cannot be appealed against. Under certain conditions, the Supreme Administrative Court could examine whether a decision by the government is contrary to any rule of law (judicial review). There is no examination of the case in substance but whether the decision has been taken in the correct order.

7.6 The WENRA Reactor Harmonisation Project

The reports of the WENRA Reactor Harmonization Project, issued in 2006, and updated in January 2008 and in September 2014, can be found on the WENRA website (www.wenra.org).

The 2014 review of the 2008 version of the WENRA Reference Levels (RLs) for existing reactors is based on lessons learned from the accident at Fukushima Dai-ichi Nuclear Power Plant. This review covered the whole set of RLs, taking into consideration recommendations and suggestions published by ENSREG as a result of the complementary safety assessments performed in Europe following the accident as well as IAEA safety requirements being updated for the same reason and the conclusions of the 2nd Extraordinary Meeting of the Contracting Parties to the Convention on Nuclear Safety. WENRA made the updated reference levels available for stakeholder consultation, prior to their finalization.

WENRA members are currently carrying out benchmarking and peer reviews of the national implementation of the revised WENRA Reference Levels (RLs). The next step will be to prepared national action plans on measures needed to align the national requirements and corresponding implementation measures at the nuclear power plants with the reference levels. It was agreed to align the legislation with the reference levels by 2017.

7.7 Regulatory inspection and assessment

See section B8.3

7.8 Vienna Declaration on Nuclear Safety

This section, in reference to Article 7, describes how Sweden implements the third principle of the Vienna Declaration on Nuclear Safety.

In section B7.1 the basis for the SSM regulations are described. In section B7.2 the ongoing comprehensive review of the SSM regulations is presented. One of the objectives for this ongoing review is to ensure that IAEA Safety Standards are more systematically referenced and used as a basis for the SSM regulations.

7.9 Conclusion

Sweden complies with the obligations of Article 7.

8. 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 national report

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

- The increase in SSM staff halted as the planned new-build in Sweden was put on hold and an early retirement scheme was implemented at SSM.
- SSM has improved its work with ensuring long-term human resources needs and the planning of recruitment and internal staff training.
- The subsequent licensee decisions in 2015 on stepwise phase-out of four Swedish reactors will have impact on staffing needs and work load of the Authority.
- Inspection policies and routines were updated and a harmonization of procedures between different supervisory areas occurred. SSM is now able to pursue a more proactive oversight in areas were earlier resources were lacking (maintenance, PSA, severe accidents, electricity and I&C).
- A follow up of the 2012 IRRS mission is scheduled to take place in Sweden in April 2016. In February 2016 SSM presented a report regarding the actions taken to follow up on the 2012 IRRS recommendations and suggestions.

8.1 The regulatory body and its mandate

8.1.1 General

The Swedish Radiation Safety Authority (SSM) was established on July 1, 2008. SSM took over the responsibility and tasks from the Swedish Nuclear Power Inspectorate (SKI) and the Swedish Radiation Protection Institute (SSI) when these were merged into the new authority. SSM works towards protecting people and the environment from harmful effects of radiation, now and in the future. The main motive for the merger was to strengthen and reinforce the supervision of both nuclear and non-nuclear activities, relating to nuclear safety and radiation protection, but also a general ambition by the Government to make civil service more efficient by reducing the number of administrative authorities.

The mission and tasks of SSM are defined in an ordinance with instructions for the authority and in the annual government appropriation directions, containing detailed objectives and reporting obligations. Other authorities with supervisory responsibility for the nuclear power plants are the Swedish Civil Contingencies Agency (MSB), the Swedish Work Environment Authority, the Nuclear Waste Fund, and the National Electrical Safety Board.

SSM is a central administrative authority reporting directly to the Minister of Environment. According to the Swedish constitution, the administrative authorities are effectively independent within the legislation and statutes given by the Government. An individual minister cannot 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 Director General of the Swedish Radiation Safety Authority is appointed by the Government, normally for a period of six years. SSM has no board; the Director General is exclusively responsible and reports the authority activities directly to the Government. The authority has an advisory council with a maximum of ten members which are appointed by the Government. Those are usually members of the 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 are 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* (SFS 2009:400). The reasons for secrecy might be due the interests of national security, international relations, commercial relations, or individuals' right to privacy. The Act clearly states that there is no needs to justify a wish to see a public document or to reveal her/his identity to have access to a document.

As all Swedish authorities, SSM issues an annual report and financial statement, submitted to the Government, which summarize major results, effects, revenues and costs. The Government carries out follow-up work and evaluates the agency's operations based on this 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 publically available; most of them are available for downloading from the SSM website.

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

8.1.2 The Swedish Radiation Safety Authority (SSM)

SSM's missions and tasks are defined in the Ordinance (SFS 2008:452) with instructions for the Swedish Radiation Safety Authority and in annual appropriation directions. In the latter, the Government issues directives for authorities including 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 shall work actively and preventively to promote high levels of nuclear safety and radiation protection in the society and, through its activities, act to:

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

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

SSM shall deal with financial issues connected with the management of radioactive wastes from nuclear activities. The Authority informs the Nuclear Waste Fund about the size of payments and disbursements from the fund, planned or forecasted, by each reactor operator or other relevant licensee, and of SSM's own activities regarding financing issues, so that the Nuclear Waste Fund can fulfil its tasks[5].

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

SSM shall furthermore:

- Take measures to fulfil Swedish obligations according to conventions, EU-ordinances/directives, and other binding agreements,
- Supervise that nuclear material and equipment is used as declared and in manner that agrees with the international commitments,
- Carry out international cooperation work with national and multinational organisations,
- monitor and contribute to the progress of international standards and recommendations,
- Coordinate activities needed to prevent, identify and detect nuclear or radiological emergencies. SSM shall organise and lead the national organisation for expert advice to authorities involved in, or leading, rescue operations,
- Contribute to the national competence development within the authority's field of activities,

[5] *The Nuclear Waste Fund* is a government authority which manages the fees paid by the power companies and the owners of other nuclear facilities in Sweden.

- Provide data for radiation protection assessments and maintain the competence to predict and manage evolving issues, and
- Ensure public insight into all the authority's activities.

The annual appropriation directions focus more on short-term issues and funding of the authorities' activities. In the latest appropriation directions, dated December 18 2015, SSM was among other things assigned to:

- Report on the measures the authority has taken or plans to take in order to ensure that the supervision of the ageing nuclear power plants, i.e. operated or intended to be operated beyond the originally foreseen operation period, include assessments on how these facilities meet the latest safety requirements and that their operation do not constitute increasing risks for human beings and the environment. In the report the authority shall describe carried out, or planned supervision activities to control that design, construction and verifying safety analyses for these power reactors account for the latest safety knowledge and experience and are that the analyses are applicable for the assessed facilities. The task shall be reported latest on October 6, 2016.
- SSM shall support the Government Offices with technical knowledge regarding the international initiative on verification of nuclear disarmament (IPNDV).
- SSM shall implement a programme of support on safeguards matters to IAEA.
- SSM shall carry out cooperative safety work with Russia and development safety work with Ukraine, Georgia, Moldavia and Belarussia. The safety cooperative work with Russia shall foremost be about management of radioactive and nuclear wastes but also non-proliferation work, strengthening emergency preparedness and response activities (including environmental monitoring) and decommissioning of nuclear power plants. The cooperation shall contribute to Swedens environmental and foreign political objectives regarding the environment, peace and safety.

The latest appropriation directions also lists some on-going tasks which are to be reported on during 2016–17, e.g. an on-going analysis and review of the emergency zones surrounding the Swedish nuclear power plants and facilities and activities involving ionizing radiation, requests for IAEA:s SALTO missions (Safe Long Term Operation of Nuclear Power Plants) and the follow-up in April 2016 of the 2012 IAEA IRRS-mission to Sweden.

SSM's work can be divided into supervision of the safety and radiation protection work connected with non-ionising and ionising radiation. As far as concerns ionising radiation, the main regulatory areas are: the 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, the public use of sources and devices in commodities, the use of detectors and scanning equipment for security reasons and exposure to ionising radiation from naturally occurring radioactive material (NORM). In this report, the focus is on the nuclear facilities as defined by the Convention on Nuclear Safety. The missions are conducted within five main sectors: reactor and nuclear materials safety, radiation protection, nuclear non-proliferation, nuclear waste safety and, since 2007, nuclear waste financing. In addition, SSM is involved in international development cooperation, managed by the Office for International relations, within the areas of reactor safety, radiation protection, nuclear waste safety and non-proliferation. Figure 5 displays the organisation of SSM as of 1 January 2016.

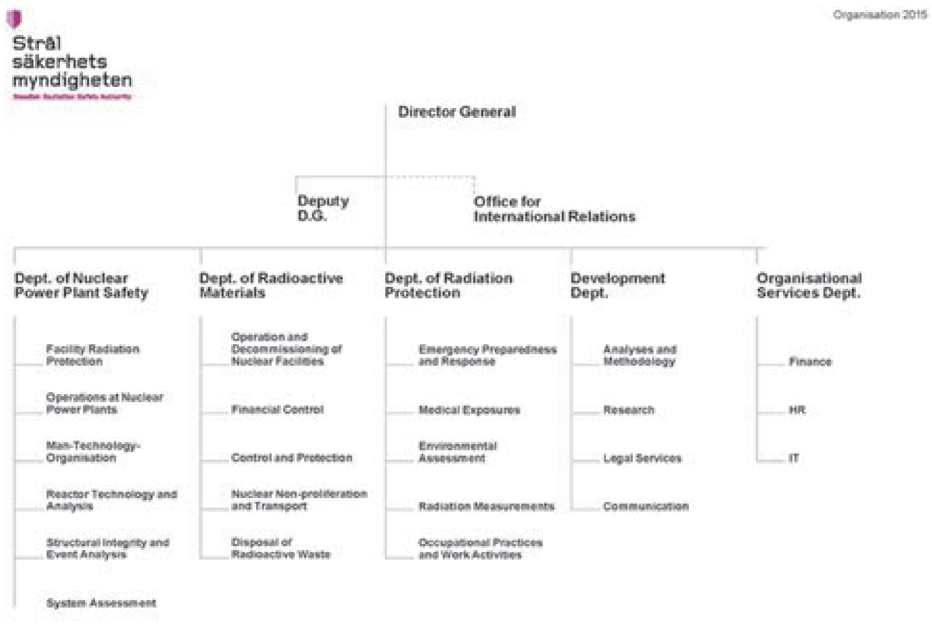

Figure 5: SSM's organisation.

The work within reactor and nuclear materials safety and related radiation protection is mainly performed within the Department of Nuclear Power Plant Safety but some units of the Department of Radioactive Materials and the Department of Radiation Protection are also involved.

Within SSM there exists a Delegation for Financial Issues Connected with the Management of Rest Products from Nuclear Activities which is an advisory body in the annual matters of suggesting the fees and the basis for calculating the fees, to the Nuclear Waste Fund. SSM also suggests the sizes of the supplementary guarantees the utilities must have available. The delegation is led by the Director General and has at most eight other members, decided by the Government and representing other authorities and independent institutions with relevant competence.

SSM has, related to 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, electromagnetic fields, and the use of ionising radiation in oncology.

8.2 Human and financial resources for regulatory activities

8.2.1 Staffing

SSM has (end of 2015) a staff totaling 305 persons, which is an increase by 11 persons since 2012. In-between, the staff number has been higher but a reduction was made when it was realized that new reactors would not be built in near future. The average age is 47 years. Of the staff, 22% are younger than 40 years, 32% are between 40 and 49 years of age, and 43% are 50 years of age and older. Around 11 % of SSM employees could retire (65 years) within five years, but one can opt to work until the age of 67.

In 2015, 26 persons were recruited (13 women and 13 men) and their average age was 45. The average staff turnover rate, excluding retirements, is about 4%., which is normal.

The *DG, Deputy DG* and *the Office for International relations* consisted at the end of 2015 of 16 persons.

The *Department of Nuclear Power Plant Safety* has (end of 2015) a staff of 87 persons who work with supervision of nuclear safety and radiation protection at the ten nuclear power reactors in operation. Of the 86 staff members, 14 % have a postgraduate degree and 68 % have a Bachelor's or Master's degree. SSM has designated one inspector for each plant as a *'site coordinator'* who serves as the main point of contact between the respective facility and the Authority.

The 69 persons belonging to the *Department of Radioactive Materials* are involved with issues of waste management, spent fuels and nuclear non-proliferation towards the operation of nuclear power plants. This department otherwise mainly work with inspections of non-power producing nuclear installations (e.g. fuel factory at Västerås, waste treatment and material investigation facilities at Studsvik), decommissioning, financial issues, nuclear security, radioactive wastes and releases from non-nuclear facilities, and with planned or existing off-site spent fuel and waste management facilities, including final repositories (see Sweden's 5th national report under the Joint Convention).

There are 16 persons of 69 at the *Department of Radiation Protection* directly dedicated to work with the national emergency preparedness activities. The department is also dealing with, laboratory measurements, calibrations and use of radiation sources, x-ray equipment, etc. for activities related to the operation of the Swedish nuclear facilities.

The "*steering and supportive sections*" of SSM account for 64 persons in total. They include the legal services, research, analyses and methodology, the communication department, the administrative unit (including human resources unit), the finance unit and the IT unit.

The educational background of SSM staff at the end of 2015 is shown in Table 4:

Education	Percentage
Post graduate degree	17
Bachelor's/Master's	63
Upper secondary school	16
Other	4
Total	100

Table 4: Educational background of SSM staff.

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 is 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. Many staff members are typically involved in several tasks, such as inspections, regulatory reviews and approval tasks, revision of regulations, handling research contracts, and participation in public information activities, each activity requiring his or her expertise. 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 put on the licensees and the different oversight practices.

8.2.2 Long-term planning and resources

In 2010, the Government assigned SSM to investigate and report on the competence situation in the disciplines of importance to the Authority, taking into account both internal and national needs. In the report, dated February 2011, it was concluded that SSM had a lack of redundancy in some competence areas within nuclear safety, for example instrumentation and control systems (I&C), PWR operation, severe accident and maintenance, and that SSM was dependent on a few key persons within these areas.

The competence situation has since then improved but SSM still strives to recruit persons with suitable competence. The national competence situation within the field of radiation protection including the situation at SSM and its future needs was reported to the Government on the 2nd of February 2015. One conclusion was that there is a lack of staff with radiation protection knowledge at a high (deep) level. SSM suggested actions, both regarding education and research, to remedy the situation.

The SSM competence model includes the steps: Attract, Recruit, Retain and Leaving the authority. The competence profiles are based on work performed in 2011. In 2012 SSM started a general analysis of the Authority in the area of expertise. The purpose of the skills survey is to provide SSM's leadership and managers with a clear picture of the Authority's current skills and, based on this, perform a gap analysis. With this analysis we can determine the skills we need in the short and long term in order to deal with current and future tasks. Competence mapping of all employees is an ongoing effort focusing on the core competencies. The mapping is documented and managed in an electronic skills module.

A new model for performance appraisal has been developed. The development will be goal-oriented and, if necessary, new goals will be set to improve skills. SSM has trained all managers and employees of the Authority in order to emphasize the importance of the development dialogue as a strategic skills tool.

A structured model for the transfer of skills was developed to help in the work secure critical competencies. This model will also be used for the training programme Competent Supervision. A pilot study was stated including 11 employees and the results will be evaluated in 2016.

8.2.3 Internal staff training

Competence development has been conducted in all departments and units and in averages 5.5 days per employee have been used for training (including the supervisory programme described below). During a year, SSM conduct about 70 joint training sessions in the areas of supervision, preparedness, monitoring, skills exercises and the work environment.

A new induction programme for employees has been developed with the aim to provide basic knowledge about the authority and the authority's role and mandate. The induction program is mandatory for all, regardless of position and includes, inter alia, the authority role, occupational health, safety and 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. The program is divided in three stages over a period of one year and all employees will also meet the Director General at an informal meeting.

During the last years, ongoing development efforts were undertaken on the part of the entire management group. The content of this work was based on the skills profiles of identified managers at SSM. Efforts have included both pure leadership issues as well as issues related to the organization and systems.

Courses are given covering the internal processes of the management system, the legal framework for regulatory activities, IT and security routines, project management, inspection methodology, nuclear technology, nuclear power plant and systems courses, as well as media training.

For technical training, SSM also uses the licensees' training programmes for operators, including simulator training. Newly employed SSM staff was also given the opportunity to observe on-site work in a control room for several weeks.

SSM launched a specific development programme for *Competent Supervision* in spring 2012. The programme concerns all employees involved in supervisory work at SSM. The aim is for them to have the same basic skills and perform supervision consistently regardless of the supervised entities. The programme has now run for about three years. It has been identified that further quality assurance of the programme is needed to reach a better quality. There are plans to further develop employees' supervisory skills at the Authority. Planning for example involves exchanging experiences internationally with other authorities.

8.2.4 Financial resources

As mentioned in previous national reports, the regulatory activities of SSM are financed by the State budget. The costs are largely recovered from the licensees in the form of fees covering 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 2013, 2014 and 2015, including the funding of the separately financed international cooperation and development work are shown in Table 5.

Budget item	2013	2014	2015	Source of funding
Nuclear safety, emergency preparedness and radiation protection (including administration)	280.4	278.9	300.5	Mainly fees
Supervision of nuclear facilities (proportion of above)	118.5	116.9	130.1	Fees
Licensing of new nuclear facilities	20.9	48.3	27.8	Fees
Scientific research and development work	81.0	78.4	73.9	Mainly fees
Final disposal of radioactive waste	52.5	56.2	54.7	Fees
Historical wastes etc.	1.8	1.5	2.0	Tax funded
Crisis management[6]	8.9	4.5	4.2	Tax funded
International co-operation and development	40.4	27.5	27.8	Tax funded
Total (million SEK)	**485.9**	**495.3**	**490.9**	

Table 5: Budget of SSM in million SEK. 1 SEK is about 0.1 Euro.

In addition, additional resources are from fees for reviewing special applications or licensing work that are paid directly to the Authority. It should be noted that the figures presented for the year 2013 in the Swedish 2013 national report were the numbers in the budget but the actual outcome presented below is much lower, below 500 MSEK, The difference is due to lower expenditures than expected for the two budget items licensing of new facilities and final disposal of radioactive waste.

8.3 Regulatory inspections and assessments

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

8.3.1 SSM's supervisory practices

SSM has continued to develop its supervisory methods, which are also documented as part of SSM's overall management system. Inspection policies and routines that were established during 2009 have been updated and new routines, including harmonization between procedures in different supervisory areas, have been issued. The development of regulatory oversight that has occurred in recent

[6] These funds are received via the Swedish Civil Contingencies Agency (MSB)

years are largely linked to the increasing of personal with competence in areas that have previously suffered from lack of resources, for example in maintenance, severe accidents, as well as electricity and I&C. It has meant that SSM has been able to pursue more proactive oversight in a number of areas where we have previously been more reactive and then more been controlled by events and conditions detected.

In total, 17 areas are defined for which the corresponding requirements are found in regulations, licensing conditions and to some extent in regulatory decisions. The ambition is to successively cover these areas in a basic inspection programme and to document the inspection findings. Moreover, the same 17 areas are applied in the annual assessments of the licensees (SSM's integrated safety assessments, see below) as well as in the periodic 10-year safety reviews. In this way, SSM is able to systematically supervise the safety situation and monitor developments. When new assessments are begun, previously performed and documented assessments of the areas can be consulted and any emerging picture consolidated. The idea is to apply the regulatory information and knowledge in a more efficient way. In order to further guide inspections and safety assessments, there is also a sub-structure in each of the 17 areas. The areas applied are:

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

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

8.3.2 Nuclear safety and radiation protection inspections

The number of compliance and surveillance inspections performed by SSM in 2015 is shown in Table 6.

Year	Forsmark	Oskarshamn	Ringhals	Total
2015 compliance inspections	3	7	6	16
2015 surveillance inspections	37	45	48	130
2015 reviews	13	28	20	61
2014 compliance inspections	13	3	6	22
2014 surveillance inspections	47	45	46	138
2014 reviews	12	37	9	58
2012 compliance inspections	7	3	6	16
2012 surveillance inspections	33	31	40	104
2012 reviews	16	12	16	44

Table 6: Compliance inspections, surveillance inspections and reviews performed by SSM in 2009, 2012, 2014, and 2015.

In the area of maintenance SSM has carried out fact-finding compliance inspections at all licensees and followed up the results during additional surveillance inspections. In the areas of PSA and severe accidents fact-finding inspections have also been performed at all licensees.

During the review period the last measures in the extensive modernisation programms which were established after the regulations in SSMFS 2008:17 on design and construction of nuclear power reactors entered into force in 2005, were implemented at the facilities. The last few years, SSM has started a series of compliance inspections and reviews to control that the measures taken have resulted in that the reactors are in compliance with the requirements of SSMFS 2008:17.

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 objects of the inspection, observations, compliance and deviations from requirements, an assessment of the significance of any deviations, and a proposal on any further regulatory actions. After most of the inspections during 2015 it was concluded that the licensees complied with the requirements, although in some cases with deviations. In a few cases SSM issued an order to the licensee to improve the activities.

In addition to compliance inspections, SSM carries out surveillance inspections to be informed on the plant status, safety problems and overall activities at the plants. Normally these surveillance inspections include 3–4 annual meetings with each reactor operations management, two annual meetings with the safety department, one inspection at each outage and yearly meetings to review safety and internal audit programmes. Special inspections are made in the occurance of an events, and to follow up organizational changes and other current issues such as findings from earlier inspections. In many cases these inspections are also focused on non-technical issues, such as safety management and safety culture.

The preparation and documentation of surveillance inspections are simplified in comparison with compliance inspections, but 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.

SSM also has an instrument called "special supervision". The use is decided by the Director General and is applied when the authority is dissatisfied with the safety performance of a licensee. It can also be applied for other special safety reasons, e.g. following an events. The special supervision regime means that more inspections are done and particular progress reporting is required. Special supervision has been applied in a several cases and is presently applied in the supervision over OKG (see section B10.3).

Additionally, SSM applies strengthen supervision when a licensee has annonced suspension and decomissioning of a reactor units (see section B10.3.)

Inspection of the licensee programmes, activities and results of surveillance and in-service inspection of mechanical components are done, according to SSM regulations, by an accredited control body ("third-party control"). If the requirements are fulfilled, a "compliance certificate" is issued by the control organisation (see section B14).

8.3.3 SSM's integrated safety assessments

SSM's integrated safety assessments are annual nuclear safety and radiation protection assessments of each major facility under SSM supervision, and are performed by a specific group of persons at the department of nuclear power plant safety. 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. A draft report, covering the status in the 17 areas mentioned above, is prepared by the group.

Of importance when drafting the report is the traceability from the basis of data, via the analysis, to the final conclusions and the appraisal. It should be clearly described how SSM evaluated the relevant issues and it 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.

In accordance with the Authority's established procedures, the draft report is distributed for comments in the organisation. The report is ultimately approved by SSM's Director General and presented at top level management meetings with each licensee.

8.4 Regulatory research

Based on what is stated about research in the Ordinance (SFS 2008:452) with instruction for the Swedish Radiation Safety Authority, the main purposes for SSM research is to:

- Maintain and develop national competence of importance for radiation protection and nuclear safety work.

- Ensure that SSM has the knowledge and tools needed to carry out effective regulatory and supervisory activities.

In order to contribute to national competence and research capacity SSM supports basic and applied research and also development of methods and processes (usually not products). However for development work the intention is that the developed method or process should preferably be used by the authority, in support of the authority work.

SSM finances basic and applied research in 2015 at a total amount of 78 MSEK. Out of this, 56 MSEK are directed to nuclear safety research.

Research is a prerequisite for SSM to be able to conduct its regulatory activities. Research to support supervision in the nuclear area is focused on strategic areas such as safety assessment, safety analysis, reactor technology, material and fuel questions, human factors, emergency preparedness and non-proliferation. Ageing of materials, components and systems, is an important focus area for research, since the Swedish reactors have entered or will soon enter into "long term operation" (operation after the originally planned 40-years life span).

In the area of radiation protection, research and development work relating to source terms, production and spread of activated corrosion products, new detection and measurement methods, and waste treatment are of importance. More general research on radioecology, radiation biology and radiation dosimetry is also of long-term importance.

Anhother focus are for SSM support is research in severe accidents. Partly, this support is directed to *Chalmers University of Technology* and the *Royal Institute of Technology* (KTH), respectively, and partly it supports a national project, Accident Phenomena of Risk Importance (APRI), jointly with Swedish industry and academy. The purpos of these projects are to develop competence and research capacity, and to demonstrate that applied strategies for severe accident sequences and conditions in Swedish nuclear power plants, are acceptable. Even though the strategies applied in Sweden are relatively unique, through these projects Sweden aslo contributes to the strategic national engagements in OECD/NEA project and in EU projects. Similar funding is directed to *Uppsala University* and *Chalmers University of Technology* in the area of "*nuclear non-proliferation*". A long-term activity in the area of cross-section measurements and analysis of nuclear data, including error propagation, is supported at Uppsala University.

8.4.1 International research collaboration

To fulfil research needs, SSM contracts universities and consulting companies. A dominating share goes to research organizations in Sweden. However, since national resources are limited, SSM actively participates in international research. There is, since many years, a clear trend of increasing international cooperation, also in safety research. SSM cooperates on research conducted by EU and OECD/NEA and takes part in a large number of projects.

In the area of nuclear safety, research is mainly performed within *Nordic Nuclear Safety Research* (NKS) in two programme areas: *reactor safety* and *emergency preparedness and response* and also within bilateral agreements with Finland. Another research project that SSM supports are The Halden Project in Norway which conducts research of importance for fuel, materials and human factors. An example of an

OECD/NEA international project performed in Sweden is the fuel project "*Studsvik Cladding Integrity Project*" (SCIP).

Since Sweden joined the EU, the importance of joint European work has increased. SSM itself is actively participating and supporting Swedish organizations participating in European Commission projects and intends to support such projects in the future. Furthermore, in the safeguards area, important joint work is performed in *European Safeguards Research and Development Association* (ESARDA).

Cooperation with NRC is prioritised and has given SSM access to developed models and computer programs for three-dimensional coupled thermal hydraulics simulations, neutron kinetic calculations as well as to severe accident analysis. An important project that SSM supports, and which this well established cooperation has meant a lot for, is related to validation of the advanced computer codes with experiments. For some phenomena which can occur in a reactor in the shut-down mode, it is sometimes advantageous to use multi-dimensional calculations techniques, "*Computational Fluid Dynamics*" (CFD). These calculation techniques need to be validated for use in the nuclear reactor context, e.g. regarding thermal transients, local variations in boron concentrations, hydraulic loads etc.

The Forsmark event in the summer 2006, led to the identification of areas where further research is needed. As a result of the international cooperation, four areas were identified for further work:

- Norms, standards and requirements and the need for their development;
- Strategies for control and tests of construction, installation and operation of electrical systems;
- A survey of models and methods used for the analysis of the dynamic behaviour of electrical systems;
- Strategies for using an integrated approach in analysing electrical systems.

The Forsmark event also emphasised the need for developing assessment criteria for the maintenance philosophy used for electrical systems and I&C systems.

Other examples of international research projects that Sweden through SSM supports are bench-marking of experience feedback systems, and development of PSA-tools. SSM is also involved in the assessment of computer platforms and applications, and in the analysis of safety aspects of the use of "*Smart Devices*" and COTS ("*Components On The Shelf*") products.

Furthermore, SSM supports the standardisation work performed within *International Electrotechnical Commission* (IEC) and the *Institute of Electrical and Electronics Engineers* (IEEE), e.g. regarding questions of environmental qualification of equipment.

8.5 Quality management of regulatory activities

8.5.1 SSM's process-based and integrated management system

SSM has an integrated and process-based management system which is certified in the areas of environment, quality management and work environment management in accordance with SS-EN ISO 14001:2004, SS-EN ISO 9001:2008 and the Swedish Work Environment Authority's regulations AFS 2001:1. The management system encompasses all activities of SSM. The system will be supplemented with a section on Information Security following SS-ISO/IEC 27001:2006. Internal and external audits are performed yearly, which are the basis for continuous improvements to the system. Figure 6 displays SSM's present process scheme.

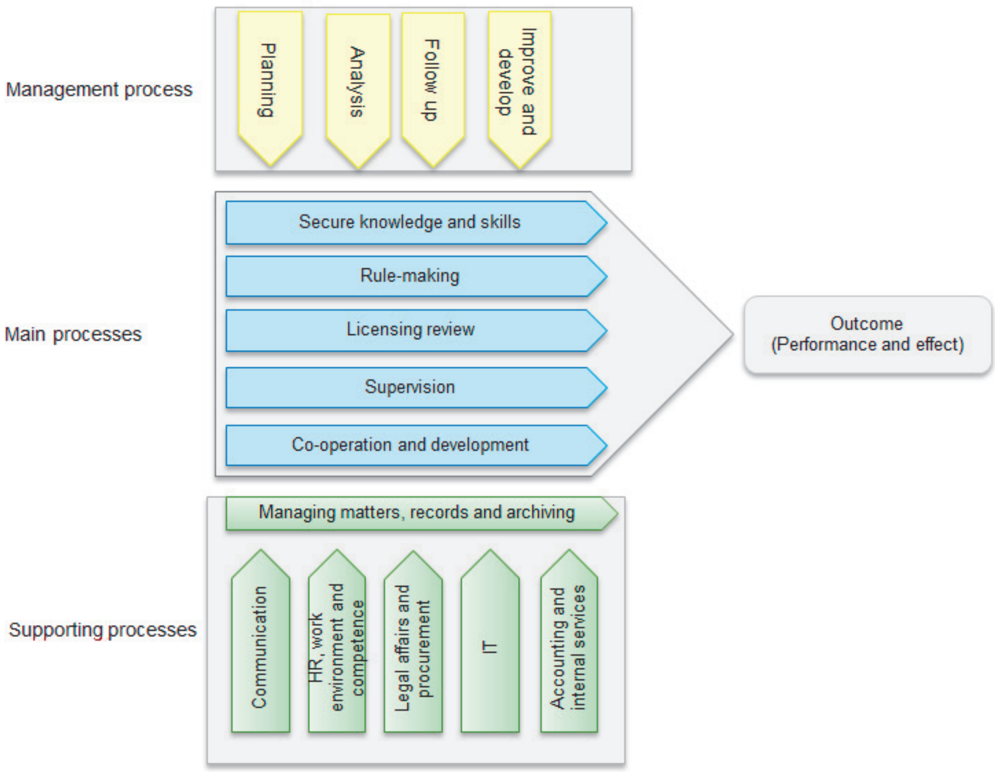

Figure 6: SSM process scheme.

An interactive process model highlighting the sequence and interaction of all key processes has been developed, validated and published on the intranet. Component sub-process information and associated guidance materials can be readily accessed by way of the process model, dedicated intranet pages and a robust document management system. Assigned process ownership applies to the key processes. Various support processes and processing of items of business (*Registrar, registration* and *archiving*) are grouped below the category *Supporting processes*.

8.5.2 Implementation of audits

SSM ensures that annual internal and external audits of the authority's activities are carried out, in addition to audits of the Swedish National Audit Office. The SSM management system should account for internal and external requirements; the latter such as those of ISO-standards, statutes and legal provisions, e.g. work environment management and information security.

The objective of internal audits is to follow up the activities of the Authority on all levels, to check compliance with external and internal requirements, to investigate how the 'shared values' are integrated in the day-to-day work, and to check if the management system is effective and adapted to its purposes. The internal auditors are appointed by the Director General on suitable audit teams on the basis of experience, competence and audit objectives.

External audits are carried out every year. In addition to the annual report and finances, the Swedish National Audit office performs checks on the effectiveness of SSM's management system. The requirements of ISO 9001, ISO 14001, the Swedish Work Environment Authority's regulations AFS 2001 and other relevant requirements are audited by contracted external auditors, accredited by the Swedish Board for Accreditation and Conformity Assessment (SWEDAC), an authority under the Ministry of Enterprise and Innovation. The latest external review was carried out in September 2012.

In February 2012, on a request by the Swedish Government, the IAEA coordinated a full-scope IRRS mission in Sweden, conducted by a team of international reviewers led by a senior regulator from a IAEA Member State. The mission was preceded by an extensive self-assessment. The subsequent action plan is a basis for continuous improvements. See section B8.7.

8.5.3 Communication

SSM's communication policy, established in April 2009 and amended in 2013, emphasises the key values of reliability, integrity and openness while defining their implementation (availability, proactive information, good quality, no unnecessary delays). Other strategy documents, also imbued with the key values, include a communication strategy, a media strategy and an internet strategy. The crisis communication strategy, established in June 2012, was formed through the experience gained during the accident at the Fukushima Dai-ichi NPP.

The aim of the SSM website is to be transparent and comprehensible, thus giving stakeholders the opportunity to monitor the Authority's work.

8.6 Independence of the regulatory bodies

The de jure and de facto independence from political pressure and promotional interests are well provided for in Sweden. The laws governing SSM concentrate solely on nuclear safety, 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 Minister of Environment who is not involved in the promotion or utilization of nuclear energy. An individual minister cannot interfere with the decision making of a governmental agency according to fundamental Swedish law.

8.7 Follow-up of the 2012 IRRS review mission

Between 6 and 17 February 2012, an IRRS-mission ("*Integrated Regulatory Review Service"*) was performed in Sweden and at SSM. The review was a 'full scope review', encompassing the entire fields of nuclear safety and radiation protection but not covering nuclear security or safeguards activities. The team submitted 22 '*recommendations*' and 17 '*suggestions*' on improvements to the Swedish system. Eight of these recommendations were directed at the Swedish Government, urging it to, among other things:

- take measures to maintain national competence in the fields of nuclear safety and radiation protection,
- establish a government level coordination body (committee, board etc.) that would be responsible for the coordination of the national efforts to cope with longer term consequences of a severe emergency and establishing a national radiation emergency plan, detailing responsibilities and concepts of operation of this governmental body and the other response organizations,
- ensure SSM has legal potential to conduct inspections of suppliers, and
- clarify the mandate and authority for the purpose of withdrawing /terminating licences.

Important recommendations and suggestions that directly or indirectly relate to SSM's work vis-à-vis nuclear power plants concern:

- the authority's resources and efforts to secure competence,
- the authority's regulations,
- the oversight and inspection processes, and
- the management system with processes and guidance.

The team presented 15 examples of 'good practice' that may be relevant for other countries and regulatory authorities to learn from. In the field of nuclear safety, this was for instance about SSM having its own MTO expertise that is used as part of regulatory supervision and that SSM's regulation has brought about a wide-ranging safety upgrade program.

In February 2014 the Government authorised SSM to arrange for a follow-up of the 2012 IRRS mission to Sweden. Arrangements were made with IAEA and in April 2016 a follow-up mission will take place. Sweden looks forward to the up-coming follow-up IRRS-mission and the possibility to describe actions taken to implement recommendations and suggestions and the further development of infrastructure, acts and regulations and the national over-sight processes in Sweden. However, as the ongoing preparation there are two of 22 recommendations given by the IRRS team still open and more work is needed in order to close these recommendations. The recommendations in question are dealing with issues related to:

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

8.8 Conclusion

Sweden complies with the obligations of Article 8.

9. Article 9: RESPONSIBILITY OF THE LICENCE HOLDER

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 last 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 continues at all plants.
- IAEA SALTO reviews have been initiated for Forsmark NPP, Ringhals NPP and Oskarshamn NPP.

9.1 Regulatory requirements

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

Section 10 in this Act 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 no longer nuclear activities are 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, without delay report to the regulatory body such information which is of consequence for the assessment of safety.

In the bill and the legislative history for the Act on Nuclear Activities (1984:3) 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 used procedures are cost effective and useful for individuals as well as companies. They must be written so that the regulatory body does not take over the prime responsibility for safety and radiation protection.

Also, SSM supervision shall ensure that the licensees have good control over the safety of the plants and that safety work is conducted with a satisfactory quality.

The SSM regulations on safety in nuclear facilities (SSMFS 2008:1), specify the responsibility of the licensee through a number of fundamental requirements on safety management, design and construction, safety analysis and review, operations, nuclear materials-/waste management and documentation/archiving. In addition it is clearly stated in these regulations (Chapter 2, Section 9, item 8) that safety shall be monitored and followed up by the licensee on a routine basis, deviations identified and corrected so that safety is maintained and further developed according to valid objectives and strategies. The meaning of this provision is that a continuous preventive safety work is legally required, including safety reassessments, analysis of events in the own and other facilities, analysis of relevant new safety standards and practices and research results. Any reasonable measure useful for safety shall be taken as a result of this proactive and continuous safety work and be documented in a safety programme that shall be updated annually.

The SSM regulations spell out three basic control principles, making the roles clear between licensee and 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.

The basic safety documentation, SAR including OLCs, PSA, plans for emergency response and physical protection, must be formally approved by SSM. Plant and organizational modifications and changes in the safety documentation are to be notified and SSM can, if needed, impose additional conditions and requirements.

9.2 Measures taken by the licence holders

A number of measures give evidence that the Swedish licensees accept the prime responsibility for safety. In the following subsections examples of such measures where activities are more or less constantly ongoing are given.

9.2.1 Safety policies

Vattenfall and OKG have developed nuclear safety policies. The safety policies are the highest-level documents expressing the most important corporate values, and are valid for all parts of each company. The policies contain a basic view on the safety issues and establish ambition levels and priorities, such as:

- 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, and to be met 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 further described in section B10.2.

9.2.2 Continuous improvements of the plants

The principles used to improve the nuclear power plants are discussed in sections B6.2 and B19. It is clear from these descriptions that the utilities take substantial initiatives of their own to assess and improve the reactors.

9.2.3 International reviews

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

9.2.3.1 IAEA OSART review missions

As the final stage in a series of OSART review missions (including follow-up) to all Swedish nuclear power plants during the period 2008-2012, an IAEA OSART seminar was held in May 2013. Exchange of experience and discussion of results including measures taken were the main objectives of the seminar and of the participating utilities as well as on the part of SSM and IAEA staff.

9.2.3.2 WANO peer review

<u>Oskarshamn NPP</u>

A WANO peer review was held at Oskarshamn NPP in October - November 2015. A total of 13 areas for improvement (AFI) were found. An action plan to handle the AFI has been established by the senior management group. The action plan has been presented to and endorsed by WANO in Paris in February 2016. The action plan has been merged together with OKGs strategic plan and thus fully integrated in the development strategy of the company. This allows the actions to be tracked for progress and evaluated in terms of their effect within the ordinary routines of management review and performance management. The follow-up review is scheduled for the fall of 2017 and the next ordinary WANO peer review is planned for the fall of 2019.

<u>Forsmark NPP</u>

WANO performed a Peer Review at Forsmark NPP in November 2015. The Peer Review resulted in 13 AFI, 6 performance deficiencies (PD) and 3 beneficial practices (BP). The AFI:s and PD:s will be handled by FKA in a specific action plan. The action plane will be reported to WANO in April 2016. The activities that are included in the action plan will be handled by FKA during the coming years until the next WANO follow-up which is planned to be arranged in the beginning of year 2018.

<u>Ringhals NPP</u>

WANO performed a Peer Review at Ringhals NPP in February 2013. Activities have been ongoing in order to reduce the gaps in each area. During March 2015, a WANO follow-up was conducted and the suggestions from the WANO team have been implemented in a post-follow-up action plan.

RAB is planning for the next ordinary WANO Peer Review in the first quarter 2017. The first gap analysis towards WANO performance objectives and criteria (PO&C) has been completed. The analysis and activities towards WANO significant operating experience reports (SOER) are ongoing and measures in order to reduce the gaps haves been taken. RAB has decided to invite WANO to perform Peer Reviews every fourth year with a following follow-up approximately two years after the Peer Review.

9.2.3.3 IAEA SALTO peer review

Oskarshamn NPP

OKG is curently carrying out intensive work to further develop and implement of the ageing management program. Large parts of this work consist of system scoping and screening as well as ageing analysis. This work is conducted as a part of a larger LTO (Long Term Operation) project at OKG. The aim of this project is to ensure long term and safe operations for the Oskarshamn NPP. Since the decisions was made to permanenly shut down and not restart Oskarshamn unit 2 and to phase out unit 1, the prerequisites for the project have changed and limited to only cover unit 3.

The IAEA Pre-SALTO mission is planned to take place at Oskarshamn NPP during 2017. Following this pre-SALTO, OKG is planning to invite IAEA to carry out a full scope IAEA SALTO mission in the period until 2023. The aim is to ensure long term and safe operations of Oskarhamn unit 3 after 2025 when the plant passes 40 years of operation.

Forsmark NPP

The Forsmark unit 1 and unit 2 will pass 40 years of operation and subsequently enter LTO in 2020 and 2021 respectively. Because of this, FKA have initiated a SALTO Peer Review program. IAEA plans to perform a Pre-SALTO Peer Review at Forsmark NPP in November 2016. Before the Pre-SALTO Peer Review mission a SALTO Workshop is arranged to take place at Forsmark NPP in April 2016.

Ringhals NPP

In March 2014, IAEA Pre-SALTO peer review mission was organized for unit 1 and 2 at Ringhals NPP, with follow-up mission in 2015. The Pre-SALTO mission resulted in two good practices and sixteen issues for improvement. During the follow-up SALTO mission it was concluded that two out of the sixteen areas for improvements identified were resolved. Next IAEA SALTO peer-review mission is preliminary scheduled for Ringhals unit 3 and unit 4 to be performed in 2018.

9.3 Conclusion

Sweden complies with the obligations of Article 9.

10. Article 10: PRIORITY TO SAFETY

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

Summary of developments since the last national report

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

- The owners of Ringhals NPP and Oskarshamn NPP decided during 2015 (see A2) to shut down two reactors each, Ringhals unit 1 and 2 at Ringhals NPP, and Oskarshamn unit 1 and 2 at Oskarshamn NPP. As a result of those decisions, measures have been taken by SSM to strengthen supervision of the licensees in order to follow the situation more closely.

10.1 Regulatory requirements

Policies that provided due priority to safety can be understood as normal safety policies and safety strategies but also safety management provisions and tools to manage a nuclear power plant in such a way that safety is prioritised and a good safety culture is created and maintained. A good safety culture that gives safety issues the attention warranted by their significance, is also a prerequisite for a robust implementation of a management system.

A basic requirement in SSMFS 2008:1 is that radiological accidents shall be prevented through a, for each facility, verified and robust design which shall include multiple barriers and a facility-specific implementation of the defence-in-depth concept. This is further elaborated in the general advice were the following bullets shall be prioritised in order to develop and maintain an effective implementation of the defence-in-depth concept. These bullets can also be interpreted as the key elements of a safety policy to be implemented by the licensees operating organisations in order to support the work with ensuring an effective management system:

- safety is always prioritised over commercial operations,
- sufficient financial resources are available for implementation of measures,
- sufficient adequately trained staff is available,
- conservative criteria are applied in the design and operation of the plant,
- safety is monitored and followed-up, failures and deficiencies are identified in a timely manner and corrected,
- the operating organisation has a strong programme in place to learn from its own and others' mistakes so that safety deficiencies that can be eliminated do not recur,
- quality management is applied in all activities,
- possibilities to improve safety are evaluated and reasonably practicable safety improvement are implemented as appropriate,
- the organisation as a whole is characterised by a good safety culture.

In SSM regulations on safety in nuclear facilities (Chapter 2, Sections 7 to 9 in SSMFS 2008:1) requirements on safety management aimed at giving safety the right priority are given:

- The operating organisation shall have the necessary financial and personnel resources and be structured to maintain safety.
- A management system shall be implemented and kept up to date so that requirements on safety are met in all relevant activities.
- There shall be documented safety objectives and safety strategies so that safety is always prioritised.
- Responsibilities, authorities and cooperation shall be defined for staff with tasks of importance for safety.
- Activities shall be planned in such a way that necessary time is 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.
- Staff shall be given the working conditions needed to work in a safe manner.
- Applicable operational experience shall be assessed continuously and reported to the relevant staff.
- Safety shall be assessed and followed up on a routine basis, 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 in SSMFS 2008:1, requires that the licensee has a updated/up-to-date safety programme: After comissioning, the safety of a facility shall be regularly analysed and assessed in a systematic manner. Resonable practicable technical and organisational measures for safey improvement 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 and 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 means for instance, results of MTO analyses, evaluation of organisational changes, evaluation of work conditions and self-assessments of the working climate and safety culture.

10.2 Measures taken by the licence holders

10.2.1 Safety policies

The safety policies (see section B9.2) issued by Vattenfall and OKG 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, local safety review committees have been established for many years at plant level to advice on principal safety issues.

All licensees have a similar structure in place for safety management and review where the responsibilities and authorities of the different levels of management are clearly defined. The basic principles are the following:

- **Safety management level 1** is represented by the plant manager. Level 1 is responsible for the overall safety review process, and for specific safety issues forwarded to him 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 2** is represented by the production unit manager, 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 report (SAR) is up-to-date and reflects sound safety practices. Level 2 shall follow up on deviations, trends and operating experience. Deviations from regulations, company norms and policies should be reported to the safety management level 1. Level 2 shall also sanction routines for the extent of work on safety related equipment, and ensure that documentation fulfils the requirements.
- **Safety management level 3** is represented by the operations department manager who is responsible for safe operation within the limits of procedures and technical specifications. Level 3 is also responsible for all work permits on safety related equipment. Safety related deviations should be reported to the safety management level 2.

Independent safety reviews are carried out by the Safety and Compliance Departments. Furthermore, when the plant manager takes decisions on important safety issues, or matters of principle, such as restart of the reactors after an outage, plant modifications in safety equipment etc., the principle is that the manager shall consult with the company safety review committee. The management structure also 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 safety review committee
- Requirements regarding plant modifications (technical and organisational).

All licensees have safety programmes in place as required by SSM regulations SSMFS 2008:1. The programmes are part of the management system documentation. They contain priorities and time schedules for technical, organisational and administrative measures to be implemented as a result of safety analyses, audits, safety culture surveys and other evaluations done at the plant.

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 groups: Assessment and Decision Making, Maintenance Process, Plant Modification Process and Safety Culture. The quality indicators measure factors such as backlog, fuel integrity, self-assessment, analysis and follow-up, and compliance to rules. A set of 21 indicators has been expanded to include more than 60 indicators and the procedures for management review of the indicators. The indicators are periodically reviewed (monthly or quarterly) by the management team. Any deviation from the expected performance is analysed and actions for improvement are decided on by the plant manager.

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 the trust for 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 the expected performance is analysed and actions for improvement 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 programme went through development and modification during 2012-2014. The structure is based on IAEA TECDOC 1141, *"Operational safety performance indicators for nuclear power plants"*.

This created a structure consisting of different key performance indicators (KPI) levels. The number of sub-indicators is increasing as complementary actions are performed in order to monitor the organisation in a more efficient manner. WANO indicators are included in a more clear way, as WANO indicators are examined through one-year values, thus managed the same way as other indicators.

The results are trended, analysed and communicated and actions are initiated where the goals have not been met. A quarterly management review is carried out by the upper management. In addition, a yearly meeting is held where results from the indicators and potential actions are reviewed. Selected indicators, their results and potential corrective actions to improve performance are presented to the board quarterly. All results are also presented on the intranet under the header "Goals and Safety Indicators".

The structured work with KPIs has formed the basis for continuous development of the management structure. Currently, the concept of "Operational Excellence" is rolled out throughout the organisation. Visual management, where KPIs are published on "visual boards" as a basis for decisions, follow up and planning, is a vital part of Operational Excellence.

10.2.3 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.

10.2.4 Vattenfall's Safety Governance

Over the past year Vattenfall has increased its governance and oversight of the nuclear facilities through the establishment of Vattenfall Corporate Independent Oversight.

Independent oversight of nuclear safety and performance is performed at two levels within Vattenfall, at the power plant level and at the Corporate Executive Officer (CEO) level (see Figure 7).

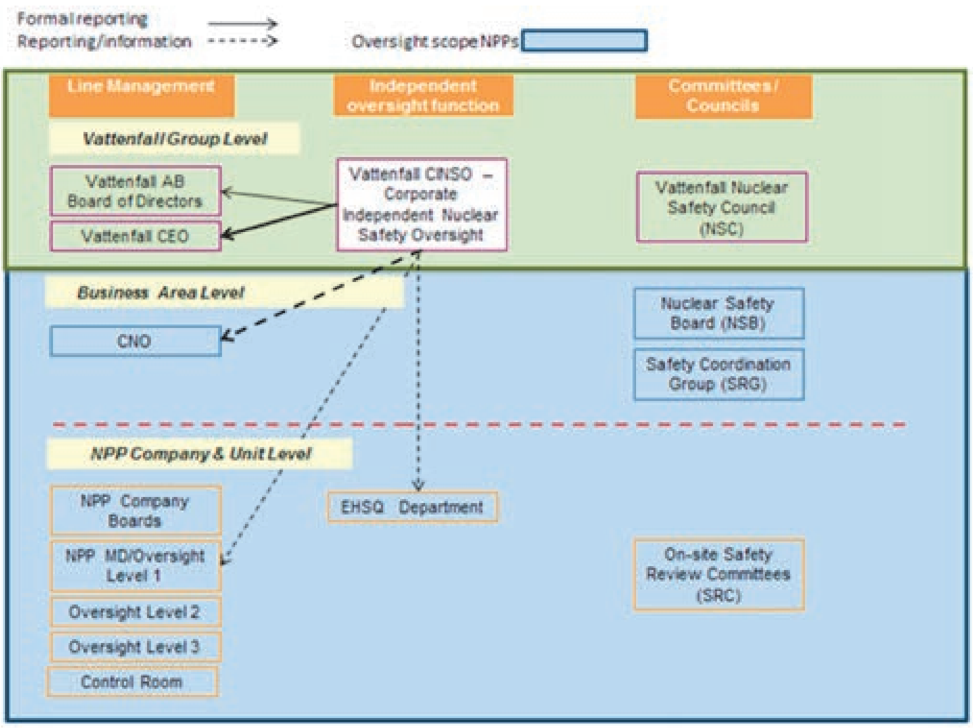

Figure 7: Vattenfall's safety management structure and CINSO scope and reporting.

10.2.4.1 Independent Oversight at Vattenfall Corporate Level

The CEO of Vattenfall obtains independent oversight of nuclear safety and performance through two functions independent of the line organisation, one being the Corporate Independent Nuclear Safety Oversight (CINSO) function and the other the Nuclear Safety Council (NSC).

CINSO shall give advice based on an independent and diversified view to the CEO of Vattenfall. 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. The CINSO function shall also provide added value to the Chief Nuclear Officer (CNO) and the license holders by reporting its findings. Vattenfall CNO, which is the utility most senior controller in nuclear safety issues and management's nuclear expert, reports directly to the CEO. NSC gives advice to the CEO in nuclear safety and performance matters from an external perspective.

10.2.4.2 Independent Oversight by CINSO

CINSO makes up an additional layer in the Defence-in-Depth by advising top management on safety and performance in the nuclear business.

Processes and performance are systematically assessed and gaps to best practice are reported to the line organisation for decision on actions. Recommendations and suggestions are followed-up. Good practices are shared with the sites.

10.2.4.3 Framework

All nuclear operations within Vattenfall shall comply with existing national nuclear laws and regulations as well as with internal Vattenfall requirements. Additionally, all nuclear activities shall comply with Vattenfall's Nuclear Safety Policy, which should also be in agreement with IAEA Safety Standards and WANO Guidelines. It is the responsibility of the line organisation to adhere to these requirements, and, with regard to compliance with nuclear laws and regulations, the responsibility lies with the nuclear licensees.

The CINSO function performs its oversight within this framework of requirements and regulations i.e. oversees that these basic requirements are fulfilled. However, the focus should be more on strategic issues of importance to Vattenfall's business risks. The independent oversight should also be in agreement with INPO/WANO principles regarding corporate oversight of nuclear power organisations. In addition, the CINSO function shall oversee that the nuclear organisations have the mechanisms to put into practice national and international best practices in order to support safe and stable operations and the Business Area Generation vision of powering society every day.

The CINSO oversight shall emphasise a proactive approach i.e. be able to detect safety and performance degradations at an early stage in order to avoid more serious problems developing.

10.2.4.4 Independence

The independent oversight role implies that CINSO shall not engage in, take responsibility for or execute authority over activities that normally would be reviewed. The CINSO reviews and way of working do not relieve management of assigned responsibilities for establishing and keeping control of nuclear safety and performance.

10.2.4.5 Graded approach

The independent oversight activities are based on a risk based prioritisation of the organisations covered by CINSO. The organisations are divided up in-to two categories (primary and secondary). The main focus for the CINSO independent oversight activities is on the nuclear facilities (Forsmark NPP, Ringhals NPP, SKB) and CNO/Staff Function Fleet Development, for which designated oversight engineers are assigned. For other parts of the nuclear organisation a plan for independent oversight activities is formulated and documented annually.

10.2.4.6 Scope

The corporate independent oversight should provide added value to both the corporate management and the licence holders. It is based on systems supervision in which systems/processes are assessed to ensure safety. This facilitates a proactive approach. In the more reactive work, e.g. follow up on incidents and events, signs of deficiencies in the safety work etc., the main focus is on evaluating how the incident or problem is being handled and managed.

Additionally, the CINSO role and function includes tasks such as assessing:

- Organisational changes at Vattenfall corporate organisations that affect nuclear safety within Vattenfall's nuclear related operations.
- Introduction of new or changed governance at Vattenfall that affects, or may affect, nuclear safety licensees.
- Other decisions within Vattenfall that affect nuclear safety and/or the responsibility of licensees according to the Swedish Nuclear Act (Kärntekniklagen) and SSM regulations.

10.2.4.7 Way of working

The CINSO function shall gather information on nuclear safety and performance through various sources and means. To be able to fulfil the independent oversight the CINSO function shall have access to documentation and meeting fora at the nuclear units as needed.

The sources include, but are not limited to, the regular reporting on safety and performance from the line organisation, operating experience reports and root-cause investigations, audit reports, major plant modifications and improvement plans and progress reports, safety culture assessments, and various types of reports produced by the regulatory bodies.

The CINSO function shall also gather information through plant visits and participation in key meetings. Plant visits can have various purposes, from general information gathering to more focused assessments of specific areas. The focused assessments can be based on identified concerns or have a more proactive approach aimed at ensuring high quality in known precursors to safety performance.

All types of assessments should be based on a systems view of safety and performance i.e. recognising the complex interplay between man/humans-technology-and organisations as well as for nuclear leaders and managers to have the skills, knowledge and ability to manage the unique interaction between the technology, human and organisational factors, economics and safety. Thus, assessments should be based on an integrated approach using various types of information sources to form grounds for judgement.

The criteria used for assessments should be based on Vattenfall Nuclear Safety Policy (see B 9.2.1) and other requirements, nuclear regulations, INPO/WANO guidelines, IAEA Safety Standards and documented best international practices. This requires that the CINSO function shall follow international developments in the area of nuclear safety and performance.

10.2.4.8 Systematic Independent Assessments, SIA

SIA is a proactive in-depth assessment aimed at reviewing areas that are assessed as important and vital for safe nuclear operations. SIA´s are performed according to a predefined schedule and the intention is that the main areas for oversight shall be covered over a six-year period and that one SIA is performed each year.

10.2.4.9 Focus Area Review, FAR

FARs are used for areas where there is a need for deeper review. The FAR is normally performed by a smaller team gathering information regarding the area during approximately one quarter. An annual plan for the FARs is developed based on previous insights and findings.

10.2.4.10 Observation reports

Observation reports are a way of documenting observations done by CINSO personnel. Observation reports are used as a tool for documenting important findings during regular monitoring of site performance. They can also be used as a way of steering the monitoring of site performance by defining areas for observation.

Areas for observations should be revised regularly and communicated to the local safety departments.

10.2.4.11 Reporting

The results of the nuclear independent oversight are compiled in annual and bi-annual safety assessment reports communicated to the CEO, the CNO and to the top management of the Business Units as well as to the local safety departments. The Areas of concern from annual reports are part of the Vattenfall Business planning directives. CINSO also reports to the Board of Directors of Vattenfall once a year.

CINSO meets with the CEO on a bi-monthly basis to report on concerns and with the CNO on a monthly basis. Meetings are held on a monthly basis with local safety departments.

Results from individual reports are presented at Nuclear Safety Council (NSC) and/or Nuclear Safety Board (NSB).

10.2.4.12 Follow-up

It is the responsibility of the CINSO function to follow-up on issues and concerns raised by CINSO at various fora. The extent to which CINSO has been involved in issues and concerns and to what degree its advice has been implemented and/or considered shall be assessed annually.

10.2.4.13 Independent Oversight by the Nuclear Safety Council

The role of the NSC is to provide advice to the CEO of Vattenfall on nuclear safety and performance issues that can pose business risks to Vattenfall. The advice shall be credible i.e. well-informed and based on Vattenfall's way of doing business, coherent i.e. reflect the thinking of the whole team as far as possible and useful i.e. address agreed strategic issues.

The members of the NSC are appointed by the CEO. The NSC shall consist of external experts with extensive experience in the nuclear field. From Vattenfall the CNO and the Head of CINSO participate. The Chairman of the NSC is the CEO of Vattenfall and the CINSO Office acts as secretary and administrator.

The main tasks of the Nuclear Safety Council are:

- To evaluate issues of strategic or otherwise principal importance regarding nuclear operations, with input from sources such as worldwide operating experience, regulatory requirements, internal and external assessments, periodic safety reviews, etc.

- To review and give advice on policies and other governing documents, major changes in organisational structures, communication regarding nuclear safety related issues, etc., for the nuclear operations.
- To provide high level oversight or commentary on the level of nuclear safety of the nuclear installations through reviewing Vattenfall reports and to put forward related considerations for improvement.
- To visit nuclear installations periodically, to observe and discuss issues and operations with staff and to provide feedback to management.
- On occasions, and at Vattenfall request, to carry out targeted information-gathering exercises or evaluations.
- To prepare nuclear safety related reports as needed.

The NSC normally meet 2–3 times per year.

The CINSO function shall provide the NSC members with a standard set of performance reports and other relevant information material on an ad hoc basis. The NSC members can furthermore request certain reports or information for review. The documented recommendations from the NSC are based on consensus among the external experts, whereas Vattenfall officers are non-voting members.

10.2.4.14 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., if not adhered to in the line organisation.

10.2.5 Safety culture programmes

Maintaining a strong safety culture in the operation of nuclear plants is considered vital by the Swedish utilities and is emphasised in the policies of the different plants and in their strategic plans. 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.

Oskarshamn NPP

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. Reoccurring 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, has been popular events that brought good discussions. When further analysing the “Action plan for safety culture” and this approach in the beginning of 2015, OKG identified that the approach was not as efficient and that the employees had some difficulties taking on-board the theoretical material presented in the workshops and incorporating it in their daily work. In order to improve the safety culture further, a "next step" was necessary. During the first half of 2015, OKG has re-worked the action plan to better suit the different departments individual needs. The goal for this is to

- better incorporate the corporate values into the organisation through management expectations of professional behaviour,
- make safety culture a corporate culture, and
- increase the use and efficiency of the human performance tools.

A deeper purpose with this approach is to support the organisation's safety culture work effectively and to identify the actual individual needs within the different departments.

The current aim with the safety culture work at OKG is to implement a change in the approach and the attitudes towards safety culture and the safety enhancement tools. It should be clearly stated how the work with the "Action plan for safety culture" correlates with the corporate values and the management expectations of a professional behaviour. This has brought a change in perspective towards a more holistic view of how safety culture messages and training are being delivered and executed. This also means that the goal relating to expectations of professional behaviour should be a vital part of each department's strategic work in order to make safety culture the corporate culture.

Forsmark and Ringhals NPPs

At Forsmark and Ringhals NPPs, the role of coordinating safety culture development and activities at Vattenfall company level is delegated to the merged Safety Culture and Business Development Department since 2015. Expertise and best practice are shared between the two plants. Development of nuclear safety culture is part of the normal procedures incorporated in the management system, driven by the reactor safety programme. The programme is revised annually and approved by the Chief Executive Officer.

A comprehensive evaluation of the 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 results from the safety culture survey that 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 the safety culture are 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, WANO and SSM reviews/inspections.

10.2.6 Safety culture during a period of preparation for decommissioning

Oskarshamn NPP

In order to maintain continuity in the work with, and implementation of safety culture throughout the decommissioning process, OKG, the owner of Oskarshamn NPP, has developed an action plan together with the operations management staff at Oskarshamn unit 1 and 2. This plan consists of 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 is maintained throughout the decommissioning process. The plan also contains defined expectations of the management of the safety promoting work methods the organization are expected to use more intensely during this process. It has been decided that the methods should be used in a way that is adapted to the current situation. The focal point is on clarifying OKG's principal values as well as management expectations of these values.

Activities that has been carried out in accordance with the plan includes a number of workshops where the main focus has been on discussing OKG's new mission (decommissioning of unit 1 and 2 alongside operating Oskarshamn unit 3) and how to handle the conversion from a psychosocial perspective, by proactively working with occupational health to prevent any health consequences and maintaining a focus on safety by applying OKG's values, as well as expectations of professional behaviour. The outcomes of safety culture surveys and analysis were also presented during the workshops.

Other activities that are to be carried out are experiences exchanges (benchmarks) with the Studsvik and Barsebäck organisations and gaining knowledge of how they handled the organisational changes and maintained a good safety culture during their decommissioning processes. OKG will also appoint more safety culture ambassadors by finding appropriate resources that can provide additional support to management in safety-related work. These procedures will be carried out together with the already existing safety culture coordinators (specially trained human-factors personnel).

Ringhals NPP unit 1 and 2

In addition to the ordinary efforts to maintain a strong safety culture at Ringhals, focus on safety culture is a considerable part of the project STURE (Safe and Secure Phase-out of Reactors 1 and 2), that has been set up to prepare for the decommissioning of Ringhals units 1 and 2. The main risks that have been identified are the risk of losing competence and experienced personnel, lack of motivation in existing personnel and risk of degradation in work processes leading to technical degradation. To ensure that the safety culture aspects are covered in the project, a safety culture specialist from the corporate staff is advising the members of the project team. A strong emphasis has also been on communication during various channels in order to secure a "true" information flow and avoid rumours and speculations. Another important activity has been a three hour training course for all managers on the theme," to lead and live during change".

10.3 Regulatory control

SSM undertakes a number of regulatory measures in order to make sure licensees give adequate priority to safety. Some examples are the following:

Inspections and reviews (most major and minor inspections and reviews as described in section B8.3) are targeted to assess how safety is prioritised. Examples are inspections of the licensee safety programmes, management of organisational changes, management of safety review, management and assessment of incidents (conservative decision making).

Investigations in connections with events and assessments of event reports are further described in section B19.1. SSM applies a special methodology, the so called RASK, for rapid response inspections following significant events. Also, the decision-making process at the licensees regarding the operational status of the reactor following an events or identified deficiencies has received increased attention in recent years.

Another tool to follow-up that the licensees give adequate priority to safety, is the yearly integrated safety assessments (see section B8.3), which provides an updated comprehensive regulatory assessment of the safety at the facility.

Also, SSM follows the licensees work with safety culture issues mainly through its regular inspections. The role of SSM in this context is to ensure that the licensees have proactive safety management. 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.

10.3.1 Regular top management meetings with the licensees.

The Director General of SSM and the department directors meet with the management group of each nuclear power plant and other major facilities at least once a year to discuss current issues and safety priorities. There are also annual meetings with the corporate executives of the utilities.

10.3.2 Special supervision

<u>Ringhals NPP</u>

In July 2009, SSM placed RAB under special supervision in order to monitor more closely the safety situation on the premises of the licensee. SSM issued a decision related to the special supervision including special conditions for the operation of Ringhals NPP. The background of the decision was a number of safety-related events over the course of several years (2005-2009).

In June 2013 decided that RAB had showed such progress and stability in improvement activities that there was no longer any need for special conditions for the operation of Ringhals NPP. This also terminated the special supervision of RAB. Considerable positive developments in the strengthening of leadership, operational experience activities, the following of documented routines, safety assessment and management follow up were noted by SSM. In summary, SSM's findings showed that RAB's comprehensive improvements and corrective actions had dealt with most of the organisational weaknesses and had established more solid and systematic approaches to their safety activities.

<u>Oskarshamn NPP</u>

In December 2012, SSM placed OKG under special supervision and issued a decision related to the special supervision including special conditions for the operation of Oskarshamn NPP. This was due to identified deficiencies in the defence-in-depth, including weaknesses in strategy and prioritisation, plant status needs analysis and needs description, leadership and management, organisation and work processes, and quality control. Since then SSM has followed OKG's comprehensive improvement program and conducted extensive supervision in order to make sure OKG's efforts result in the rectification of the identified deficiencies.

Today, SSM' findings show that OKG continues to strengthen and develop its organisation. Strong management follow-up and enhanced processes for long term plant strategies have given OKG much better conditions for the safe operation. However, SSM still finds issues that are deemed to be symptoms of the original weaknesses and therefore continues with the special supervision.

10.3.3 Strengthened supervision due to early shut down decisions

In 2015, SSM decided to strengthen the supervision of RAB and OKG due to the decisions of early shutdown of Ringhals units 1 and 2 and Oskarshamn units 1 and 2 in order to follow the situation more closely. SSM focuses on the activities that the licensees are initiating in order to manage the new situation. Issues that are observed are specific decision points, communication activities, competence and staff retention, support to managers (including the ability to lead through times of change and to cope with the situation at hand), wariness, motivation, commitment and fitness for duty, assessments conducted, and the capability to maintain the safety level and the safety culture. The strategy is to monitor the licensees continuously in the preparations for and during the decommissioning.

10.4 Measures taken by SSM to prioritise safety

One of the basic ideas of SSM's management system is that SSM is to devote its supervisory resources to the most important safety issues. The annual activity-planning process has, as its starting point, the current regulatory challenges, which are documented, as well as input from SSM's integrated safety assessments and other regulatory processes. The supervision database in use is an important tool for the integrated safety assessments but is also used to support SSM in prioritising the forthcoming supervisory activities related to the most important safety issues. Inspection results, international work, research and other inputs could indicate that SSM needs to devote regulatory resources to specific facilities and safety issues. Furthermore, the general safety regulations (SSMFS 2008:1) allow SSM a flexible approach with regard to the review of modifications to the plants, safety cases and technical specifications. The licensees have to notify SSM of such modifications. SSM has an established procedure with specified criteria to assess the notifications and to decide which are important from a safety point of view (see section 14.3.5). This system allows SSM to concentrate its review resources on the most important safety issues and at the same time retain full insight and control over the measures taken by the licensees.

10.5 Conclusion

Sweden complies with the obligations of Article 10.

11. 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 last national report

During the current review period, the following developments have been made with regard to the obligations of Article 11:

- Significant financial funds have been invested in Swedish nuclear power plants during the last few years.
- Transfer of competence is still of high priority at all Swedish nuclear power plants.

11.1 Regulatory requirements

In order to obtain a licence in Sweden, large economical resources must be committed in order to manage the far reaching safety obligations required in the Act on Nuclear Activities and SSM regulations. Every presumptive licensee must be assessed in this respect. In addition to this basic requirement, licensees must pay a fee on every produced kWh to a state controlled fund, the Nuclear Waste Fund, according to the Act (2006:647) on Financing of Management of Residual Products from Nuclear Activities. This is to ensure the financing of decommissioning, handling and disposal of spent fuel and nuclear waste, including the research needed for these activities. The amount is calculated based on an operating time of 40 years. In the event of a longer operating time, fees for the handling the additional spent fuel will have to be paid, but all the fixed costs are included in the cost estimate for 40 operating years. In order to account for earlier shut down, the licence holders must also provide financial securities to the Nuclear Waste Fund[7]. Licensees also have to pay regulatory and research fees invoiced by the regulatory body. These fees are determined in Ordinances and are paid to the Government (see also section B8).

Regarding human resources, the SSM general safety regulations (SSMFS 2008:1) are clear about the staffing, competence and training of personnel at the nuclear facilities. The licensee has to ensure that the staff has the competence and suitability needed for all tasks of importance for safety and this has to be documented. Long-term planning is required in order to ensure enough staff with sufficient competence and suitability for the safety related tasks is available. A systematic approach should be used for the definition of competence requirements, planning and evaluation of all safety related training. Annual competence assessments shall be performed. These general requirements apply also to the extent applicable on the use of contractors. It is also a requirement that there is a careful balance between the use of in-house personnel and contractors for safety related tasks. The competence necessary for ordering, managing and evaluation of the results of contracted work should always exist within the

[7] The average fee for 2015 is 0.035 SEK/kWh. Required financial securities amount to 14 billion SEK.

organisation of a nuclear installation. For operational staff at the nuclear power plants and research reactors there are more specific regulations (SSMFS 2008:32, see section B7.2). These regulations also include operations managers and plant managers to the extent the latter are involved in the operational decision-making. Operational staff must be formally authorized by the licensee for the specific position. The authorization is valid for three years under certain conditions.

11.2 Financial resources to support the safety of the nuclear installations

The majority owners of the Swedish nuclear power plants are Vattenfall and Sydkraft NP, with ownership shares as shown in Figure 2 in Chapter A. As mentioned in Chapter A, 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 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.

All safety investments in the nuclear power plants have so far been financed by corporate funds, as decided by the utility boards, on commercial grounds for the licensees. This means that realistic plans for writing off the investment have to be made. Costs for safety improvements are considered to be an integrated part of the operating costs. A high safety level, demonstrated by a good safety record, is considered an essential component of the total business concept.

11.3 Staffing and training for safety related activities at the nuclear power plants

11.3.1 Staffing situation

The Swedish operating organizations were previously considered to be small compared to most other nuclear power plants around the world. The low number of staff has to some extent been compensated by the use of a large number of consultants and contractors, among these the original vendors.

A challenging factor in the continued use of consultants is that several with experience from the start of the nuclear programme have changed positions and/or are no longer available. The number of contractors used during a unit refuelling outage, normally lasting between 2–5 weeks, is as before between 500 and 1000.

The staffing and competence planning at the plants has been reinforced over the last 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 recruiting has been assessed.

The need to "rejuvenate" the nuclear power plant organizations is obvious when considering the average age of the plants, as the average employee working today is 46 years old. In addition to these figures, about 20 employees per year are due to retire from OKG over the forthcoming years. Of OKG's circa 950 present employees, the ratio is 80/20 male-female. The situation is comparable to those at FKA and RAB.

All licensees work actively to transfer knowledge from experienced staff, who will soon retire, 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 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.

11.3.2 Transferring of competence at OKG

During the past review 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 next five years for transferring of competence, and
- from this plan create individual plans for those who are expected to leave the company within the next three 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 unit 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 will be altered in order for OKG to meet the challenges of keeping two units in decommission and one unit in long term operations. In the near future 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 2015-2050. The aim of this analysis has been to assess the need of various competencies and estimate the staffing levels during the entire expected life span of the company. When units 1 and 2 are finally decommissioned the number of employees at OKG will most likely be half of current figures.

Reducing the number of employees by half without redundancies cannot be done solely by retirements. Several voluntary reassignments are also needed to help avoid redundancies. Substantially reducing the number of external recruitments is also an obvious measure to pursue this aim. In this situation it is absolutely vital for OKG to have efficient procedures for internal transferring of staff in order to keep strategic competencies from leaving the company. OKG needs to create an environment where employees are encouraged to move between different positions; developing their competence and leaving new positions open for others.

Developing skills by on the job training will however not be enough. In obtaining new competence areas competence transformation is an important measure. OKG needs to be efficient in transforming competence for employees on positions that are no longer going to be needed. Quickly transforming employees from traditional competence areas to new areas needed in the decommissioning of the plants requires good relations with both local and national schools.

Not only the number of employees will be reduced in coming years, the number of consultants and contractors within the company is likely to fall at a quicker rate. This is a logical measure in the overall perspective but it must be carried out responsibly bearing in mind that many consultants are being used not only to cope with the quantity of the work scope but also because many of them carry high level competence profiles.

11.3.3 Transferring of competence at Ringhals NPP

In the next few years, about 30 employees are expected to retire each year from Ringhals. Strategies to transfer the important competencies are based on an annual competence and staffing plan, containing future needs and the balance between Ringhals employees and contractors/consultants. The need for competence transfer is an annual process. The "competence transfer" means an intentional learning with a clear goal in a situation where a person (mentor) with important knowledge retires, resigns or where Ringhals from a vulnerability perspective needs to change a specific skill. The mentor then transfers the competence to one or more persons (adepts) so that the knowledge is left at Ringhals.

The competence and staffing plan is based on an annual inventory regarding what strategic competencies Ringhals needs to fulfil the 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 an overall list of the persons who may be candidates for skills transfer.
- Selecting: To determine which persons' competence should be transferred.
- Competence Inventory: To create an understanding of the skills and that each mentor is expected to transfer. And select one or several "adepts" and to assess the need for support from human resources (HR) to implement all the skill changes.
- Training: The purpose of this training is that stakeholders are to have a common understanding of the following areas: what skills transfer is, what each role entails, the areas included in the transfer of skills and the support/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. Find forms for monitoring and starting skills exchange.

- Competence Exchange Activities implemented: To implement the planned activities to achieve the set of competence transfer goals.
- Monitoring and evaluation conducted: Follow up so that the objectives of competence shift are achieved and to look at experience for further process development.

11.3.4 Transferring of competence at 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 in transferring competence (knowledge, skills and attitude) consist of several steps:

- Whose competence is important to transfer? The identified need of transferring of necessary long-term competence is documented in the annual strategic action plans, following a dialogue between the respective managers and HR people.
- What kind of competence? The chosen individuals work in groups developing the existing task analysis, focusing on specific competencies of each person. In view of explicit and tacit knowledge by for example interviews, observations and verbal records, new information is gathered on performance of the tasks.
- To whom shall the competence be transferred? The results of renewed and deeper competence task analysis are used to complement available work methods for the competence transfer and documentation, e. g. instructions, material for training, work rotation, supervising/guiding, pre-job briefing, and daily working practise. Depending on the level of knowledge and experience recipients/adepts and suitable methods are identified. The measures have to 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/adept and supervisors. For those employees who shall act as supervisors the measures have to be discussed in the development dialogues and documented in the personal action plans.

11.3.5 Training of nuclear power plant staff

All licensees have a systematic approach in place for the 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.

For control room personnel an internal promotion schedule is applied in which the operators begin as field operators. The qualification time to become a reactor operator is about 5 years, and to become a shift supervisor no less than 7 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 is 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 annual re-training, partly on a simulator, divided into two periods, one focused on normal operation start up and shut down procedures and one on transients and accidents. All simulator sessions are evaluated systematically.

Competence assessments are performed every year by operations management against specified criteria to check the required competence for the specific position and to define further training needs. Every three years a more extended check is made also with regard to fitness for duty. This extended check is required in order to issue the authorization which is valid for three years. The systematic approach is being extended to maintenance staff and other groups with tasks of importance for safety.

The line managers of the operating organizations 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 fed into the training programmes.

KSU has significant resources for training and production of training material. In 2015 the company had 245 employees. The total numbers of training days per year during the review period vary between four and five thousand; see Table 7. KSU also has an extensive instructor training programme for its own staff with several qualification levels.

Year	Training Days
2013	4 780
2014	4 572
2015	4 226

Table 7: Training days per year during the current review period.

Since year 2000 most operators 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 centres. The old simulator for both Forsmark unit 3 and Oskarshamn unit 3, which is located at the KSU central facility in Studsvik, is nowadays used for special projects and some general training still remain in Studsvik.

Since 2008 the KSU also utilizes the training of maintenance personal for the shut-downed units at Barsebäck NPP in realistic environments. At Barsebäck NPP is also provided training to the operational personnel, specifically in areas in which a realistic environment enhances the training quality. The training in Barsebäck plant will only be able to continue until about 2018–20 since the site is in decommissioning process.

The amounts of training have decreased the last few years due to the completion of the extensive modernisation programs.The amount of training days is estimated to decrease even more in the coming five years due to the decommissioning of four units at Swedish NPPs (see Figure 8). The estimation is uncertain, however, because the need for future training in decommissioning activities it is expected that the training needs will probably slightly increase.

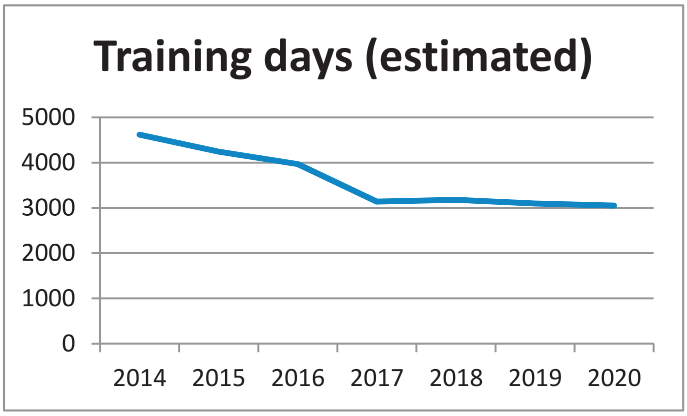

Figure 8: Training days of plant NPPs staff and estimation for coming years.

11.4 Regulatory control

Through its oversight, SSM has concluded that the licensee's compliance with SSM's requirements on 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 over several years observed delays and quality problems in the modernization and power uprate programmes at the nuclear power plants. It is paramount that these problems do not affect the safety of the plants negatively. SSM is therefore continuing to focus attention on the licensees' systems for ensuring quality of services purchased, e.g., assuring supplier and consultant competence. Also, The licensees' reliance on contractors and consultants might decrease in the forthcoming years, due to a planned permanent shutdown of the four oldest units. If this will affect the long-term availability of specialists of different contractors is difficult to predict, and is therefore something that will be considered by SSM in its supervision.

11.5 Situation with regard to the national availability of qualified experts in nuclear safety and radiation protection

In a report to the Government in 2011, SSM presented an analysis showing that the availability of competence in the nuclear field was satisfactory. Based on this, SSM's conclusion in the previous review report was that no special measures were needed in the nuclear field. SSM however noted that some future challenges may have an impact on the national availability of expertize; the generational shift among staff.

The new situation in Sweden with the decision to permanently shut down of the four oldest reactors will have an impact on the industry and the regulatory body. However, it is difficult to predict the precise effect it will have on the national availability of qualified experts. Since the organizations will have to be reduced in staff, one could argue that it should be easy to secure resources and a good availability of competence, at least in a short term perspective. On the other hand, there is the risk that staff will leave the industry because of the fact that they do not see a future in the nuclear industry in Sweden. If a great number of people decide to change careers, Sweden would likely face a shortage of qualified experts and specific competencies. Thus, in the upcoming years it may likely be a challenge for both the industry and SSM to ensure the availability of qualified experts in nuclear safety and radiation protection.

Another challenge in the forthcoming years, for both the industry and the authority, is to build-up and strengthen the technical and radiation protection competence in decommissioning. This is essential in order to be well-prepared for these activities.

11.6 Conclusion

Sweden complies with the obligations of Article 11.

12. 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 last national report

During the current review period, the following developments are of relevance with regard to the obligations of Article 12:

- All licensees have processes for the support of human factors and organizational learning.
- The Human Performance (HuP) area has received increasing attention including e.g. more resources, training programs, seminar series and HuP learning labs.

12.1 Regulatory requirements

Most of the initiatives regarding control room design and evaluation, staff working conditions, safety management and organizational issues, earlier discussed with the utilities, are now included as requirements in the safety regulations (SSMFS 2008:1 and SSMFS 2008:17). The regulations SSMFS 2008:1 contain extensive requirements related to human factors on:

- the operating organisation, economical and personal resources,
- management system,
- safety objectives and strategies,
- responsibilities and authorities,
- planning of the nuclear activities,
- preparation for safety decisions,
- competence assurance, fitness for duty,
- staff working conditions,
- operational experience feedback,
- monitoring and follow up of safety, and
- design adapted to human capabilities and limitations.

The regulations SSMFS 2008:17 contain more specific requirements on

- design to allow operators sufficient time to understand the situation and take safe actions,
- design of the central control room and the secondary control room/control post,
- evaluation of the control room design as well as verification and validation of new solutions, and
- design requirements to detect and control core instability.

SSM requires that the licensees have adequate staff competent on human factors, to make independent safety reviews (see section B14.1) of relevant issues. There is no explicit requirement to have staff with behavioural science competence in the line organisation of the operators, but SSM recommends this in order to integrate the MTO perspective early in plant modifications, experience feedback, investigation of events, assessments of safety culture, etc.

12.2 Measures taken by the licence holders

Today the interaction between human-technology-organisation (MTO) concept has become an established component in the nuclear safety work at all Swedish nuclear power plants, supported by policies, responsibilities and organizational structures. Today, all the licensees have MTO specialists with a behavioural science background or similar industrial field experience in their independent safety review functions (see section B14). All licensees have specialist teams whose work focuses on human and organizational issues. The responsibility for these teams is to gather competence (both technical and behavioural) and to work with MTO issues, experience feedback, safety culture, management development and organizational 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 organizational modifications,
- event analysis,
- safety culture programmes, and
- specific development and analysis projects.

The Swedish licensees use a set of specific methods for the 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).

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 the control room,
- evaluation of the control room function during outages,
- team training of control room operators,
- safety climate surveys,
- safety diagnosis of the plant organisation,
- assessment of organizational modifications,
- Resilience Engineering in maintenance outage,
- Human Performance Tools in maintenance, and

- learning from successes in maintenance (i.e. Safety II)8.

12.2.1 Ongoing activities

Organizational changes

All licensees have formal procedures for the assessment and review of organizational 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.

Safety culture

An overview of the current safety culture programmes at the plants is given in section B10.2. Safety culture questionnaires are used as a tool for development of the safety culture together with other activities. A common initiative by the licensees has been taken to improve the questionnaire.

Network for Human Performance and Safety Culture

A network for Human Performance and Safety Culture (HUSC) involving the licensees in Sweden and Finland, SKB, KSU and Westinghouse, was established in 2006, and with the aim to exchange information and to develop expert knowledge in the area by annual expert group meetings.

Projects related to Human Performance and safety culture

A task to improve Human Performance relating to accidents or near misses was assigned to the safety managers at RAB and FKA during 2015. The scope was extended by Vattenfall Business Area Generation to also include safety culture. With this increase in scope, SKB were also included to take part in this improvement. The goal is that everyone working at, or for, Vattenfall (managers, employees and entrepreneurs) have a high risk awareness that always is carried with us daily, both when working and in our free time. The working out of the goal looks slightly different at SKB, RAB and FKA, as the sites have different needs in the area of Human Performance. Common themes are e.g. work with management expectations, managers in the field, improved communication between people, cooperation in work situations and continuity in training.

Seminar series to improve 'every day safety'

At FKA, a seminar series held to improve 'every day safety' with regards to Human Performance has been developed and run through the maintenance department since 2014. Both FKA employees and entrepreneurs have taken part in these seminars. A seminar for re-training is currently developed, to be rolled out during the second quarter 2016.

Human Factors Engineering

All licensees take into account the human factors perspective in plant modifications, which affect the work of operators and other personnel, to ensure that their work performance is not negatively affected, Human – System Interface (HSI). This is done through a number of analyses and by dealing with known issues in the existing configuration. The modifications are ultimately subject to a

[8] Maintenance success concept used originally in aircraft industry.

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.

Research in Human Factors Engineering

Research in the area of HSI, the best practises in main control room and research on operators need for computer-based tools, is being conducted at the Norwegian Institute for Energy Technology (IFE) in collaboration with the utilities in Sweden and Finland. Research on Resilience Engineering (RE), Human Performance (HuP) and Learning from successes in maintenance is performed jointly by IFE, VTT Technical Research Centre in Finland, Ringhals NPP in Sweden, and is sponsored by the Nordic Nuclear Safety Research (NKS)[9].

12.3 Regulatory control

The MTO section at SSM is integrated with the technical sections of the nuclear power plant safety department and participates in inspections, safety reviews and other regulatory activities. The twelve professionals in the MTO section, an increase by two in recent years, all have a behavioural science background.

Current issues for the MTO section include inspections and reviews of management systems, organisations and organisational change, safety culture, safety management, competence, training, staffing, and fitness for duty, working conditions for safety, plant modernizations, MTO perspective of plant modifications and investigation of events.

Current regulatory research initiated by the MTO section includes projects on:

- Consequences of the design and use of instructions
- Flexibility in management systems
- Gender and safety
- Safety culture and safety aspects at research facilities with radiation risks and many temporary international users.

Beside these R&D projects, SSM financing postgraduate studies and is planning to finance an associate professorship in Man-Technology-Organisation at a national university. For many years now the Authority has also provided support to the Halden Reactor Project.

12.4 Conclusion

Sweden complies with the obligations of Article 12.

[9] NKS (Nordic Nuclear Safety Research) is a forum for Nordic cooperation and competence in nuclear safety, including emergency preparedness, serving as an umbrella for Nordic initiatives and interests. It runs joint activities financed and supported by Nordic authorities, companies and other organisations (http://www.nks.org).

13. 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 last national report

During the current review period, the following developments are of relevance with regard to the obligations of Article 13:

- Internal Cooperation Areas, including e.g. quality assurance development, has been established throughout Vattenfall's Nuclear Fleet to further enhance collaboration and share experiences across the Nuclear Fleet.
- The RAB Management System has been further developed into an integrated, modernized and user-friendly Management System. RAB has also developed the process for handling of requirements, by completing the structure with correct actions and verifications.
- Within FKA a more effective audit process for outages and occupational hazard issues is newly in place due to the Occupational Health and Safety Management Systems Requirements (OHSAS 18001) certification.

13.1 Regulatory requirements

The SSM general safety regulations SSMFS 2008:1, Chapter 2, Section 8, require that nuclear activities with regard to design and construction, operation and decommissioning, shall be managed, controlled, assessed and developed through a management system so designed that requirements on safety will be met. The management system, including the necessary routines and procedures, shall be kept up to date and be documented. This view on quality and safety being integrated with other business concerns into a total integrated management system is in line with the IAEA Safety Requirements on Management Systems, GS-R-3.

It is further required in SSMFS 2008:1 that the application of the management system, its efficiency and effectiveness, shall be audited systematically and periodically by a function having an independent position in relation to the activities being audited. An established audit programme shall exist at the plant.

In the general advice to the regulations it is made clear that the management system should cover all nuclear activities at the plant. Furthermore, it should be clear from the management system how contractors and vendors are to be audited, and how to keep results from these audits up to date. 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 importance with respect to safety of the different activities and special needs that can arise. Normally all audit areas should be audited as a minimum every four years. The auditing activity itself and the management function of the plant should also be periodically audited.

13.2 Measures taken by 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 sixth national report, certain changes in the basic principles have been made to one of the management systems currently in use. RAB has launched an updated Management System, with greater focus on integrated processes and information modelling.

At Vattenfall corporate level a peer network consisting of representatives from the license holders continues to collaborate in order to support further development of integrated management systems at each level. Internal Cooperation to improve requirement handling has also been established. The Management system reviews are in compliance with IAEA Safety Standard RS-R-3, and are performed in order to ensure the continuing suitability and effectiveness of the management systems in use.

Forsmark NPP

Continuous improvement of the management system is a priority, including a high level of involvement and commitment from the management team. The Management System has been updated to reflect and to be in line with the new organisation introduced in October 2015.

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

FKA is in compliance with the current version of GS-R-3. A management system review was commenced to identify potential gaps when the new issue of GS-R-3(GS-R part 2) were published.

A more effective audit process for outages and occupational hazard issues is newly in place due to OHSAS 18001 certification.

Ringhals NPP

The RAB Management System has been developed into an integrated, modernized 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 have also developed the process for handling of requirements, by completing the structure with corrective actions and verifications. The ambition for RAB is to fulfil external requirements on management systems, derived from nuclear as well as conventional industry models.

Oskarshamn NPP

OKG is presently developing and updateing the management system. The steering documents have for instance been developed further with a major focus on clarifying the allocation of responsibility, authorizations and delegations.

All departments and sections within OKG have their own management manuals. Training sessions on the management system and its structure have been systemised and standardised.

13.2.2 Audit programmes

At the licensees corporate level, review programmes are in place to help ensure and confirm that the 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 audit programmes. These 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 four-year period. At FKA and RAB, audit teams consisting of 2-4 individuals who are experienced in the review area and an audit team leader. The audit programmes in use fulfil the requirements on independent assessment in the IAEA Safety Guide GS-G-3.1.

FKA and RAB also have different methods for self-assessment. The management system at both plants requires that self-assessments shall be performed at different levels in the organisation. Both methodes for performing self-assessments are based on IAEA Safety Guide GS-G-3.1.

During this review period, changes were implemented within the internal quality audit organisation at OKG. This to strengthen the compliance to internal and external requirements. Established teams review the same areas for a period of three years and there is also an assigned counterpart for each audit area.

13.2.3 Audits of suppliers

Audits of suppliers are carried out jointly and in cooperation between the Swedish licensees. There is also a joint teams for management and supervision of supplier audits. 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

SSM has reviewed the management systems of all the plants and concludes that they comply with the regulatory requirements. Each year, SSM checks the licensee’s work to improve their systems. In addition, SSM meets with each licensee annually to review which internal audits have been carried out and their results. SSM concludes that the internal audits at all plants are managed and conducted in a satisfactory manner.

13.4 Conclusion

Sweden complies with the obligations of Article 13.

14. 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 last national report

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

- SSM are undertaken a comprehensive task in clarifying requiremnts and the integration between safety, security and radiation protection, with the goal toregulate them together in the new regulatory requirements which are planned to be implemented during the fall of 2017. In this work, special attention is directed towards regulating PSR.

14.1 Regulatory requirements

14.1.1 Verification by safety assessment

Requirements on safety assessment, safety review and reporting are defined in Chapter 4 of the regulations concerning safety in nuclear facilities SSMFS 2008:1. The legally binding requirements and the corresponding general advice can be summarized in the following points:

- A comprehensive deterministic safety analysis shall be performed before a facility is constructed and before it is taken into operation. The analysis shall subsequently be kept up-to-date. The analyses shall be based on a systematic inventory of events, event sequences and conditions which can lead to a radiological accident. In addition to the deterministic analysis, the facility shall be analysed using probabilistic methods in order to provide a more complete picture of safety. The regulations' general advice helps to determine the acceptability of using probabilistic arguments when assessing the design and operation of a reactor facility.
- A preliminary safety analysis report shall 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) shall 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 of safety reviews (see section 14.1.3) before submitted to the regulator. All stages of the SAR shall be reviewed and approved by SSM. Thereafter the safety analysis report shall 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. In the general advice SSMs expectations concerning the structure and contents of the SAR are further described.
- Licensees have to notify SSM of significant events and all plant and organizational modifications affecting conditions reported in the SAR, as well as modifications to the SAR itself and the Operational Limits and Conditions (OLC). The statement of the independent safety review made by the licensee must be attached to the notification.
- 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 organizational, resulting from such analyses or assessments shall be documented in a safety programme and implemented in a timely manner. The safety programme shall be reviewed and updated on an annual basis.
- SSM shall determine 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 it is clarified that the periodic review of the facility's safety and 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 levels of safety and radiation protection assumed in the licence for the nuclear facility. The general advice also specifies the periodic safety review should cover, 17 safety 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 Verification by surveillance, testing and inspection

Sweden has since the beginning of its nuclear programme had specific requirements on 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, in SSMFS 2008:1, on operations, includes requirements on continuous surveillance, maintenance and testing of structures, systems and components to ensure that they meet the safety requirements. Programmes are required for maintenance, surveillance, inspection and testing as well as for ageing management. The programmes shall be documented and kept up to date. The ageing management programme should include identification, surveillance, handling and documentation of all ageing mechanisms, which could affect structures, systems and components of importance for safety.

Functional testing to verify operability has to be performed periodically as well as before structures, systems, and components are taken in operation after maintenance or other interventions. Programmes for testing active components should reflect consequences for malfunction and the probability of this occurring. The functional testing has to be carried out with the frequency and scope that provide confidence that the equipment will function as credited in the safety analyses. Integral tests of the entire safety function should be performed. If it is not possible to fully verify the safety function by testing, it should be justified that the function can be verified sufficiently despite limitations of the testing.

Requirements regarding 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 organizations and laboratories, requirements on in-service inspection and control, requirements concerning repair, replacement and modification of structures and components, as well as requirements on compliance control and annual reporting to SSM (see Appendix 1).

14.1.3 Verification of safety decisions and Safety review

Chapter 2, Section 9, item 4 in SSMFS 2008:1, stipulates that decisions on safety issues should be preceded by adequate investigation and consultation so that the issues are comprehensively examined. In the general advice it is specified that for this purpose a safety committee should be established with the aim of functioning as an advisory group for principal safety issues. The safety committee should advise the manager who has the ultimate responsibility for safety at the facility.

Chapter 4, Section 3 in SSMFS 2008:1, specifies the requirements for the safety reviews. The objective is to make sure 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 shall be performed in two steps. The first step, the primary review, shall be carried out within those parts of the licensee's organisation which are responsible for the specific issues. The second step, the independent review, shall be carried out by a safety review function, established for this purpose and with an independent position in relation to the organisation responsible for the specific issues.

In the general advice it is specified that primary safety review should be as complete as possible, not take credit for the outcome of an independent review and typically address:

- that the motives for implementing a measure are acceptable from the standpoint of safety,
- that presumptions and delimitations as well as input data for analyses, investigations and modifications are correct and reasonable, as well as that standards and other rules cited are suitable for the case in question,
- that the methods and analysis and calculation models applied are verified and qualified or well tested, that they are applicable in the case in question and that they have been applied within the parameters of their possibilities and limitations,

- that the analysis, investigation or calculation results are correct, that the measures are suitable from the standpoint of safety and that they can be conducted in the intended manner and with a sufficient level of quality, as well as that proposals for measures in response to events that have occurred or conditions that have been detected are such that they are capable of preventing a recurrence, and
- that the measures, as a minimum, lead to maintaining, yet preferably improving, the level of safety.

The general advice also specify that the independent review should not duplicate the primary review but apply another perspective and focus on:

- whether the matter has been handled in a correct manner by the line organisation,
- whether conclusions and proposals have been justified in a professionally correct way,
- whether all relevant safety aspects, including physical protection, have been considered and the relevant safety requirements been met, and
- whether the proposed measures will result in a maintained or increased level of safety.

Issues that according to requirements in SSMFS 2008:1, are subject to safety review are:

- technical or organizational modifications to a facility which can affect the conditions specified in the safety analysis report,
- principal modifications in the safety analysis report,
- modifications in emergency response plan,
- modifications in 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 in regards of deficiencies in barriers and in defence in depth and the measures taken as a result of the deficiency, and
- plans for the necessary measures to ensure safe confinement of the non-conforming waste (nuclear waste arising which, in terms of quantity and type, deviates from specification in the safety analysis report).

14.2 Measures taken by the licence holders

14.2.1 Safety analysis reports

Before constructing and commissioning the Swedish nuclear installations, comprehensive and systematic analyses and assessments of safety were performed. The analyses and assessments were documented in a final safety analysis report (FSAR), for each unit and submitted to the regulatory authority for review and approval.

The different units in the Swedish nuclear power programme were built over a time period of about 20 years up to 1985. This period was characterized by extensive development which was reflected in the scope and comprehensiveness of the FSAR documents of the units, from the first rather limited one for Oskarshamn unit 1, up to the very comprehensive FSARs for Forsmark unit 3 and Oskarshamn unit 3.

As a consequence of the temporary shutdown of the five oldest BWR reactors between 1992 and 1993, following the Barsebäck incident in 1992, the utilities initiated major reassessments of the FSAR. The reassessments started with pilot projects in 1993/94 and were scheduled for completion before 2000. The objectives were:

- to develop complete modern safety analysis reports (SAR) for all units and to verify the basis for the reports,
- to identify and present any deficiencies in safety, so that corrective measures could be taken by the licensee, and
- to recommend further measures, taking into account the recent international development in relevant safety requirements and practices.

These projects have been described in earlier national reports. Considerable work has been performed, especially for the older reactors, and it was necessary to extend the time schedules. The last project ended in 2005.

As a result of more stringent regulations in SSMFS 2008:1 the work to supplement the SARs with additional information has continued. Some additions that recently have been made or are in progress are:

- Information on how the requirements on design and construction in SSMFS 2008:17 are being met.
- Extending of the systems descriptions beyond the safety systems to include other SSCs of importance for the defence-in-depth.

Still the SARs will need to be regularly updated over the next years with the plants modifications following from the implementation of the NAcP (the Swedish national action plan developed as a result of the EU stress tests)

The safety requirements included in the SAR are regularly assessed for their applicability, and the licensees have specific procedures in place to evaluate new or revised codes and standards. These procedures include:

- Periodical check-up on the release of new codes and standards
- Assessment of the applicability of international standards and requirements
- Decision on specific application to the plant
- Revision of the requirements in the SAR

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

14.2.2 Deterministic safety assessments

The safety analyses of the Swedish plants presented in the original SARs were from the beginning essentially structured according to the US rules. The events to be analysed were divided into different classes depending on the expected frequency and significance (severity) of the event. From the beginning the highest class contains the DBA, typically a large loss of coolant accident such as: double ended guillotine break of the largest pipe. The methods and methodologies 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 part of the fission products would be released to the containment. It was then shown that the containment leak tightness was sufficient enough to limit the radioactive realises to the environment.

The introduction of the severe accident mitigation requirements in 1986 meant that a new class of accidents, including severe fuel damage (core melt), were introduced, and the SAR analyses was extended to show that the acceptance criteria for these cases (see section B18.1) were satisfied.

As a result of the new regulations SSMFS 2008:17 issued in 2005, the need for an update and extension of certain analyses was identified and these tasks were included in the reactor specific modernisation plans (see section B6.2) and completed by December 2015. The reviews and updates mainly consisted of a few external events and some beyond design basis events.

14.2.3 Probabilistic safety assessments

While the deterministic safety criteria and analysis serves as the licensing basis for design and construction of the nuclear power plants, various risk-informed applications are being developed and used as a complementary tool to evaluate and ensure the safety at the plants.

The Probabilistic safety assessment (PSA) programme started in the late 1970s with limited assessments. When the periodic safety review (PSR) programme was initiated in the early 1980s, a basic PSA study (level 1, internal events) had to be included in the PSRs In the second round of PSRs a more comprehensive PSA was required.

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 authority and at consultancy/contractors and vendors. One item of particular importance is the reliability data bases accumulated from operational experience. These data bases are available in the reability data handbooks called the Reliability data of components in Nordic NPPs (the T-book), and the 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 is in the process of being finalised and provides high quality data for piping components. Extensive development of common-cause (CCF) data was also performed in the last decade within an OECD/NEA project. These dependency data are now transferred into the domestic PSA models.

The Nordic PSA Group (NPSAG) was founded in December 2000 by the nuclear utilities in Finland and Sweden. NPSAG is a common forum for the discussion of issues related PSA of nuclear power plants, with a focus on research and development needs. The group follows and discusses current issues related to PSA both nationally and internationally, as well as PSA activities at the participating utilities. The group initiates and co-ordinates research and development activities and discusses how new knowledge shall be used. Over the years, international contacts have increased, especially with partners in Europe. This is in line with the group's aim to create a common and lasting basis for the performance of PSA and for risk informed applications of PSA in Europe.

According to the safety regulations SSMFS 2008:1, all Swedish reactors have to be analysed with probabilistic methods to supplement the deterministic safety analyses. All nuclear power reactors have complete level-1 and level-2 PSA studies including all operating modes and all relevant internal and external hazards for the sites. Work has been performed to further develop the studies and to finalize studies for low power operation, area events (internal events) and external hazards.

The basic PSA studies are expected to be updated every year taking into account the past year's plant modifications which have an impact on the PSA-result. In principle the licensees are moving towards applying a so-called *"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 earlier 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 be able to identify weaknesses in the designs and to be used to assess plant modifications, modifications of technical specifications and procedures as well as assessment of the risk significance of events.

A large number of safety improvements based on PSA have been implemented over the past years. Generally, they cover measures to protect against CCF, improvement of fire protection, improvement of operator support and improvements in maintenance and testing.

Historically, the PSA results were an important input for the modernization of Oskarshamn unit 1, which was completed in 2002, as well as for Ringhals unit 1 and unit 2 which were completed in 2009. The PSA tool has also been used in planning measures to be taken to comply with new requirements. For newer reactor generations, for which deterministic requirements are more feasible to comply with, PSAs have been used less frequently for justification of the planned measures.

14.2.4 Periodic safety reviews

Periodic safety reviews (PSR) started in Sweden in the early 1980s as a result of the Three Mile Island accident. The requirements regarding the reviews have developed over the years and are now comparable to those recommended in the IAEA safety standards.

The licensees are required to submit a PSR of each reactor unit at least every 10 years. The review shall verify that the plant complies with the current safety requirements as well as having the prerequisites for safe operation until the next PSR, taking into account advances in science and technology. The analyses, assessments and proposed measures as a result of the review shall be submitted to SSM.

Starting in 2005 the PSR included 15 defined safety areas as well as an integrated assessment. The areas are the same as those used in the SSM inspection programme (see section B8.3). From 2009 SSM has included two new areas in the PSR process: *On-site radiation protection* and *Radiation protection of the general public and the environment*.

The licensee must take the initiative to begin a PSR and must inform SSM when the planning starts. A meeting is held with SSM to discuss the proposed scope, contents and methodology of the PSR. Typically a project is formed to conduct the review, involving 15-20 staff of the licensee. One goal is to include a few young engineers in every project in order to transfer knowledge. The total work effort is calculated to be of the order of 8–10 man years per PSR.

Aging management is an important issue in the forthcoming PSRs. When performing the PSR, the safety issue of long-term operation must specifically be address and it must be demonstrated (through sufficient analyses) that the plant is able to operate safely beyond 40 years of operation.

14.2.5 Safety programmes

All licensees have safety programmes in place as required by SSM regulations SSMFS 2008:1. The programmes are part of the management system documentation. They contain priorities and time schedules for technical, organizational and administrative measures to be implemented as a result of safety analyses, audits, safety culture surveys and other evaluations performed at the plant.

14.2.6 Verification by surveillance, testing and inspection

A number of different verification programmes are used 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. These programs can be gathered in the groups: surveillance, in-service inspection, preventive maintenance and safety reviews. The programs have been further described in earlier national reports. The following are the most important points.

Surveillance

The operational limits and conditions (OLC) are developed to ensure that plants are operated in accordance with design assumptions. The document is commented in more detail in Chapter 19 of the report. The OLC document also clarifies what types and with what frequency functional tests are to be carried out in order to verify 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 paid to the verification of the operability of safety systems when going from shut-down to a power operating mode, and is ensured today by the use of a large number of parameters, computerised tools and new procedures. The operability is further commented on in Chapter 19.

In-service inspection

In order to document the industry's interpretation of the regulations issued in 2005 (SSMFS 2008:13), the Swedish licensees have revised their earlier common document serving as an industry standard. This document is divided into general, technical, quality control, and in-service inspection requirements; and has served as support for the development of plant specific documents in these areas.

Organizations required for the 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.

The regulations require that all safety related components are 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 relevant research information. The volume of inspections is high, between 1,000 and 5,000 inspections and tests per site are performed every year.

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

Preventive maintenance

Maintenance is optimised with regard to the relation between corrective and preventive maintenance. The preventive maintenance implemented at the Swedish nuclear power plants includes predictive (condition-based), periodic and planned maintenance, and serves the purpose of maintaining equipment within its design and operating conditions and extending its life, thereby eliminating, or at least minimizing, the risk for failures that can limit safe and reliable plant operation, or result in forced outages. A well-balanced preventive maintenance programme is based on engineering analysis for which safety as well as economic aspects are considered. The programme is well defined and periodically revised as additional operational experience is gained.

Predictive maintenance results are used to trend and monitor equipment performance so that planned maintenance can be performed prior to equipment failure. Examples include the following:

- Vibration monitoring and diagnostics
- Acoustic analysis
- Lubrication oil and grease analysis
- Non-destructive examination
- Bearing temperature analysis
- Insulation analysis
- Valve diagnostics/Active power measurement

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. Typically, 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 regulations SSMFS 2008:17 allow 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).

Optimization is also carried out in order to find the right balance between maintenance and equipment modification.

Modification activities are also carried out as part of the Plant Life Management (PLM) programme, which deals with the life expectancy of components, to fulfil the total plant life expectancy. Various PLM-programmes exist at all the nuclear power plants. They are part of the long-term plans and strategies included in the safety programmes.

14.2.7 Safety reviews

In order to verify that the operation of the 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. operations 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, independent, review is then performed by an independent department or function within the licensee organisation. This independent department or function shall not been 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 used to back up the function.

The objective of the secondary review is to assess whether the primary review has included the relevant types of analyses and investigations, and that it is of sufficient quality, rather than to repeat 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 levels of the power plant organization. There are review committees at the operating unit level, and also at the power plant level (see section B10.2). These consist of individuals representing different disciplines in order to achieve a broad view of the subjects discussed. The members are appointed on the basis of their personal qualifications and knowledge. On some committees and councils there is also one or more external member.

Committees working at the 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 to plant modifications. Committees working on the power plant level focus on issues of principle such as safety policy and strategy, the plants' adherence to the authority regulations, and general reviews of the safety and quality activities.

14.2.8 International reviews

See sections B 9.2 and B 10.2

14.3 Regulatory control

14.3.1 Safety analyses and safety analysis reports

SSM has reviewed updated safety analyses and revised safety analysis report as a result of notifications related to plant modifications, measures taken following the stress tests, power uprates and the modernization programmes to comply with SSMs regulations concerning design and construction of nuclear power reactors, SSMFS 2008:17.

SSMs reviews aims at verifying that the updated SAR reflect 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.

Probabilistic Safety Analysis (PSA)

PSA reviews and follow-ups are a continuous task for SSM. Since 2014 licensees are submitting a yearly report to SSM which includes information regarding the PSA status as well as relevant information regarding plant changes, method changes, R&D and operational experience of importance for the plant specific PSAs. SSM PSA oversight supervision also includes reviews of living PSA reporting, treatment of fire and other hazards in the PSA, topical meetings with licensees and site visits on a yearly basis. Additionally a SSM PSA review may be initiated as a result of notifications regarding plant modifications or other measures taken by the licensees. Another important part of the SSM PSA supervision is to examine the processes used by licensees, for instance to ensure that PSAs are used in all relevant applications.

Furthermore, SSM follows the PSA development internationally by participation in PSA working groups and R&D networks such as the Nordic PSA group (NPSAG) and OECD/NEA Working Group on Risk Assessment (WGRISK), as well as through participation in other international meetings and conferences.

14.3.2 Periodic safety review of nuclear facility

Periodic safety reviews (PSR) of nuclear facilities in Sweden are required in accordance with the nuclear activities act (1984:3). The law states that an overall assessment of the facility's safety and radiation protection shall be conducted at least every ten years. 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 shall 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 a safe long-term operation of nuclear facilities in Sweden. SSM formally decides the dates when each unit should submit their PSR (see Table 8).

Reactor unit	Submission date	Expected date for SSM review to be published	SSM review
Oskarshamn 1*	Specific areas in April 2017. Complete assessments in December 2017.	2018	2017–18
Oskarshamn 2*	Specific areas in April 2017. Complete assessments in December 2017.	2018	2017–18
Oskarshamn 3	Specific areas in April 2017. Complete assessments in December 2017.	2018	2017–18
Forsmark 1	April 2018	2019	2018–19
Forsmark 2	April 2018	2019	2018–19
Forsmark 3	2015	December 2016	Ongoing
Ringhals 1	2015	2016	Ongoing
Ringhals 2	2015	2016	Ongoing
Ringhals 3	April 2019	2020	2019
Ringhals 4	April 2019	2020	2019

Table 8: Schedule for future PSR.

SSM requires that licensees present a plan for conducting the PSR in order to find an agreement upon the overall arrangements including the scope of the PSR, the methods used in the analyses, etc. SSM are maintaining a dialogue and host frequent meetings with the licensee during the entire PSR process. When PSRs are submitted to SSM, SSM conducts comprehensive reviews and assessments of the submitted reports and their references. In its reviews, SSM will compare the statements made by the licensees with findings from the regulatory reviews. The regulatory assessments of the PSRs are submitted to the Government.

In recent PSR reviews, SSM has concluded that the safety improvements suggested by the licensee have the potential to provide an appropriate basis for continued operations. SSM also identified additional areas of improvements to

*The owners of Oskarshamn 1 and 2 have announced that they plan to permanently shut down the reactors in 2017. If the decision is realized, it may influence the requirements and the submission dates for these units.

ensure safe future operation of these reactors. SSM decided that the licensees should implement actions to improve the identified weaknesses in a timely manner, and for each unit, specific dates for the completion of the required actions have been defined.

Some of the safety improvements that have been identified by SSM, during the recent PSR reviews, relates to long-term operation of the oldest units in Sweden. The licensees have now decided to permanently shut down the oldest four units in the near future, during 2017–19, see Chapter A. Because of these decisions, some of the actions prescribed by SSM may, therefore, no longer be necessary.

14.3.3 Inspection and testing of plant structures, systems and components

The regulation SSMFS 2008:13, sets requirements for certain inspections and inspection intervals of 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 principles and rules for allocating inspection groups have been reviewed and approved by SSM. The inspection programme resulting from the use of the principles shall be reviewed by the accredited inspection body to certify that the program fulfils the regulations and additional SSM decision rulings.

Three inspection groups, A, B and C, are used where A includes components with the highest relative risk and C those with the lowest. The relative risks can be assessed with qualitative or quantitative methods as described above. In inspection groups A and B, the non-destructive inspection systems used shall be qualified by a NDT qualification body to detect, characterize and size any existing defects to the required standard. The Forsmark and Oskarshamn power plants use this kind of qualitative risk-informed models for in service inspection.

As far as concerns Ringhals NPP, 2–4 quantitative risk-informed models are used to optimize the inspection programmes. In these programmes, probabilistic pipe failure models are combined with consequence evaluations from the PSA to guide inspections of piping components. The rationale for using these models is to perform inspections where it is most justified in terms of the relative risk of core damage or risk of release of fission products. SSM must ensure that the changes in the inspection programmes can be implemented without an increased risk of core damage and releases to the environment. SSM has imposed strict requirements on input data and validation of the models as well as improvement of the models as new information and data become available.

As well as the division into inspection groups, mechanical components shall also 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 the quality assurance measures needed for repairs, replacements and plant modifications.

Hence, the Swedish system builds on the regulator, SSM, setting up a framework (the regulations) including principles, methods and modes for inspections and testing. An accredited inspection body reviews the inspection programmes in detail and issues certificates of compliance with the SSM regulation. A qualification body, approved by SSM, qualifies the non-destructive testing systems used and certifies their suitability for the component and application in question. The inspection companies (laboratories) conducting the inspections must be accredited for the tasks and methods they use with regard to quality system, technical procedures and competence by a national accreditation body. In Sweden, this is 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.

14.3.4 Ageing management

As stated in section B14.1.2, SSMFS 2008:1 requires an integrated programme for management of degradation due to ageing. The programme needs to include all structures, systems and components of importance for safety. This includes mechanical, electrical and I&C components. Also concrete structures needs to be included in the ageing management programs.

In recent years, SSM has intensified its reviews and inspections of the NPP's program for aging management, considering that the Swedish NPPs are getting older. SSM has in their inspections found shortcomings in some of the plants aging management, and has therefore requested that licensees correct these deficiencies. Follow-up reviews and inspection are done to control that the measures taken by the licensees having the intended effect.

14.3.5 Review of notifications

According to regulations, licensees have to notify SSM of all plant and organizational 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.

The notifications must be substantiated and justified in such a way that SSM can assess that they comply with the regulations. SSM occasionally makes its own analyses to verify the calculations submitted by the licensees. SSM also checks that this independent review attached to the notification has sufficient quality. If SSM is not satisfied with a notification, the licensee has to supplement 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.

Notifications dealing with new or complex technology are most often reviewed further by SSM, if necessary assisted by external experts. Larger plant modifications have to be notified as a preliminary safety analysis report in order to systematically clarify all the interactions with the existing safety case. Before test operations, the preliminary safety analysis report must be supplemented so that it justifies the finalised detailed design solution and presents a demonstration of safety. Following the commissioning and the first entry into routine operation, necessary findings shall be incorporated in the SAR and the SAR shall be finalised so that it describe and represent the nuclear power plant as-built status.

A standing group of experts (ABG) has been established by SSM in order to make a first assessment of all notifications. The group makes a proposal to the reactor safety management meeting regarding each notification. The proposal are as follows:

- No further action
- To be postponed until the notification meets the expected quality
- The notification should be further reviewed in specified aspects
- The proposed modification shall not be allowed until SSM has reviewed the documentation further.

For this first assessment, a set of criteria has been developed on the safety significance of the notification, other relevant circumstances, and the degree of confidence SSM has in the independent safety review process of the licensee. For instance, if a notification has to do with new or complex technology, is of high safety significance or if confidence is low, there is a high probability that a notification will be reviewed further. The department head makes the final decision whether to review or not.

SSM has over ten year experiences from this process. The pre-review of notifications is today a well-functioning routine which works well and meets the expectations of SSM. It is also clear that SSM has the necessary regulatory control of the modifications, without having to review everything in detail and issue approvals. This has enabled SSM to allocate resources to more important safety tasks. The ABG criteria in use sort about 20–25% of all notifications into the recommendation "review to be performed".

Between 2011 and 2013 the review recommendations increased sharply, peaking at ~45% increasing in 2012. This was mainly due to large projects at the NPPs such as modernization, power uprate and life-extension projects. SSM experienced an increased workload during this time.

Since many of the large modernization projects have been finalized during the review period, the number of review recommendations issued by the ABG have decreased steadily back to nearly the same levels as before. The number of review recommendations, to compare with top level in the previous years, was just 30% in 2015.

The statistics of the number of notifications to SSM regarding the operating NPPs 2013–15 can be seen in Table 9.

Year	Licensee	Number of notifications	Further review	Prohibited until further notice
2013	FKA	57	27	1
	OKG	56	21	1
	RAB	75	34	0
	Total	188		
2014	FKA	34	5	1
	OKG	42	11	0
	RAB	90	44	0
	Total	166		
2015	FKA	50	17	1
	OKG	62	15	0
	RAB	70	23	0
	Total	182		

Table 9: Number of notifications to SSM regarding the operating NPPs, 2013–15.

14.4 Vienna Declaration on Nuclear Safety

This section, in reference to Article 14, describes how Sweden implements the second principle of the Vienna Declaration on Safety.

In section 14.1.1 the regulatory requirements for verification by safety assessment are presented.

In section 14.2.1 through 14.2.6 the licensee implementation of the regulatory requirements for verification by safety assessment is presented.

In section 14.3.1 through 14.3.2 regulatory activities to follow up on the second principle of the Vienna Declaration on Safety are presented.

An important instrument for implementing of the second principal of the Vienna Declaration on Safety is the periodic safety review (PSR) process. In the fourth bullet in section 14.1.1, regulatory requirements regarding the PSR are described. In section 14.2.5 the licensee work with the PSR is presented. In section 14.3.2 the regulatory supervision in regards of PSR is presented.

14.5 Conclusion

Sweden complies with the obligations of Article 14

15. 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 last national report

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

- An extensive revision of the Swedish legislation is ongoing including the SSM Code of Statutes with regard to implementing the binding requirements of Council Directive 2013/59/EURATOM of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom .
- Focus on reducing doses to the most exposed workers has continued with a positive effect; the number of individuals exceeding 10 mSv per year has decreased significantly the last ten years. The yearly collective dose to workers has been relatively stable during the review period.
- Radiation protection education and training has been regularly reviewed and strengthened.
- Efforts to reduce releases of radioactive substances to air and water have been effective and the activity amounts, as well as the corresponding calculated doses, have decreased or remained at the same order of magnitude.

15.1 Regulatory requirements

National radiation protection regulations are specified in the SSM Code of Statutes (SSMFS). A brief general description of SSMFS is provided in this report's section B7.2 and a list of relevant regulations with a description of corresponding content, is given in appendix Appendix 1.

The Swedish occupational radiation protection requirements aimed at the nuclear facilities, at present, are in accordance with the binding requirements of the *Council Directive 96/29/Euratom of 13 May 1996, laying down basic safety standards for the health protection of the general public and workers against the dangers of ionising radiation.* The requirements were also summarized in the 4th Swedish national report.

An extensive revision of the Swedish legislation including the SSM Code of Statutes with regard to implementing the binding requirements of the *Council Directive 2013/59/EURATOM of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom* is on-going, see section B7.2.3 and B7.4.2.

15.1.1 Occupational radiation protection

The regulations in SSMFS 2008:51 and SSMFS 2008:26 contain extensive requirements related to protection of the public and occupational radiation protection in connection with activities involving ionising radiation as well as workers at all nuclear facilities. These requirements are based on the fundamental principles of radiation protection by the International Commission on Radiological Protection (ICRP), justification, optimisation of protection and application of dose limits.

Regulations regarding appointed radiation protection manager and the actual on site radiation protection expert, are specified in SSMFS 2008:24.

Regulations applying to outside workers of category A, working within the radiologically controlled areas in Sweden, as well as Swedish workers of category A performing similar tasks abroad, are specified in SSMFS 2008:52.

The regulations in SSMFS 2011:2 stipulate detailed requirements on procedures for clearance of materials, rooms, buildings and land in practices involving the use of ionising radiation.

15.1.2 Environmental radiation protection

The Swedish Radiation Safety Authority's regulations SSMFS 2008:23, concerning the protection of human health and the environment from discharges of radioactive substances from certain nuclear facilities apply to nuclear power reactors during normal operations.

The requirements comprises dose constraints for releases of radioactive substances to water and air, also requirements on monitoring all releases of radioactive substances to water and air. In addition to all non-monitored releases having to be investigated, plus setting an upper boundary for possible unmonitored leakage to air and water from each facility.

Compliance with the dose constraint is demonstrated by calculating the dose to the most exposed individual (critical group). The dose models used should calculate the dose from one year's releases integrated over a 50 year period, and the calculated dose should consist of the sum of the effective dose from external exposure and the committed effective dose from internal exposure. The dose models are to be regularly updated and approved by SSM.

The discharge limit is achieved by restricting the radiation dose to the critical group. Sweden has no statutory nuclide-specific discharge limits. The effective 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 water and air (authorized releases).

Releases via 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 radio-nuclides 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 using the Best Available Technology (BAT).

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 shall be performed according to monitoring programmes determined by SSM. The programmes specify the type and sampling frequency, sample treatment, radionuclides to consider, reporting etc.

Sampling shall be performed at and outside the facilities. The samples shall be analysed by the nuclear facilities or by external laboratories that have adequate quality assurance systems. To verify compliance, SSM performs inspections and takes random sub-samples for control measurements at SSM or at other independent laboratories.

Nuclear reactor licensees shall report annually to SSM on adopted or planned measures to limit 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.

Releases of radioactive substances to air and water as well as results from environmental monitoring shall be reported twice a year to SSM. Events that lead to a substantial increase in releases of radioactive substances from a nuclear facility shall be reported to SSM as soon as possible, together with a description of the actions taken to reduce the releases.

15.2 Measures taken by licence holders

The earlier national reports include descriptions of the measures taken by the licensees to comply with the radiation protection regulations. The following sections describe the current situation at the nuclear facilities and provide relevant examples of the ongoing work.

15.2.1 Organisation of radiation protection at the nuclear power plants

Radiation protection resources are centralised at Swedish nuclear facilities, though normally some persons are allocated to specific units. The licensees frequently hire external radiation protection (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 40–50%.

Radiation protection responsibilities follow 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 work 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.). Management plans RP work in conjunction with the overall management of the plant, and particularly in connection with the overall health and safety activities.

Ringhals NPP

A major reorganisation was conducted within RAB in January 2014. The specific "Protection" department already existed before this reorganisation. A section dedicated for safety instruments was transferred to the maintenance department. Thus, since the reorganisation, the department consists of sections dedicated for environmental protection, health and safety, physical protection and radiation protection, and a new section dedicated for education, training and development within radiation protection.

Forsmark NPP

A major reorganisation was conducted within FKA in October 2015. During the reorganisation, a new "Protection" department was created to mirror RABs organisation. Thus, since the reorganisation, the department consists of sections dedicated for environmental protection, health and safety, physical protection and radiation protection.

Oskarshamn NPP

The decisions to phase out the two oldest units at Oskarshamn NPP will affect the organizational structure in radiation protection. Measures will be taken to ensure adequate competence and resources during the future process.

15.2.2 Internal procedures for radiation protection

Work is continuing to harmonize procedures at and between sites in order to only have any site-specific procedures when necessary. This includes behaviour-related instructions, such as procedures and rules for passage of "step overs" and usage of prescribed personal protective equipment (PPE) in radiation and contamination controlled areas. Some examples of focus areas are clearance of materials, measurements of dose to the lens of the eye, enhancing practical training of exposed workers in the controlled areas, enhancing the process of making dose budgets, as well as categorisation of radiation protection related events and incidents

15.2.3 Radiation protection education and training

A total review and update of the stipulated radiation protection information, education and training, given to all personnel prior to working within a supervised or controlled area, were carried out earlier. The additional and enhanced practical training was harmonised between the Swedish nuclear installations during the review period. The training is now required by and conducted at all facilities.

The specific education of all RP personnel working with clearance of materials was ongoing during the previous review period. This education was implemented during this review period. The course on handling of radiation sources had been revised and work on harmonisation between all the nuclear installations is ongoing.

A review of in-depth radiation protection education and training for certain personnel categories, such as operations, maintenance and chemistry, was launched during the review period. Work on harmonising the education and training course between all the nuclear installations is ongoing simultaneously.

At Barsebäck, the plant under decommissioning, both units previously underwent full chemical system decontamination with a decontamination factor of >100.

This has made it possible to use the units as a maintenance training facility for staff from operating NPPs.

15.2.4 Activities to stop spread of contamination

Activities to stop the spread of contamination have been enforced further at all sites. The activities cover individual follow-ups of alarms at exit gates by identity registration when conducting the measurement, changes in work procedures, enhanced checks closer to workplaces, increased use of mobile filter units, new measurement equipment for tools and small items, as well as further increased information, education and training efforts.

Measures are continuously being taken in order to reduce releases of aerosols from the NPP in operation. These measures are equally important for stopping the spread of contamination.

At the Ringhals NPP, new equipment for clearance measurements has been purchased and implemented. Routines and logistics for the clearance process were successively improved during the review period.

15.2.5 System radioactivity measurements

On-line dose rate measurements at several places, primarily in the reactor water cooling and clean-up systems, 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.

At the Forsmark NPP, all units have on-line off-gas nuclide-specific systems for gamma measurement as a tool for early detection of fuel failures. The same type of measurement systems are in use at Oskarshamn unit 3. At Oskarshamn unit 3 a more effective system for monitoring releases of radionuclides via the main stack was installed in 2015.

A project on increasing the number of dose rate measurement instruments was initiated at Forsmark NPP during the review period. The project was identified as a post-Fukushima action, but will be beneficial during normal operation as well. A seminar on activity build-up in plant systems is conducted on a yearly basis. The source term status including recommendations for source term reduction is described in a yearly report addressed to the production units.

15.2.6 Dose reduction and ALARA programmes

The alpha value, used at Ringhals NPP in the optimisation process, has been 10,8 million SEK per saved man sievert (10,8 MSEK/manSv) since 2015. The former alpha value, since 2008, was 10 MSEK/manSv. This is still valid at Forsmark NPP. At Oskarshamn NPP the value of 11 MSEK/manSv is used since beginning of 2015. The alpha value is used when applicable. In the event 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.

All NPPs are continuing improvement of their radiation protection activities by using the principle of optimization 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 previous ten year period are presented in section B15.3.1.

During the review period, a joint ALARA Benchmark was conducted at the Forsmark and Ringhals NPPs. The benchmark mission was led by ISOE/CEPN[10]. Suggestions from the mission have been assessed and a majority of them have been included in the facility-specific ALARA programmes.

Forsmark NPP

More extensive chemical system decontamination was conducted at Forsmark unit 3 in 2011 and at Forsmark unit 2 in 2012.

A new electronic personal dosimetry system has been acquired. The new system allows work-specific alarm limits to be applied. The limits are decided when planning the radiation protection measures to be implied. FKA has also acquired a new system for teledosimetry, as well as a gamma camera to be used when building lead shielding or identifying leakages. As an administrative measure for enhancing radiation protection, workplace coaching support has been developed for foremen and other persons in charge.

Ringhals NPP

During the review period, a more extensive chemical system decontamination was conducted at Ringhals unit 1 in 2014.

A new ALARA committee has been established. The main focus for the committee is to supervise continuation of long-term development of radiation protection. The committee also evaluates the ALARA plans and objectives for individual and collective doses, and follows up radiation protection activities. Committee members are managers with personnel who work in the controlled area or can affect design and/or conditions in the controlled area, together with radiation protection experts.

A number of dose constraints have been implemented 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 has been established throughout the organisation. Each department manager now has the responsibility to establish a dose prognosis for work within the department during the year. The main focus of the activity is to spread the responsibility and dedication for 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 > 80 mmanSv, a specific ALARA plan must always be established.

At Ringhals unit 4, fuel decontamination has been performed yearly for several years. At Ringhals units 2 and 3, fuel decontamination was performed for the first time in 2015.

Also, at Ringhals unit 4, extended (number of hours) oxidising chemistry cleaning, before outage, has been performed in order to clean the reactor water systems

[10] ISOE Information System on Occupational Exposure

15.2.7 Programmes to reduce the release of radioactive substances

Plans and action programmes for the purpose of reducing releases of radioactive substances from nuclear power plants to the environment are still ongoing. Some examples of measures implemented are given here.

All sites have programmes for separation and minimization 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

Most of the measures mentioned in earlier national reports were implemented in 2012. Reducing releases of aerosols has been implemented as a responsibility in the line organisation. A clear trend has been identified demonstrating that the releases have been reduced and that the measures implemented are giving good results. Some examples of routine measures implemented during the review period include using mobile filter units and a robot for cleaning the pools in the reactor hall. There is also an enhanced procedure for leakage search using forced ventilation and a gamma camera.

Planning for minimising release of aerosols is now implemented as a part of outage preparation.

Ringhals NPP

Ringhals has developed new methods for removing water borne activity and conventional chemicals from different sources. A 3,000 m^3 storage tank at Ringhals unit 1 has been installed for reuse of reactor pool water during outages. After renovation, the evaporator at Ringhals unit 1 is in operation based on a temporary permit. Releases to air from Ringhals unit 1 have been reduced by minimising leakage of air into the turbine. A new method for leak-testing using ultrasound has been introduced with good results. This method replaces traditional helium.

At Ringhals unit 2, the membrane filtration system has been permanently installed in the feedwater tank system.

A programme for cleaning fuel elements ultrasonically has been used at Ringhals unit 3 since 2012. As of 2015, the programme is expanded to include Ringhals units 2 and 4 as well. The removal of both activated and not yet activated deposits limits the general source term of the plant, which will also affect the effluents.

At the Ringhals NPP, the dose to the critical group (most exposed individual) is mainly due to C-14. The release of other radionuclides contributes less than 5% of the total dose.

Oskarshamn NPP

In 2014, off-gas flows were reduced considerably at Oskarshamn unit 1 after some operational trouble between 2012 and 2013. Oskarshamn unit 2 was stopped in 2013 to install safety improvements which clearly have resulted in minimal releases. The decision to phase out the two oldest units at Oskarshamn NPP will reduce future releases from the Oskarshamn NPP.

In-core filters in Oskarshamn unit 3 aiming at capturing foreign debris in the reactor core have been in operation since 2009. The filters are of the same size as the fuel assemblies and are placed in the reactor core. Following a preliminary evaluation which indicated that the filters gives no effect , these filters are not in operation as of 2015.

Releases of Co-60 and Ag-110m to air from Oskarshamn unit 3 have been elevated as of 2009, when the unit was uprated to 3900 MWth (see 6.2). In 2015, releases of Co-60 were at the same levels as before uprating. There is an increased focus on releases of aerosols from Oskarshamn unit 3. Increased levels of silver in reactor water began in 2009. A possible source has been found, but it has not been verified. Releases of Ag-110m are probably caused by increased levels of Ag-110m in the fuel pools during and after outages.

15.2.8 Other events and activities during the review period

Increased difficulties in planning and managing major programmes within time schedules and dose budgets were reported in the fifth Swedish national report. The situation had unfortunately not improved as much as expected during the sixth review period. During the recent review period, a joint project was launched involving all Swedish nuclear facilities on developing a method for dose budgeting with its improved quality.

Forsmark NPP

The moisture content in the steam to the turbine side at Forsmark unit 1 and Forsmark unit 2 is barely detectable after the old steam separators was replaced as part of the power uprates conducted during earlier review periods. At Forsmark unit 3, baffles were positioned on the steam separators of the reactor tank during the outage in 2007 in order to decrease vibrations. This led to an increase in steam moisture content and consequently an increase in dose rates on the steam lines, by a factor of two. The situation at Forsmark unit 3, unfortunately, is unchanged. Work to identify effective measures for lowering the moisture content is ongoing.

Oskarshamn NPP

A similar situation as the one in Forsmark unit 3, exists at Oskarshamn unit 3 since 2009.

Great efforts regarding logistics of handling and measurement of material for clearance purposes have been made at the Oskarshamn NPP. Much time has been invested in preparation of the clearance process, which has proved to be necessary in order to achieve an effective system.

15.3 Impact of the Swedish nuclear facilities

15.3.1 Worker protection

Work to improve the radiological environment and to optimise radiation doses at the reactors is described in the facility/plant ALARA programmes. An Authority's inspection in 2011 indicated a need for a clearer integration of radiation protection optimization in the line organisation. Since then, this area has improved, although there is still potential for improvement. Therefore, regular follow-up is being conducted within regulatory control.

Figure 9 shows collective radiation doses at Swedish NPPs in operation during the period 2006–15. As observed, the total collective dose over the last five years has varied due to the extent and type of work being conducted in "high" radiation areas during the outages; for instance, the Barsebäck NPP is no longer part of the dose statistics because the first unit was shut down in 1999, and the second unit in 2005.

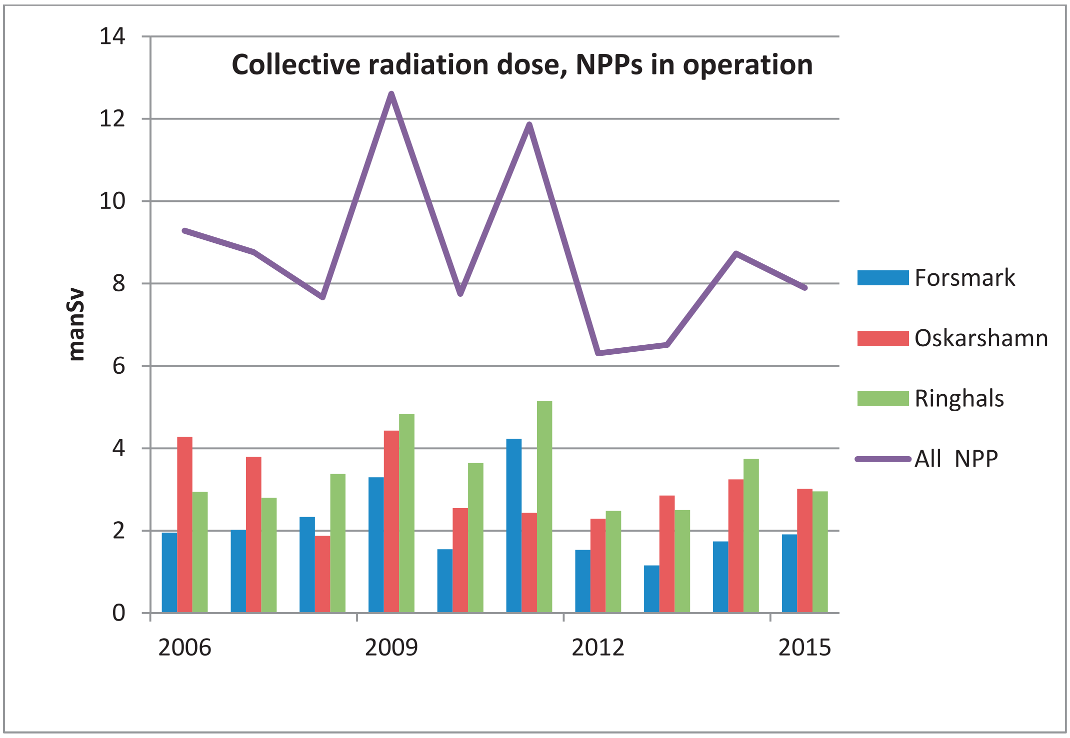

Figure 9: Collective radiation doses at Swedish NPPs in operation during the period 2006–15.

The radiation exposure is mainly due to contamination of surface layers by Co-60. However, fairly low radiation levels are achieved as a result of continuous efforts to reduce production and distribution of Co-60 in the reactor systems.

As presented in Table 10, the number of persons who received intake of radionuclides leading to committed effective dose >0.25 mSv (the Swedish limit for registration) during the last five years is constantly low.

Year	# Number of persons with a registered committed effective dose (> 0.25 mSv)	Committed effective dose [mSv]
2011	0	–
2012	1	0,4
2013	1	0,6
2014	0	–
2015	1	0,3

Table 10: Number of persons with committed effective doses >0.25 mSv at Swedish NPPs in operation 2011–15.

The low number of intakes leading to registered committed effective dose reflects low contamination levels and effective work procedures. Average individual dose increased slightly between 2010 and 2011, but decreased slightly again in 2012, and has since then remained on a relatively stable level. The number of high individual doses has been kept low.

For some specific worker categories, the average individual dose per year over a ten-year period is shown in Figure 10. Only doses >0.1 mSv in any monitoring period (≤ 1 month) are used when calculating average doses.

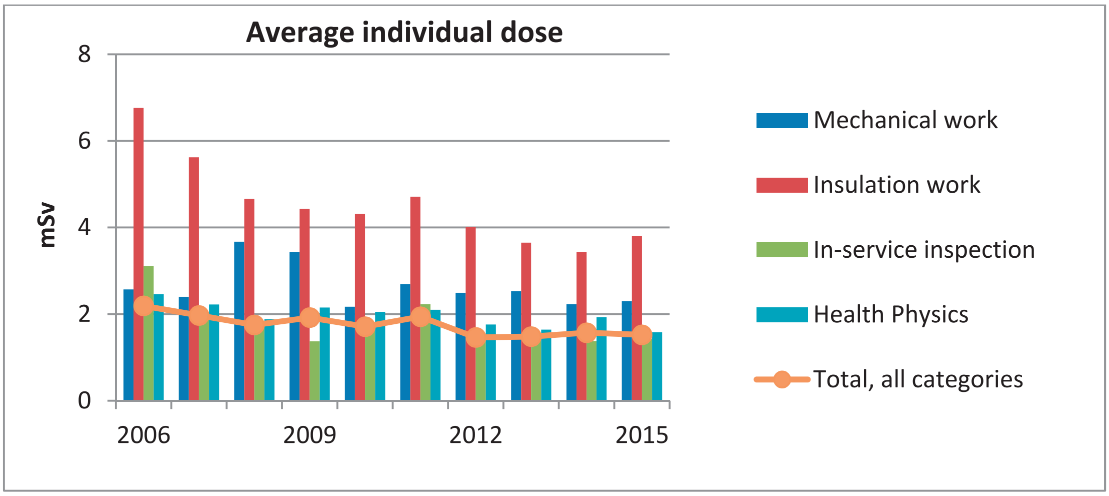

Figure 10: Average individual doses to selected worker categories at Swedish NPPs in operation during the period 2006–15.

Some statistics over radiation doses at Swedish NPPs during the same ten-year period are shown in Table 11. As can be seen there is a significant decrease in the number of individuals exceeding 10 mSv per year, which is an effect of a specific focus the licensees have put on reducing doses to the most exposed workers. Also, no annual effective dose exceeding 20 mSv has been received since 2009.

Year	Total dose [manSv]	Average dos [mSv]	Highest dose [mSv]	# Number of persons with a dose >10 mSv	# Number of persons with a registered dose (≥ 0.1 mSv)
2006	9.3	2.2	25.0	170	4 238
2007	8.8	2.0	19.5	119	4 347
2008	7.7	1.8	18.6	67	4 294
2009	12.6	2.0	22.8	127	6 403
2010	7.8	1.7	16.9	68	4 462
2011	11.9	2.0	19.3	95	5 838
2012	6.3	1.5	17.5	23	4 251
2013	6,6	1,5	16,9	20	4 416
2014	8,7	1,6	15,2	13	5 229
2015	7,9	1,5	14,2	34	5 091

Table 11: Radiation dose statistics for Swedish nuclear power plants over the last ten years.

15.3.2 Public doses and releases to the environment

SSM has issued regulations on the limitation of releases of radioactive substances from nuclear installations to the environment. The regulations limit the calculated effective dose to representative individuals in the critical group. There are no formal limitations of releases of specific radio-nuclides. However, all liquid and atmospheric releases of radio-nuclides shall be measured. The dose constraint is 0.1 mSv per year and site and is independent of the number of release points at the site. Calculation of doses includes six different age groups, and the dose limit is applied to the age group that is receiving the highest dose during the year.

Figure 11 displays the estimated radiation doses resulting from the discharge of radionuclides during the period 2000–15 at Swedish nuclear power plant sites.

The effort to reduce the releases of radioactive substances, by administrative and technical means, have been effective. The released activity amounts, as well as the corresponding calculated doses to the most exposed individuals (<1μSv/year and site), have decreased in recent years. Releases to water and air from Swedish reactors are mostly at the same level as releases from other reactors of the same type and size in other countries. Further actions to reduce the gaseous and liquid effluents are planned.

The concepts *reference values* and *target values* are used for nuclear power reactors as a measure of the application of *Best Available Technique* (BAT) for reducing releases of radionuclides. These values are defined by the licensees and are valuable in achieving the long-term objective of reducing the releases and effluents of radioactive substances.

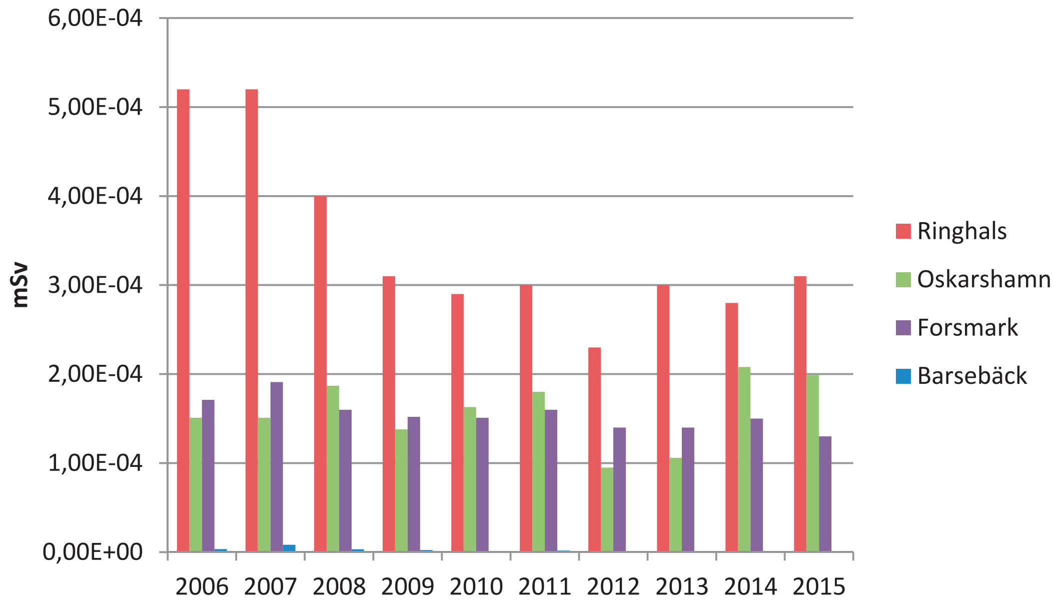

Figure 11: Estimated radiation doses in millisievert (mSv) to the representative individuals of the critical group from releases of radionuclides from the Swedish nuclear power plants for the period 2000–15.

15.4 Regulatory control

SSM inspection activities are described in section 8.3.

15.5 Conclusions

Sweden complies with the obligations of Article 15.

16. 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 last national report

During the current review period, the following developments are of relevance with regard to the obligations of Article 16:

- New regulations, SSMFS 2014:2, on on-site emergency preparedness and response entered into force on 1 January 2015. The regulation contains new provisions on endurance of the on-site emergency response organization and on the establishment of a logistics centre in a location distanced from the site.
- A national contingency plan for dealing with a nuclear accident was compiled in 2014–15. The plan describes basic conditions such as legislation, organizations involved, responsibilities and coordination in the event of a nuclear or radiological emergency.
- New monitoring stations are currently being 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. All stations will be delivering on-line data in late 2016.
- An IAEA pilot exercise was conducted in Sweden in 2015. The scenario was a terrorist attack on transport of spent nuclear fuel and radioactive waste. The purpose of was to test and evaluate the emergency management system in a terrorism-related emergency.

16.1 Regulatory requirements

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

- Act on Nuclear Activities (1984:3) (on-site emergency preparedness and response)
- SSM's regulations (SSMFS 2014:2) concerning emergency preparedness at nuclear facilities (on-site emergency preparedness and response),
- 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 Defense and Heightened Alert (2015:1053) (off-site emergency preparedness and response), and
- Health Care Act (1982:763) (off-site emergency preparedness and response)

16.1.1 On-site activities

Regarding on-site emergency preparedness and response, the Civil Protections Act (SFS 2003:778) and Ordinance (SFS 2003:789) provide general requirements on facilities conducting dangerous activities. The Act requires preventive measures and emergency preparedness to be arranged by the owner or operator of a facility conducting dangerous activities.

The Act on Nuclear Activities (1984:3) contains general provisions on emergency response in case of accidents at a nuclear facility. The Act requires the licensee to have an organisation with sufficient financial, administrative and human resources to carry out protective measures in connection with an accident in 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 more specific regulations for licence holders in the fields of nuclear safety and radiation protection. SSM's former regulations on on-site emergency preparedness (SSMFS 2008:15) have been replaced by new regulations. The new regulations on on-site emergency preparedness (SSMFS 2014:2) were issued in 2014 and entered into force on 1 January 2015. Special transitional rules were stated for some requirements that will require extra time for their implementation. As for the previous regulations, SSMFS 2014:2 uses the concept of threat categories (I, II and III) based on the IAEA emergency preparedness categories, which introduces, in the regulation, the application of a graded approach depending on the radiological hazard at the nuclear facility., SSM's regulations SSMFS 2014:2 require the licensee to take prompt actions in the event of emergencies in order to:

- classify the event according to set alarm criteria,
- alert the facility's emergency response organisation,
- assess the risk for and size of possible radioactive releases and time related aspects,
- bring the facility to a safe and stable state, and
- inform SSM.

The actions planned to be taken in the event of an 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 (on-site and off-site). The plan is subject to a safety review by the licensee and must be approved by SSM. The plan shall be kept up to date and validated through regular exercises.

SSMFS 2014:2 requires licensees of NPPs to provide an emergency response organization capable of dealing with simultaneous emergencies at all reactor units at the site over a minimum period of one week. Another new requirement in SSMFS 2014:2, that has been subject of a transitional rule allowing exemptions until 1 July 2018, states that the licensees of facilities categorized as belonging to threat category I must be capable of setting up a logistics centre in a location distanced from the site. This logistics centre should have capabilities of 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).

16.1.2 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 for 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 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, rescue commanders competence requirements , 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 radiological emergency response plan. The Swedish Civil Contingencies Agency (MSB) is responsible on national level for coordination and supervision of preparedness for an off-site rescue services response to radioactive releases.

The Ordinance with instructions for the Swedish Radiation Safety Authority (2008:452) contains provisions imposed on SSM that apply in 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 the nuclear installation in case of nuclear emergencies.

Two ordinances, SFS 2015:1052 and SFS 2015:1053, entered into force on 1 April 2016. These ordinances replace the former Emergency and Preparedness and Heightened Alert Ordinance (2006:942) that is now split into two without any major revisions of the content being made. The aim of Ordinance 2015:1052 on Emergency Preparedness and Surveillance Responsible Authorities' Measures at Heightened Alert is to ensure that governmental authorities at national and regional level, through their work, reduce vulnerabilities in the society and develop a good capacity for handling their tasks during emergencies, crises and during heightened alert. The ordinance demands, among other things, each authority being affected by a crisis, for example radiological release, to carry out the necessary measures to manage the consequences of such event. In crisis situations the authorities shall cooperate and support each other. Ordinance 2015:1053 on Total Defense and Heightened Alert contains provisions on civil defense during period of heightened alert.

16.2 National structure

The Swedish emergency management system is based on three principles:

- The principle of responsibility– meaning that the entity that is responsible for an activity under normal conditions also should have this responsibility in 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 handled where it occurs and at the lowest possible level in the society (affected municipality or county).
- Furthermore, the Swedish emergency management system distinguishes between authorities with responsibilities over a specific region (municipality, county and country) and authorities with responsibilities in specific areas of expertise, for instance SSM in the field of radiation protection and nuclear safety. The Swedish Civil Contingencies Agency (MSB) has the task of coordinating the various stakeholders.

A national contingency plan for dealing with a nuclear accident was compiled in 2014 and was reported to the Government on 31 January 2015. This national plan describes the basic conditions such as the relevant legislation and the authorities involved in the handling of an incident and the responsibilities of these authorities. The plan also describes national coordination and liaison work of relevant authorities.. The document outlines what resources are available at the national level and how they are requested and coordinated. International support is also described in the plan. In addition to this contingency plan, there is a national action plan for improvements in emergency preparedness work.

As a nuclear emergency could potentially affect a widespread area the principle of proximity does not fully apply. This is why the county administrative board in the affected county (region) is responsible for planning and leading regional emergency preparedness work involving nuclear activities with potential off-site consequences. The county administrative board appoints a rescue commander who decides on measures to be taken to protect the public, provides information and alarms to the public and is responsible for managing decontamination activities following radioactive fallout/releases. The responsibility for directing the rescue services also lies within the county administrative board in the affected county or counties unless the Government decides otherwise. Surrounding each NPP, inner emergency zones are established where potassium iodide (KI) tablets for iodine thyroid blocking and information on urgent protective actions to be taken in the event of a nuclear emergency are pre-distributed. Moreover, residents in the inner emergency planning zone are provided with special radio receivers. These are used for alerting the residents in the event of an emergency at the NPP.

The Government is responsible for crisis management at the 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 certain contacts with international organisations. The Government Offices assist the Government in the crisis management work. Within the Government Offices the responsibility principle is to be applied during times of crisis. This principle implies that the responsible ministry under normal conditions also is responsible during a crisis.

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

SSM is tasked with responsibility of coordinating the emergency preparedness and response measures necessary for preventing, identifying and detecting nuclear and radiological events that might cause damage to human health or the environment. In the event of an accident involving nuclear activities in Sweden, or outside of Sweden with consequences for Swedish citizens, SSM is the appointed National Competent Authority (NCA) and is responsible for providing advice and recommendations concerning protective measures regarding radiation protection, radiation monitoring, mitigation and decontamination following a release of radioactive substances. SSM also maintains and lead a national expert response organisation for radiation monitoring and expert support, and provide advice and recommendations to the public and the responsible authorities. SSM is also tasked with for keeping the Government informed about the situation, current and anticipated developments, expected developments, available resources and measures taken and planned following a request from the Crisis Management Coordination Secretariat at the Ministry of Justice, or from MSB, SSM is to provide the information needed in order to assess the situation. Authorities that have mandate during crises and that cooperate with SSM or receive advice and recommendations from SSM include county administrative boards, MSB, the Board of Health and Welfare, Customs, the Swedish Meteorological and Hydrological Institute, Police Authority and Swedish Coast Guard. The Swedish

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

A number of authorities, organisations and laboratories will cooperate or operate as supporting functions to the national organisations mentioned above in the event of a nuclear or radiological emergency. Participating authorities that have cooperating roles for crisis management include, for example, the National Food Agency, which is responsible for taking decisions on action levels for the content of radioactive materials in foodstuffs, and the Board of Agriculture, which is responsible for taking decisions on action levels regarding agricultural practices and products.

As mentioned earlier, MSB has a responsibility in preparedness work to support the coordination of preparedness measures taken by local, regional and national authorities. MSB also provides competent authorities with communication networks for the competent authorities during extraordinary events. MSB has overall responsibility for the Swedish national digital radio communication system ('Rakel') that connects national emergency services and others in the fields of civil protection, public safety and security, emergency medical services and healthcare during emergency situations, the system is currently being implemented or is already used by municipalities, counties, national agencies and even 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.

16.2.1 Alerts

In the event of an emergency at a Swedish NPP (threat category I) the licensee is responsible for immediately contacting the national alarm centre (SOS Alarm AB), which will alert the authorities and organisations responsible for emergency management, see Figure 12.

In the event of an emergency at a nuclear facility categorized in threat category II the alarm chain is similar but to some extent different in terms of the role of SOS Alarm AB.

In the event of a radiological or nuclear emergency abroad (with a possible request for assistance), the alert goes to the Swedish Meteorological and Hydrological Institute (SMHI), which is the national point of contact (National Warning Point, NWP). Upon an alert SMHI will, through the SOS Alarm AB, 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 with roles and responsibilities in the acute phase of a nuclear accident or incident.

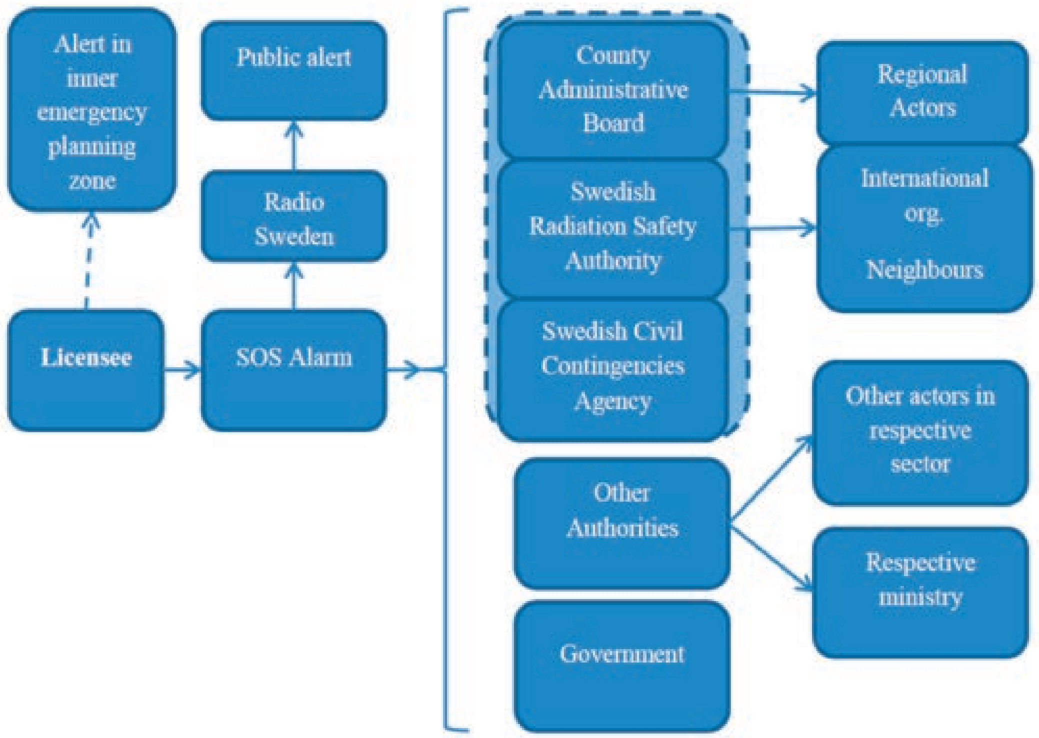

Figure 12: Current alarm sequence for an emergency event at a Swedish nuclear power plant.

16.2.2 Monitoring

Sweden has a gamma monitoring network which presently has 28 permanent stations spread throughout the country. The stations are designed to provide warnings and rapid information on radiation levels. Each gamma station continually records the dose rate and can be monitored on-line. If the integrated dose or dose rate exceeds a pre-defined alarm level the officer on duty at SSM is alerted. 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 Swedish NPPs. The new monitoring stations will provide information on the dose rate at 90 locations around these plants. While the national gamma monitoring network is primarily used as an early information system, the new stations will, when the on-line data transfere is taken in to operation in late 2016, provide fast, reliable and automatic information on dose rates to be used in the decision making on early public protective actions in case of an accident at a Swedish NPP. Figure 13 shows monitoring stations set up around Forsmark NPP.

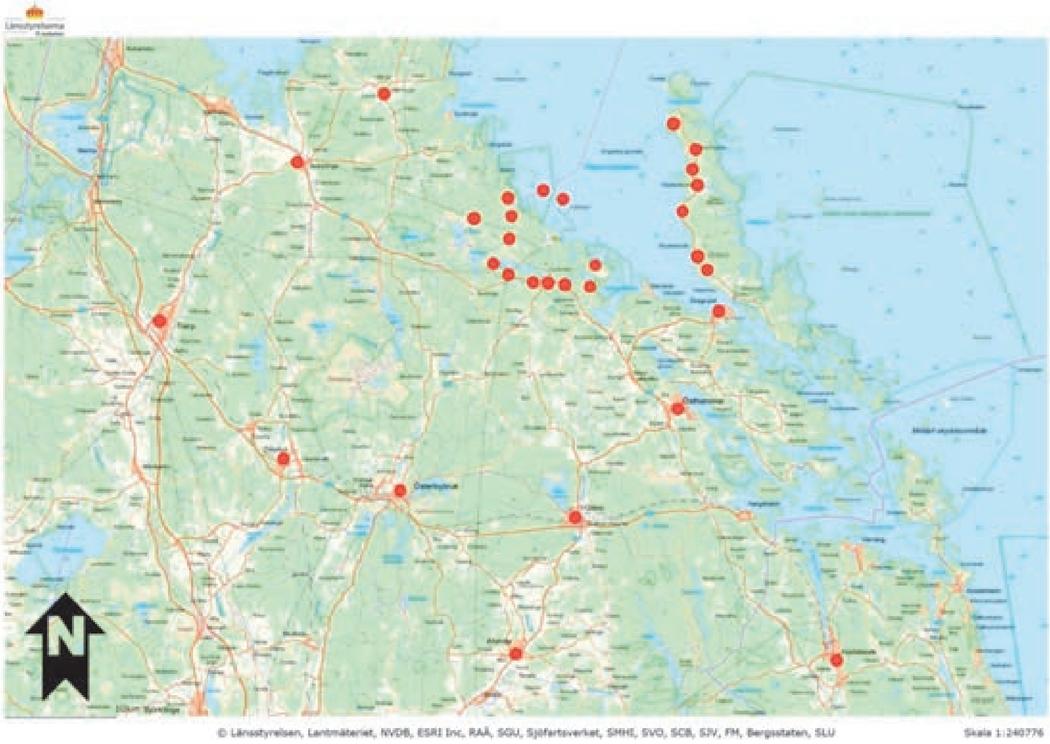

Figure 13: New monitoring stations around Forsmark nuclear power plant. Copyright: Länsstyrelserna i Sverige/The Swedish County Administrative Boards.

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 sample the air continuously in order to collect radioactive materials in the air. The air filters are regularly collected and transported to laboratory for measurement and evaluation. The system is sufficiently sensitive to measure activity levels in the order of tens of $\mu Bq/m^3$ (corresponding to approx. 100 atoms per cubic metre) and is therefore also used for environmental monitoring.

As county administrative boards are responsible for protecting the public during and after a nuclear or radiological emergency their emergency response plan also covers monitoring. Monitoring of dose rates and collection of air samples for public protective actions are performed by the local rescue services from municipalities within each county at predefined locations or routes. During a nuclear emergency the relevant county administrative board coordinate the response and monitoring activities with the national expert response organisation and authorities.

The national expert response organisation comprises authorities, organisations and laboratories with a role in emergency preparedness for and response to a radiological or nuclear emergency. The organisation is coordinated by SSM and its main purpose is to perform field measurements. Figure 14 provides a summary of the contracted capabilities covering laboratory and field measurements, mobile ground vehicle and airborne measurements, weather forecast and plume dispersion prognoses.

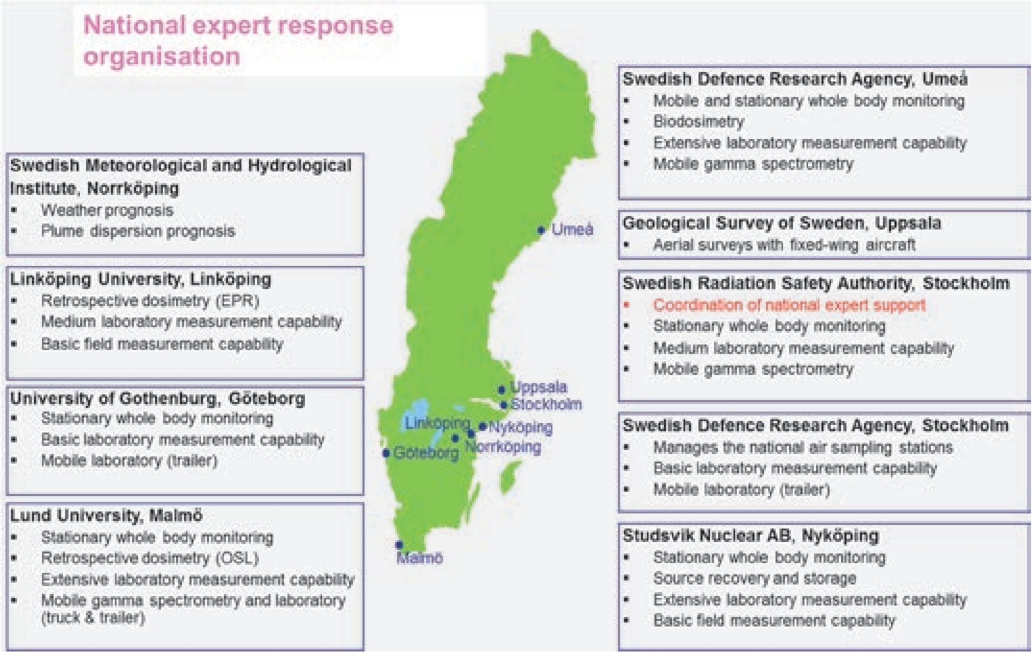

Figure 14: National expert response organisation for nuclear and radiological emergencies.

In addition to the tasks shown in Figure 14, individuals engaged in the national expert response organisation may also have a role in providing expert advice during the response.

A number of voluntary organisations, such as the Women's Voluntary Defence Service, the Women's Motor Transport Corps and the Women's Auxiliary Veterinary Corps, are prepared to provide assistance in the event of a nuclear or radiological emergency. One area of assistance that the voluntary organisations are trained for is rapid collection of agricultural field samples for transport to the national expert response organisation laboratories for measurement. This arrangement provides information to be used in the decision-making guidance for agricultural countermeasures.

16.2.3 Medical Emergency Preparedness

County councils are responsible for medical disaster preparedness. Injured persons are cared for and treated:

- through qualified medical care in the injury area, or
- in hospitals or at medical health centres.

At the major national hospitals, mainly the university hospitals, more advanced treatment and care can be arranged. Cooperation and sharing of resources also takes place between European hospitals in the event of major accidents.

The Nuclear Medical Expert Group (RN-MEG) is part of the operative emergency resources available to the National Board of Health and Welfare (NBHW) in connection with radiological incidents. They assist the NBHW, and through the NBHW also other authorities, with specific medical advice regarding for example acute and late radiation injuries, and treatment thereof. Medical doctors from the medical fields of hematology, oncology, radiology and catastrophe medicine are represented in RN-MEG.

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

16.3 Measures taken by license holders

The licensees, at all sites, are working with measures to fulfil the new requirements of SSMFS 2014:2, on *on-site emergency preparedness and response at nuclear installations* which entered into force on January 1st 2015. Measures regarding requirements on the ability to establish an off-site "logistic centre" for heavy equipment, decontamination, monitoring and follow-up of radiation doses, etc. are to be taken. The licensees also carry out measures which were identified and reported during and after the so called "EU Stress Tests" and were included in NAcP. Some more specific information of performed work is given below.

Forsmark NPP

At Forsmark NPP, a new emergency level for internal use, in accordance with requirement in SSMFS 2014:2, has been introduced for events that are not considered to have the capacity to pose a hazard to the environment or to public health. A new local emergency force, "LBS", was introduced with staff from the internal fire brigade and surveillance force. The LBS is intended to be the local "first responders" and one important task is to have the knowledge and experience needed to manage the mobile equipment (the Flex equipment) that has been acquired for dealing with unexpected events.

Mobile equipment was acquired to cope with unforeseen events. This purchase was one of the measures taken to follow-up on the experience from the Fukushima accident. The equipment includes floodlights, portable power units, bilge pumps etc. but also equipment to secure the power for the reactors safety systems in the form of mobile diesel generators. Arrangements have also been made with suitable connection points.

The number of staff has been increased for the emergency response organization. An agreement has been made with the Swedish Meteorological and Hydrological Institute in order to receive early warning about extreme weather conditions. An agreement has also been made between Swedish licensees for assistance within the radiation protection area encompassing staff and protective equipment, during emergency situations. Extra equipment was acquired for this purpose.

A new principle has been introduced so that staff that is not needed for management of an event is not present at the site in order to minimize and avoid the risks for the staff. Already when the emergency class "alert" is declared, staff which is not urgently needed is ordered to leave the site and return home

Ringhals NPP

The on-site operational support centre has been modernized at the Ringhals NPP. A new autonomic IT-infrastructure has been built to ensure access to critical software used by the emergency response organization. Satellite communication has been installed to enhance communication capability during disturbances in the national telephone system. The Internet is also available by satellite connection.

Diesel generators with a minimum seven days fuel supply have been connected to the on-site operational support centre. The generators start automatically in the event of a power loss. A new UPS (Uninterrupted Power Supply) has been installed, to ensure that there will be no interruption in the power supply to critical equipment. . It is designed to keep the Emergency Command Centre running for at least four hours. The entire on-site operational support centre is connected to the diesel generator supported grid, and critical components are connected to the UPS.

A new fibre connection has been installed and connected to the on-site operational support centre which enables the personnel in the emergency response organization to view process data from Ringhals unit 2, using the existing process information system. Servers for collecting the process data have been placed in the on-site operational support centre. The data will be available in the event that Vattenfall's Intranet should be unavailable.

The emergency response organization has been augmented by additional staff to ensure endurance for not only seven days, but also incidents involving all four units.

A new function for evacuation "Ringhals Evacuation Centre" (REC), has been implemented. Mobile equipment, to be used at the REC, for scanning of contamination, diesel generators and personal protective equipment has been acquired and placed in containers close to the plant. If needed the equipment and staff at REC can be moved to the future logistics centre.

For the future logistics centre a location and facilities have been allocated. An agreement has been signed with the owner of the facilities. The logistic centre will be set up close to rail- and highway connections at a distance of about 30km from the plant. Large areas for storage of heavy equipment and vehicles are available, as well as facilities for decontamination of vehicles. Personnel areas include locker rooms, showers, cafeterias and offices.

As at the Forsmark NPP, a new principle has been introduced implying that staff who are not needed to manage an event is ordered home as early as possible.

RAB is also part of the agreement between licensees in Sweden on assistance within the area of radiation protection, relating to staffing and protective equipment.

Oskarshamn NPP

Post-Fukushima improvement work is ongoing in the preparedness field. An example is the final stages of the establishment of an off-site operational support centre. Latest command management technology such as smartboards, sound and video equipment etc, has been installed in the off-site operational support centre. The off-site operational support centre's technology will be identical to the 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 which of the operational support centres to operate from. The two operational support centres gives the opportunity for shared management and relocation, if necessary.

Another example of post-Fukushima improvement is the mutual agreement regarding protective equipment that the Swedish NPPs have concluded. Furthermore, the mutual agreement on pooling resources during an event will provide additional reinforcement of an effected plant.

OKG places great emphasis on the response organisation to function well during stressful conditions. Consequently, all personnel belonging to the emergency response organisation, a workforce of around 140, are annually trained and re-trained in command and control methodology. This arrangement works well, which was confirmed during e.g. a Greenpeace intrusion at the site. OKG has, eight members of staff from the emergency preparedness organisation around the clock

In 2015, OKG conducted an internal audit, SSM conducted one compliance inspection, and WANO conducted a peer review of the emergency preparedness area. 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 during the latest WANOs inspection are currently being managed in the existing development plan for the emergency preparedness and response arrangements.

16.3.1 Exercises

A number of on-site functional exercises are conducted annually at all nuclear sites. Specific plans exist for these exercises. Exercised functions are for instance accident management, communication within the emergency response organization, 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 SAMÖ/KKÖ (See section B16.5) have also been carried out.

Forsmark NPP

At the Forsmark NPP, training, retraining and exercises are carried out according to pre-decided plans for staff involved in the emergency preparedness and response work. Training with the local "first responders" has been arranged, especially in use of the acquired mobile equipment.

Ringhals NPP

At the Ringhals NPP new exercises for the multidisciplinary technical support have been developed. A functional exercises as well as co-exercise with operations shift crew in the simulators have been conducted. Multiple exercises have been carried out at the new REC function in order to evaluate and improve new routines.

In November 2015 the county administrative board in Halland led a joint exercise in which RAB participated. The focus area was "Evacuation of the Värö peninsula" and it was provided that there was a release of radioactivity from Ringhals NPP. This exercise allowed RAB to practicing procedures for severe accident management.

In addition to the annual functional exercises, RAB 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.

Oskarshamn NPP

At Oskarshamn NPP the 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 the capacity. The plan is monitored continuously and reported on at the last meeting of OKGs emergency preparedness council. Training activities are adaptable to the content, structure and time aspects emerging from needs/experiences. This is in addition to adaptation to other parties' exercises or events that is considered valuable for the emergency response organisation. A adaptation is carried out by selecting a scenario, as well as by means of fast and flexible planning.

In the coming year, OKG plans to practice with involvement of the Swedish armed forces and police. In late 2017, a major regional exercise is planned. Its main focus will be evacuation. OKGs goal is to practice the functions of the logistics centre and the future exercise activities will be adapted to allow for this training.

16.4 Regulatory control

Over the past few years, regulatory control of on-site emergency preparedness and response has focused on the implementation of the new requirements of the regulations SSMFS 2014:2. During the autumn of 2014 surveillance inspections were carried out at all nuclear facilities of threat category I–III to ensure unanimous interpretations of SSMFS 2014:2 (see Table 12).

Facility	Threat Category
Forsmark (NPP)	I
Oskarhamn (NPP)	I
Ringhals (NPP)	I
Studsvik (facilities for fuel and materials testing)	II
SVAFO (waste management and storage)	II
Clab (central interim storage facility for spent fuel)	II
Westinghouse Electric Sweden AB (fuel fabrication facility)	II
Barsebäck (permanently shut down NPP)	III

Table 12: Swedish nuclear facilities categorized in threat categories.

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

16.5 National Exercises

A number of emergency response exercises of various scopes are conducted annually in Sweden. These vary in complexity from limited scope to full-scale exercises. Periodical tests of the alerting systems between the power plants and authorities are performed each year.

Every other year, a full-scale exercise is performed 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 evaluation of regional level command, national inter-agency cooperation and public information work. Often, full-scale exercises are also used to test international communications. The respective county administrative board where the plant is located has the responsibility for planning these exercises, often with the assistance of the national agency MSB, 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.

The expert response organisation is exercised annually in field measurement exercises and by participating in laboratory intercomparison measurements. SSM has a central role in organizing these exercises and also uses the exercises to train its own field measurement organisation. The contracted organisations maintain their own equipment and arrange for internal education and small-scale exercises.

Several full-scale exercises have been arranged since Sweden's sixth national report under the Convention on Nuclear Safety, two of them are described below. A full-scale exercise, SAMÖ Fokus, was arranged in 2014 by the administrative board of Kalmar County. The exercise was a follow-up exercise on the 2011 SAMÖ KKÖ exercise, taking off where SAMÖ KKÖ had been terminated. At that time, of the exercise, a significant radioactive release had taken place at Oskarshamn NPP affecting major parts of southern Sweden. The exercise was focusing on communication with media and the public and to test developed communication arrangements based on lessons learned from SAMÖ KKÖ. SAMÖ Fokus was evaluated by Swedish Civil Contingencies Agency (MSB) who noted that communication arrangements had been clarified since SAMÖ KKÖ but that difficulties remained among the collaborating authorities regarding the establishment of a common operational picture.

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

In 2015, IAEA arranged a full-scale PILOT exercise in Sweden in collaboration with SSM, the Swedish Police Authority and SKB. The scenario of the exercise was a terrorist act directed at the M/S Sigrid, SKB's transport vessel for spent nuclear fuel and radioactive waste. The purpose of the exercise was to test and evaluate the Swedish emergency management system in connection with a terrorism-related emergency, a transport accident and management of confidential information.

Regulatory exercises

In addition to above, SSM conducts a number of more limited functional exercises every year. Exercised functions are for instance assessment of core damage and source terms, prognosis and assessment of environmental consequences and doses to the public of a scenario and arrangements on national and international notification and communication. Specific plans exist for these exercises.

Experiences and lessons learned from recent exercises have been input to the ongoing review and development of SSM's emergency response organization. Further information on the review can be found in section B16.7.

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 2013 Sweden, together with the other Nordic countries, published the document "Protective measures in early and intermediate phases of a nuclear or radiological emergency – Nordic guidelines and recommendations". The document gives comprehensive recommendations on the Nordic countries' common approach to the implementation of the 2007 ICRP system of radiological protection during an emergency exposure situation. From the overall aim: a reference level of 20 mSv during the first year of exposure after the emergency, dose criteria and operational intervention levels are derived and presented for each of the protective actions considered.

16.6.1 Measures taken to inform neighbouring states

SSM has been appointed Competent Authority in accordance with the IAEA Convention on Early Notification in the Case of a Nuclear Accident and EU Council Decision (87/600/Euratom) on early notification. SMHI is the designated National Warning Point implying, availability around the clock. SSM and the 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) describing communication and information procedures between the countries in the event of a nuclear or radiological emergency or incident. NORMAN was revised in 2015 and contains an extensive list of scenarios and agreements on information exchange in different scenarios. In compliance with NORMAN, communication exercises are performed five times per year by these countries

16.6.2 Assistance

Sweden has registered 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. Sweden contributed to development of the RANET system by participating in field exercises in the Fukushima prefecture, which were hosted by the IAEA at its Capacity Building Centre in Japan. Swedish participation since 2013 has involved field assessment teams from SSM and from the national expert response organisation in three international exercises. Sweden also provided the IAEA with an instructor for one of these exercises.

16.6.3 Nuclear accidents abroad

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

In the event of a nuclear accident abroad, affected local county administrative boards still have the responsibility to inform and take potential protective action in their region as per the principle of proximity. SSM's role as an advisory authority is maintained in the event of a nuclear accident abroad.

16.7 New developments in emergency preparedness

A development project together with Swedish NPPs regarding electronic transmission of nuclear power plant parameters was launched in 2012. A first memorandum of understanding was signed by the Director General of SSM and the managing directors of the NPPs in the autumn of 2012, which included four phases of development and a specification of requirements regarding the first three phases. In 2015, phases one and two were completed, including a transmission solution and a shared standard for visualizing the parameters. By the end of 2016, the online visualization tool, together with transmission of process parameters, are to have been implemented and in use. July 2018 is the planned point in time for feeding the online visualization tool with simulated process parameters for educational and training purposes.

MSB has developed recommendations on common grounds for collaboration and management of emergency situations, 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 creating shared direction and coordination. Moreover, the goal is to make it easier for authorities to work together in a structured and consistent way, and to efficiently make resources available to society. Approximately 70 parties in the field of civil contingencies–experts, researchers and operational staff have been working for the past two years on development of these recommendations. The common grounds are now being implemented by several authorities in Sweden, including county administrative boards and SSM. The recommendations are based on experiences from emergency response exercises and real emergency cases. As for implementation of the common grounds at SSM, specific experiences from SSM's area of expertise have been taken into account, which has led to a major review of SSM's emergency response organisation. The purpose of the review is to enable SSM's role in the emergency management system to efficiently provide advice and recommendations to other authorities.

The analysis, referred to in section B7.4.2, for identification of necessary amendments to the Swedish regulatory framework regarding implementation of Council Directive 2013/59/Euratom, has led to several suggestions made in the field of emergency preparedness and response. SSM proposes that reference levels be set in the amended Radiation Protection Act, which would have an impact on prerequisites for emergency planning and call for a review of several Acts and Ordinances. SSM collaborates closely with MSB in this process.

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

A national strategy for radiation measurements in the event of a nuclear or radiological accident is being developed by SSM, MSB and county administrative boards with NPPs. The project covers the period 2015–18. In 2015–16, the project focuses on an accident at a Swedish NPP. In 2017–18, the project will broaden its scope to cover other nuclear and radiological emergencies.

New GIS software is being developed by SSM for reporting, storing, extracting and visualizing radiation monitoring data and environmental samples collected during an emergency. The new software, RadGIS 2.0, will replace RadGIS 1, which was developed in the 1990s. RadGIS 2.0 will be used by all Swedish organisations that perform radiological monitoring and sampling during a radiological or nuclear emergency. The project will be completed by the end of 2016 and implemented by appropriate organisations within the national structure for emergency preparedness and response.

Based on the Nordic Flag Book[11] and in collaboration with the National Food Agency, Board of Agriculture, county administrative boards, MSB, National Board of Health and Welfare and Police Authority, SSM is in the process of developing national guidelines on urgent and early protective measures in the early and intermediary phases of a nuclear or radiological accident. The guidelines will use the concepts of reference levels, dose criteria and operational intervention levels in an emergency exposure situation in line with recommendations contained in ICRP 103 and IAEA GSR Part 7. The project will be completed in 2016.

In collaboration with the Swedish Civil Contingencies Agency (MSB), the National Food Agency and others, SSM is developing revised guidelines on clean-up and food production following fallout of radioactive substances in Sweden. As the two guidelines mainly address the same authorities, shared work on revisions is closely linked. New guidelines will be finished by 2017, and information and possibly education and training in accordance with the new guidelines will commence after this.

16.8 Conclusion

Sweden complies with the obligations of Article 16.

[11] The Nordic Flag Book was presented in the sixth Swedish National Report to the CNS and further discussed during the review meeting in spring 2014.

17. 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 last national 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 and will take actions in accordance to the NAcP with the aim of improving robustness and safety. Such actions include update of the dimensioning values related to external hazards and implementation of any needed measures at the NPPs.

17.1 Evaluation of Site related Factors

17.1.1 Overview of arrangements and regulatory requirements relating to siting and evaluation of sites of nuclear installations

Resilience to failures and other internal and external events, including natural phenomena and human induced situations and activities, is regulated in Section 14 of SSMFS 2008:17. According to these requirements a nuclear reactor shall withstand natural phenomena and other events that arise outside or inside the facility and which can lead to a radiological accident. Natural phenomena and events with such rapid sequences that there is no time to take protective measures when they occur shall also be assigned to an event class12. For each type of natural phenomenon that can lead to a radiological accident, an established action plan shall be available for the situations where the dimensioning values run the risk of being exceeded. In the general advice to Section 14 of SSMFS 2008:17, examples of natural phenomena that should be taken into account, such as: extreme winds, extreme precipitation, extreme ice formation, extreme

[12] If an event is assigned to an event class it means that a deterministic event analysis will be carried out and presented in the Safety Analysis Report for this event and that the specified analysis assumptions and acceptance criteria are documented.

temperature, extreme sea waves, extreme seaweed/algae growth or other biological conditions that can affect the cooling water intake, as well as extreme water level and earthquakes, are listed.

Safety classification is regulated in Section 21 of SSMFS 2008:17. According to these requirements structures, systems and components of the 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.

17.1.2 Actions required by the licensees as a consequence of the stress test performed after the accident in Fukushima

Following the EU stress test, Sweden developed a national action plan (NAcP). The NAcP covers e.g. measures related to natural hazards required by the Swedish licensees. All measures were completed in 2015. In the subsections below measures from the NAcP are described. Information on actions taken in the area of on-site emergency prepardness is presented in section B16.3.

Technical and administrative measures, taken by the licensee, shall as far as possible seek for the most robust solution in all situations. Therefore decisions on technical and administrative measures shall be based on complete and verified analyses and data. For this reason many of the measures listed in the NAcP highlights the need of further evaluations and reassessments. According to the NAcP, the outcome of these evaluations and reassessments shall result in that reasonably practical technical and/or administrative measures shall be taken and that the licensees shall report on the status and the time schedule for implementation of such measures.

Safety margins assessments considering external hazards

Safety margin assessments considering all external hazards have been performed. Weaknesses and potential improvements were identified.

Seismic plant analyses

Evaluation of structures, systems and components against ground motions exceeding the values specified for the design basis accidents have been performed. These evaluations put special emphasis on the safety margins assessments.

Following the EU stress test, the EU countries agreed that a return frequency of 10^{-5}/year (with a minimum peak ground acceleration of 0.1g) should be used as a basis for plant reviews/back-fitting. 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
- The pipes between the reactor containment and the MVSS that allows a controlled pressure relief of the reactor containment have been further evaluated. The function of the pipe is essential to fulfil the requirements regarding release of radioactive nuclides to the society and to the environment in case of a core meltdown.

Investigations regarding secondary effects of an earthquake

Investigations regarding possible secondary effects of an earthquake have been performed. Fire analyses at Swedish NPPs are in general performed according to SAR but an analysis of fire starting as a result of an earthquake had previously not yet been carried out at any of the Swedish NPPs. Additionally, detailed analysis of earthquake induced flooding, such as an analysis taken into account leakage from broken water storage tanks and cracks in cooling water channels, were performed.

Review of seismic monitoring

Seismic monitoring systems are installed at all Swedish sites. The utilities have reviewed and updated the procedures and training program for seismic monitoring, and implemented them.

Investigation of extreme weather conditions

An investigation have been performed of plant characteristics in extreme weather conditions. The investigation especially assessed plant robustness against combined extreme weather such as ice storms and simultaneous heavy snow load on structures. A systematic analysis of other possible combinations of naturally occurring hazards were also performed.

Some possible improvements were identified in the national report of the EU stress tests (e.g. improving the resistance of some buildings against tornado induced missiles and heavy snow load). It is however expected, that these further analyses have resulted in the identification of additional measures which can be taken to protect the plant against negative impacts of extreme weather.

Investigation of the frequency of extreme water levels

An investigation of the frequency of extreme water levels have been performed.

This analysis considered the combined effects of waves and high sea water levels (including potential dynamic effects of such events). Historically extreme sea water levels in Scandinavia have mainly been connected to very high wind speeds. Thus it is important to extend the analyses with such combined effect.

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 verifyed the capability of the plant to mitigate internal and external flooding events. The analysis also included an evaluation on how the potential water volumes are distributed inside the plants following the external flooding.

Evaluation of the protected volume approach

Studies have been performed to identify critical areas and rooms inside the plants following a flooding event. This study especially considered the need of further improving the volumetric protection of the buildings containing safety related equipment located in rooms at or below ground level.

Investigation of an improved early warning notification

At all sites, the need for an improved early warning systems for deteriorating weather have been investigated, as well as the provision of appropriate procedures to be followed by operators when warnings are made.

Develop standards to address qualified plant walk-downs

The licensees have develop standards to address qualified plant walk-downs with regard to earthquakes, flooding, on-site fires and extreme weather conditions. The aim has been to provide a more systematic search for non-conformities and correct them (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 could affect essential safety systems of the plant have been recognized and evaluated. The walk-downs also included the mapping of potential on-site fire initiators.

17.1.3 Assessment made and criteria applied for evaluating all site related factors affecting the safety of the nuclear installation

Safety analyses are performed in order to prove that the plant at any given time can be operated without undue risk of radiological accidents. The safety analyses should cover all events that may occur during the lifetime of the facility. A safety analysis has two main parts; a deterministic and a probabilistic analysis. The safety analysis is based on the identification of a number of initiating events that are being analysed using deterministic methods and, if approriate, realistic methodes. The basis for the original design was safety features to ensure the robustness of the facility during external events with a a probability of $>10^{-4}$ per year. Today events with a probability of $>10^{-6}$ per year are being analysed.

The licensees have, for all facilities at their sites, identified external events that may lead to a radiological accidents. The basic principle is that initiating events are divided into categories based on the frequency of which the event is estimated to occur. 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 which 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 occure, such as sandstorms. The events that are being considered are assessed in terms of

- probability of occurrence with respect to the conditions at the site,
- if the event sequences are covered by other events, and
- if further analysis or other measures need to be taken.

In addition to event frequency the selection of external events are also based on the rapidity of the event sequence. For rapid events, where reasonable time between warning and initiation of the event cannot be expected, dimensioning design values are determined and the events are classified based on frequency. For more slowly evolving events, where ample time of warning and preventive actions can be expected, dimensioning design values are determined but the events are not classified based on frequency. Frequency is however determined when possible and relevant. For rapid events with a probability of $>10^{-6}$, the plants are designed to be able to be brought to, and maintained at a safe states. For slow events there are action plans and instructions with predetermined limits for when the plant shall be brought to and maintained in a safe state. 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 over pressurized verifying that the containment is not over pressurized 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 like radiation induced embrittlement are verified through inspection programs including, e.g. monitoring of irradiation and non-destructive testing.

In addition to the deterministic safety analyses, a probabilistic safety assessment (PSA) of external events (excl. seismic PSA[13]) for each reactor unit is performed. The purpose of the PSA is to evaluate the plants resistance to various events. The probability of core damage and the probability of releases to the environment are evaluated in the PSA study.

17.1.3.1 Practices to collect data for characterizing the site

Meteorological and hydrological data are acquired from SMHI, the Swedish Meteorological and Hydrological Institute. SMHI has since 1966 performed oceanographic investigations at sea outside of the relevant sites. SMHI has also performed local meteorological survey and the fog conditions in the areas that have been studied.

Snow and wind loads are acquired from Swedish building regulations. Normal wind load (>10^{-2} load) comes from Eurocode (EN 1991-4) using the national values from regulations provided by Boverket (the National Board of Housing, Building and Planning) that specifies reference winds from various parts of the country. To estimate a wind with a probability of 10^{-3} >10^{-6}, values measured by SMHI for 24 years have been used.

Information is also gathered through observation of ocean levels and precipitation data. Information regarding the bedrock is available through drilling protocols and photos taken during and before the construction of the NPPs. Local meteorological investigations are performed on site using observation mast where temperature, wind speed and wind direction are recorded. The temperature of the cooling water intake is measured. Equipment that measures ground acceleration and the response of the civil structures is also available.

17.1.3.2 Nearby installations with material that could jeopardize the safety of the nuclear installation

Forsmark NPP

Forsmark nuclear power plant is located in a relatively isolated area. There are no other installations with dangerous materials near the power plant. Oil spills from ships operating on the Baltic Sea are considered in the external event analysis. Forest fires near Forsmark nuclear power plant are also considered.

Ringhals NPP

There are quite a few heavy transports at Ringhals NPP, following predetermined routes where consideration is taken regarding possible accidents. If a vehicle hits a

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[13] No seismic PSA:s have been performed for the 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).

part of a building it may not lead to a progressive collapse of the building structure. The dimensioning loads are set after the vehicles which normally are on site, the fuel transport vehicle of 100 metric tonnes and the average trucks of about 10 tonnes. When necessary, impact protection of structures has been installed. Temporary heavy transports are subject to risk assessment in the same manner as construction work in order to prevent the occurrence of damages. Also lift cranes are regarded as heavy transports; they are often placed along the facades of buildings which put load on the underground culverts place close to the buildings. Culverts shall manage the erection of a mobile crane with the lift capacity of 45 tonnes and a weight of 36 tonnes.

Hydrogen gas explosions/deflagration at the hydrogen gas plant (HGP) or at the turbine building of Ringhals unit 1 constitutes the largest risk for explosions/deflagration. Smaller explosions could be caused by containers containing hydrogen gas, but the actual effect of such are judged as negligible. The distance from the reactors Ringhals unit 1 and 2 to unit 3 and 4 is too long for an event affecting the latter two, initiated at the Ringhals unit 1 and 2 reactors. In these analyses, distance dependent units like pressure, impulse density and heat impact are studied. The analysis for 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 becomes the dimensioning case. The present analysis of the HGP only accounts for the explosion/deflagration part. A hydrogen deflagration at the HGP can result in loss of the external power. The study of "Loss of external power" covers this case.

At the site there are used, and are transported, relatively small amounts of chemicals which could give rise to releases of gases which could affect the ventilation, especially the ventilation of the control rooms. Earlier an external risk also existed due to the fact that Södra Cell AB (a factory producing pulp) used chlorine in its pulp production. Existing surveillance automatically closes the air supply air if gas releases are detected. A judgement is made depending on the distance to the source.

Ringhals NPP has its own harbour, dimensioned for bulky transports so that reactor vessels, steam generators and other heavy components can be received. The harbour is mainly used by the special vessel M/S Sigrid which is a special built ship (double hull, separated engine rooms etc.) for transports of spent nuclear fuel and low- and intermediate level wastes.

There are two close-by fairways along the coast. The largest, the so called "T-route" is mostly used for larger ships and passes 20 kilometers (10 nautical miles) west of the Ringhals site. All transports of chemicals are along this fairway. The informal fairway "Öresundsrutten" is closer to the coast and is used both by cargo ships and tankers, especially those which are northbound. The risk of external influence from these can exist through releases from these ships, either through an accident or by illicit dumping. The chemicals that are transported along the west coast of Sweden are hydrocarbons, acids, hydroxides and other aggressive chemicals. Transports of hydrocarbons, i.e. crude oil, represent up to half of all transports through Kattegatt. The transport of acids, hydroxides and other aggressive chemicals only constitutes a small fraction of the transports in Kattegatt. Releases with a potential to harm or endanger safe and stable operation of the nuclear power plant could occur along the larger fairway. An impact on the sea water that is used for cooling could exist from the sea transports that occur along and outside of the coast.

Main public roads, railroads and common fairways with transports of large amounts of goods are at a distance of at least 3 kilometers. This means that an explosion is at such a distance that an influence from fire is not relevant. An explosion or transport accident just outside of the plant site could lead to loss of external power. The study of "Loss of external power" covers this case. Since the distance is long enough, chemical releases do not merit urgent actions to be considered, actions will however be taken in connection of such an event.

Oskarshamn NPP

Oskarshamn NPP site is like Forsmark NPP located in a relatively isolated area. The site is situated on the coastline of the Baltic Sea in Oskarshamn municipality on Simpevarp Peninsula, straight line 8 km northeast of the village Figeholm and straight line 20 km northeast of the town of Oskarshamn.

Hydrogen gas explosion at the hydrogen gas plant or at the turbine building are considered as a risk. The analysis for existing buildings was performed in 2007. The safety distance between the nuclear power plant and the hydrogen gas plant with respect to the blast, heat radiation and tremors at a hydrogen explosion is contained. The safety distance between the nuclear power plant and the hydrogen gas plant is not withheld with respect to objects relocated by a blast (missiles). A missile can reach the nuclear power plants but the buildings are dimensioned for tornadoes and hence generated missiles.

There are no other installations with dangerous materials near the power plant. Oil spills from ships operating on the Baltic Sea are considered in the external event analysis. Forest fires near Oskarshamn NPP are also considered.

17.1.4 Overview of design provisions used against human made external events and natural occurring eternal events and the impact of related sequential natural external events

See section B18.

17.1.5 Regulatory review and control activities

Site re-evaluations are part of the periodic safety reviews, see section 14.3.2.

A review of the implementation of the NAcP, which was reported to SSM in the end of 2015, is on-going. SSM has also ensured that all measures identified in the NAcP had been appropriately considered for each reactor.

Most measures in the NAcP will be followed by a phases two, which includes implementation of reasonably practicable/achievable technical and administrative safety improvements. Phase two is expected to be completed 2020.

17.2 Impact of the Installation on individuals, society and the environment

17.2.1 Criteria for evaluating the likely safety related impact of the nuclear installation on the surrounding populations and the environment

Forsmark NPP

The dose conversion factors which are used to convert released Bq to dose for the population living close to the power plant (critical group or most exposed individual) are more than 10 years old and were derived by Studsvik AB for the Forsmark NPP. Recently a common project between the reactor owners (PREDO) was finished which suggested updated conversion factors based on "state-of-the-art" models and calculations. The environmental control program which exists at and around the power plants aims at verifying that no unknown sources for releases of radionuclides to water and air exist or that any un-allowed accumulation of radioactive substances occur in the neighbouring areas 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 Ringhals NPP was established. With this catalogue the main characteristics of the dispersion can easily be established. The release of gases was performed from the reactor building or in its close vicinity.

No special study of the hydrological dispersion conditions exists. The dispersion can however be described by hydrological observations, e.g. how the surface water is affected by the water streaming out from the Baltic Sea and how often it is exchanged (less than a month), the bottom water being contained between 1-4 months per year and the ouflow of water from rivers, streams and point releases by industries and sewage installations.

Other forms of identified disturbances consists 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 the on-growth of mussels and barnacles in the water tunnels for cooling waters. Non-foreseen, non-ionising related accidents such as explosions, fires or pipe breaks on raw water lines in the area could 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 peninsula Värö both trawling and coastal fishing is performed. According to the consistent views of the inspector of fisheries at the County Government of Halland, the chair of the local fishing associations for BUA and Videberg and from the Coastal Laboratory of the Swedish Agency for Marine and Water Management at Gothenburg, the releases from the power plants has no discernible effect on fishing.

The report no. 3463 of the Environmental Protection Agency from 1988 describes the results of test fishing during 1975–85 regarding easily discernible sicknesses and defects. The test comprised of 29,000 cods, 13,000 flounders and 7,000 eels. For some of the material the fish has been more laboriously examined.

At large, the occurring frequency of sicknesses and parasites was representative for the regions of Bohuslän and Halland. Any effects from the Ringhals NPP could not be detected, furthermore no effects were observed on the production of plankton and algae since the area around the peninsula Värö does not deviate from the rest of the Coast of Halland.

Oskarshamn NPP

The SSM regulation states in the introduction that the limitation of emissions of radioactive substances from the nuclear facility shall be based on the optimization of radiation protection and performed with the best proven technology. BAT means that the most effective measure to limit the release of radioactive substances and their harmful effects on human health and the environment, and do not entail unreasonable costs, will be introduced. One should also consider that the personnel radiation doses can increase when emissions into the environment is reduced. The regulation 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 shall not exceed 0.1 mSv. With the critical group refer to persons who computationally expected to obtain the largest dose from the plant.

17.2.2 Implementation of criteria in the licensing process

A general description regarding the licensing process is presented in section B7.3 and the Environmental impact assessment is further described in section B7.3.1.

Protection of the Environment is further described in section B15.1.2.

17.3 Re-evaluation of site related factors

17.3.1 Activities for re-evaluation to ensure continued acceptability of the safety of the nuclear installation

The most common reason for initiating a change in the design basis is experience feed-back from both internal and external sources. With methods used to collect and evaluate information from the own facility and facilities of the same type, and through the systems for international feed-back and reporting, the safety design basis is kept up-to-date and relevant. Experience feed-back from both internal and external sources are further described in section B19.

In an attempt to keep the design basis up-to-date and complete, inventories are kept about new events which need to be addressed in the safety assessment. In this additional work, the initiating events are studied which already were 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, matching the assumed frequency.

Since the systematics of the original event identification was to identify the worst events that could occur within each event category, only a few events have been added to the event list. It is however possible that new potential initiating events are identified. All new events are categorized in accordance with the occurrence frequency and their safety impact on the facility, as was earlier done during the original event identification. Identification of new initiating events is performed partly through the systematic work with probabilistic safety assessments which are periodically carried out and partly via the internal and external systems for feed-back exchange and reporting.

Activities related to the EU stress tests and the NAcP are further described in section B17.1.2.

17.3.2 Results of recent re-evaluation activities

All licensees have conducted evaluations and reassessments in accordance with the NAcP. The overall conclusion from these recent reassessments of external events is that the safety case described in the safety analysis report remains valid. It also concludes that on-going work related to extreme natural phenomena will provide prerequisites to manage extreme events leading to improvement of the plants' "defence-in-depth".

The result from the evaluations and reassessments also identifies a number of reasonably practicable or achievable administrative and technical measures for further improvements. A list of reasonably practicable administrative and technical measures for each NPP has been submitted to SSM in February 2016 for regulatory review. The main areas of improvements identified are new independent core cooling systems, more robust cooling of spent fuel pools and more robust supply of emergency power. According to the NAcP, reasonably practicable administrative and technical measures identified by the evaluations and reassessments required by the NAcP, shall be implemented at the latest 2020.

Before the accident in Fukushima Dai-ichi NPP and the EU stress test, actions in the area of natural phenomena and other external events, were taken by the licensees within the scope of the modernisation programs, see Appendix 2.

17.3.3 Regulatory review and control activities

See section B17.1.4.

17.4 Consultation with other Contracting Parties likely to be affected by the installation

17.4.1 International arrangements

Sweden is party to all of the relevant conventions expected for a country operating nuclear power plants including the Espoo convention and the Aarhus Convention. Sweden is also obliged to report construction of new facilities, dismantling of facilities and radioactive discharges under the Euratom Treaty.

17.4.2 Bilateral arrangements with neighbouring States

Bilateral arrangements with neighbouring countries regarding Emergency Preparedness and Response, see Article 16.

17.5 Vienna Declaration on Nuclear Safety

This section, in reference to Article 17, describes how Sweden implements the first and the second principle of the Vienna Declaration on Safety in regards of siting.

17.6 Conclusion

Sweden complies with the obligations of Article 17.

18. 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 last national report

During the current review period, the following developments have taken place with regard to the obligations of Article 18:

- Modification/back fitting measures included in the modernization programs for existing nuclear power reactors, initiated in 2005, have been completed 2015.
- Assessments based on the NAcP, have been carried out and regulatory review is ongoing. Implementation of measures is proceeding at all NPP.
- Re-assessments of the robustness of electrical power supplies is ongoing due to national and international events indicating a need for a more rigorous approach to electrical system design.

18.1 Implementation of defence in depth

18.1.1 Overview of arrangements and regulatory requirements concerning the design and construction of nuclear installations.

Chapter 2 – Basic Safety Provisions, in the Swedish Radiation Safety Authority's Regulations and General Advice concerning Safety in Nuclear Facilities (SSMFS 2008:1), outlines 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 the implemnetation of the defence in depth concept for nuclear facilities as well as obliging licensees to report to the authority any identified anomalies that can affacet the defence in depth or barriers of the facility according to a pre-defined classification scheme. According to the requirement, anomalies or deficiencies should be analysed by the licensee and reported to the authority.

Chapter 3 of SSMFS 2008:1 outlines the basic requirements on defence in depth in Section 1 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.

"The design shall:

- be able to withstand component and system failures,
- be reliable and have operational stability,
- be able to withstand such events and conditions which can affect the safety function of the barriers or defence in depth, as well as
- make it possible to maintain, inspect and test structures, systems and components and as far as reasonable facilitate a safe 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 failure in safety classified equipment leads to acceptable levels of safety. SSMFS 2008:17 also includes design requirements regarding 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.

Besides the regulations 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 (see Appendix 1)

The regulations in SSMFS 2008:1 stipulate that guidelines shall be developed to manage beyond design basis events. Regulations regarding design and construction of nuclear reactors to cope with beyond design basis events (including severe accidents with core melts) are found in SSMFS 2008:17. Requirements on release mitigation in the event of severe accidents are given in a governmental decision in February 1986, as a condition for operation after 31 December 1988.

18.1.2 Status with regard to the application for all nuclear installations of the defence in depth concept

All Swedish facilities basically follow the INSAG-10 approach to defence in depth, which is referred to in SSMFS2008:17, and in practice also consider the WENRA approach of Design Extension Conditions. The Swedish nuclear plants were designed at a time when the focus was on three levels of defence in depth, but has followed the advancements to more specifically address Beyond Design Basis Accidents and Design Extension Conditions.

Measures to increase the level of safety and strengthen the defence in depth at all the Swedish NPPs have gradually been taken in accordance with new knowledge and experience. New knowledge and experience have emerged from lessons learned from incidents and accidents, from research, from safety analyses and from 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 Swedish regulations on design and construction of nuclear power reactors which were issued in 2005 have resulted in extensive back fitting and modernisation programmes for all Swedish NPPs. Also, insights from the European stress tests have identified further areas of improvement that will be implemented in the upcoming years to strengthen the robustness of Swedish nuclear power reactors.

Since the original designs were taken into operation, measures have been taken to improve e.g.

- the physical and functional separation
- diversification of safety functions
- 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

Further information regarding prevention and mitigation of severe accidents, is given in section B18.1.4

Seismic

Sweden uses a design envelope with margin to realistic seismic events at the Scandinavian Peninsula. Earlier built reactors were not originally designed against a design basis earthquake but have considered earthquake requirements in maintenance and modernisation measures. Practicable approaches to strengthen the reactors capabilities to withstand earthquake have been taken to ensure that no undue risk with regard to seismic criteria being excluded from the initial design basis is foreseen. Also, when installing new equipment and implementing measures seismic events must be taken into account.

Flooding and tsunami

The general risk of flooding was re-assessed after the Fukushima Dai-ichi accident and measures to cope with extreme water levels have been taken or are under implementation.

The tsunami risk in Sweden is low given the geographical location of the country. After the Fukushima Dai-ichi accident the tsunami risk was reassessed and no additional measures to particularly mitigate a tsunami were identified.

Other external hazards

The facilities' characteristics in regards of extreme weather conditions have been re-assessed after the Fukushima Dai-ichi accident. In general the evaluations indicate that the facilities are robust but for some areas measures to strengthen the protection against extreme weather conditions have been taken or are under implementation.

Simultaneous accidents at multiple units

Simultaneous accidents at multiple units were not included in the design basis of existing nuclear facilities. Safety systems as well as severe accident managements systems at the Swedish nuclear plants are however dedicated to one unit only. Shared auxiliary systems principally encompass the off-site grid, station black-out generators, inlet and outlet channels to the ultimate heat sink. Evaluations and measures to cope with multi-unit accidents are part of the NAcP, where the requirement on an independent core-cooling specifically addresses the loss of ultimate heat sink and extended loss of AC power.

18.1.3 Extent of use of design principles, such as passive safety or the fail-safe function, automation, physical and functional separation, redundancy and diversity

The earliest reactor designs in Sweden incorporated limited redundancy and separation but enhanced diversification of safety functions through the use of isolation condenser and steam-driven pumps. Later designs favoured increased redundancy and separation with a lower degree of diversification. Back fitting and modernisations have led to major improvements of the older designs to increase redundancy and separation and new designs have taken actions to increased diversification and protection against common-cause failures.

Single failures are considered in the design of all facilities and to a large extent mitigated. The same applies for 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 with engineering judgement and operational experience.

Active components of the safety functions should be able to withstand a single failure occurring during all events within the design basis envelope, as well as active components belonging to the mitigating systems. A reasonable diversification in order to withstand common-cause failures should be applied in the design of the safety functions for events up to and including unanticipated events (except LOCAs).

All the designs are generally fail-safe, which means that the loss of the active function leads to a favourable state of the plant. The level of active functions required varies for different designs of different generations, but for all designs the severe accident mitigation systems have passive actuation parts which would mitigate consequences of a sequence where there is a risk of containment over-pressurisation.

The separation of systems, physically and functionally, is an important area in which a number of back-fitting measures have been implemented over many years as reported previously. In many cases, the need for improved separation was identified through PSA analyses. Swedish reactors have been retrofitted to comply with the regulatory requirement of functional diversification. The functions of reactivity control, overpressure protection, cooling and residual heat removal, and the containment, shall all have diversified backup capabilities.

18.1.4 Measures taken by the licensee

Major safety improvements are presented in Appendix 2.

Measures to improve the capabilities to withstand natural hazards and to mitigate potential effects of natural hazards are described in section B17.

The objective of implemented or planned design measures or changes (plant modifications, back fitting) is to prevent beyond design basis accidents and to mitigate their radiological consequences, were they to occur. Some examples are:

- Structural integrity assessed for containment and Containment Filtered Vent for beyond design seismic events
- Battery capacity extended to 8 hours
- Mobile 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.

Severe accident mitigation measures

The governmental decree of February 1986, following the Three Mile Island accident in the United States 1979, substantially strengthened the nuclear reactors capabilities to manage design extension conditions. This governmental 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 MW thermal power, provided that other nuclides of significance are limited to the same extent as caesium. This resulted in an extensive back-fitting 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 large LOCA and degraded pressure suppression function to protect the containment from early over pressurization,

- hydrogen 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 reactors in operation have chosen the Multi Venturi Scrubber System (MVSS) concept to fulfil the requirements of filtered venting, and a conceptual illustration of the overall severe accident mitigation concept for the BWRs and PWRs is presented in Figure 15 and Figure 16 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. A venturi scrubber is a gas cleaning device that relies on the passage of the gas through a fine mist of water droplets.

The design of the venturi is based upon the suppliers' broad experience in this area, gained when designing venturi for cleaning polluted gases from various industrial plants. The MVSS can be activated automatically, via a rupture disc, or manually. There are two separate venting lines from the containment for these two modes of operations. The venting line with the rupture disc 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 made inert to avoid hydrogen combustion.

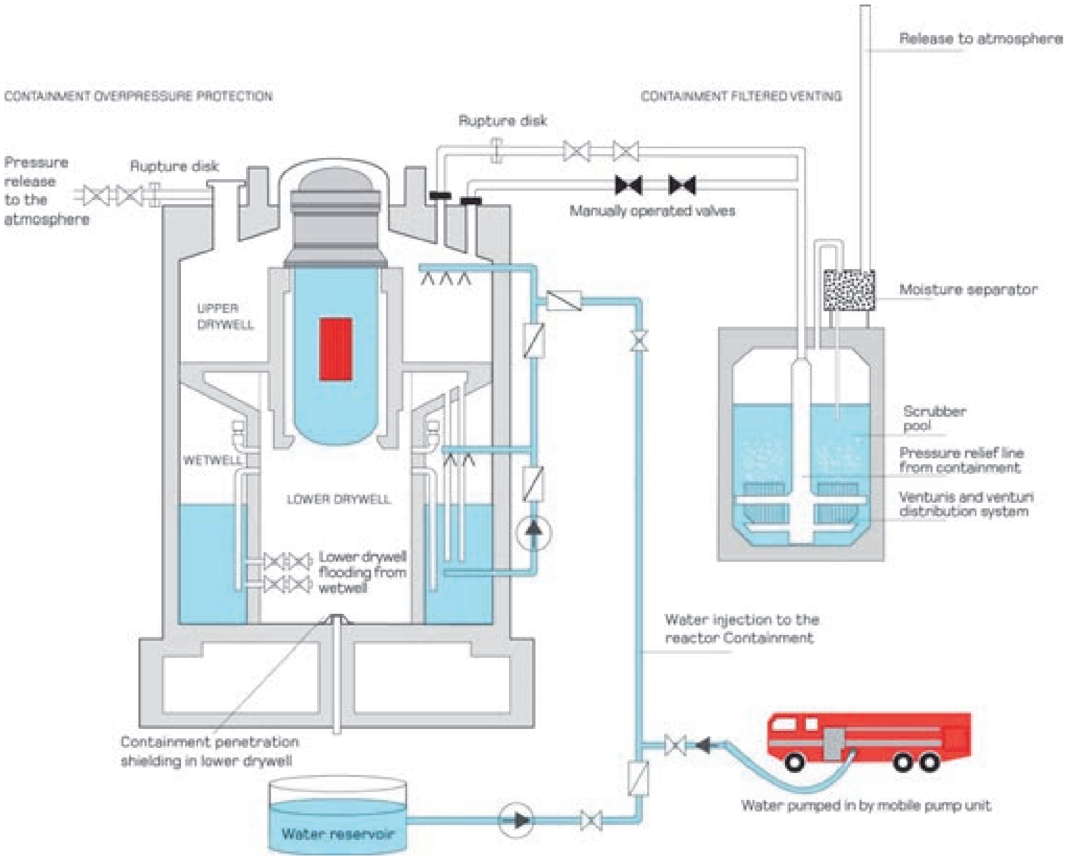

Figure 15: Schematic view of the severe accident mitigation features installed in Swedish BWRs.

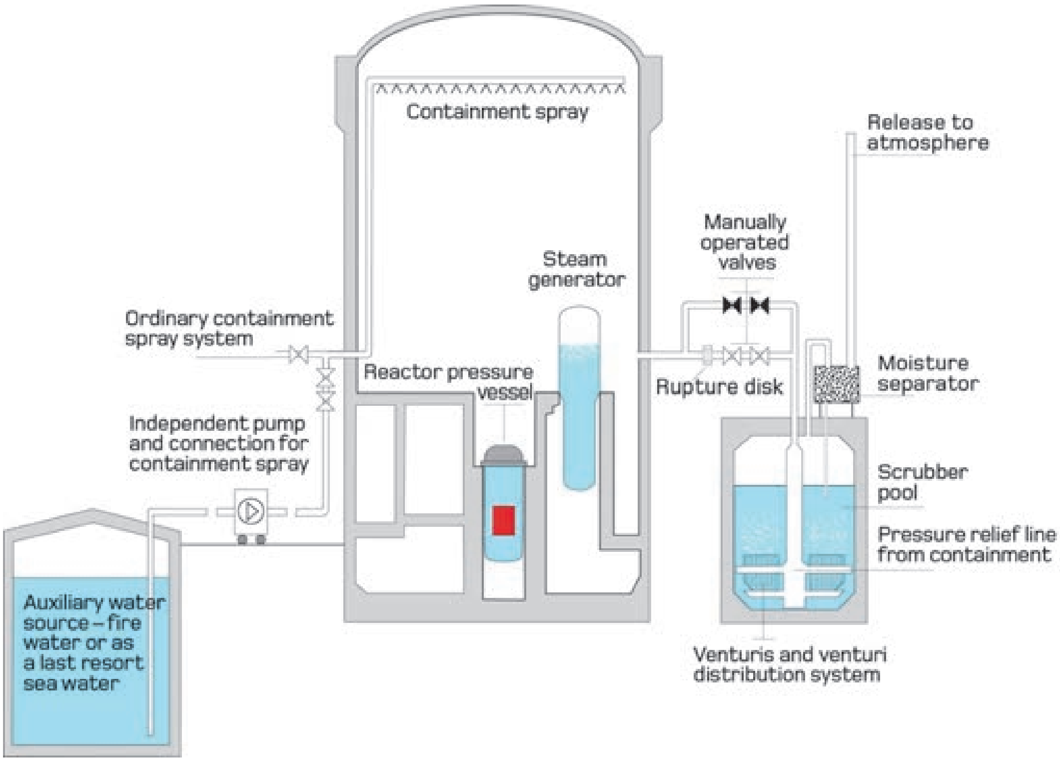

Figure 16: Schematic view of the severe accident mitigation features installed in Swedish PWRs.

The Swedish strategy for dealing with a core melt in BWRs is to let the core debris 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 associated with this strategy is 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 and this programme is still progressing since there are still uncertainties connected with the Swedish strategy which need to be addressed. Through the Swedish strategy, a major initiating interaction between concrete and core melt will most likely be avoided. However, there are still some open issues identified related to steam explosions which could occur when the core melt interacts with the water and the coolability of the core debris in the containment. The severe accident research is now targeted at confirming that the uncertainties connected to the chosen solution are acceptable.

Since the governmental decision in the 1980s, the Swedish utilities and the regulator have collaborated to monitor international research within the area of severe accidents

18.1.5 Regulatory review and control activities

Anomalies or deficiencies analysed by the licensee and reported to the authority are reviewed by SSM to ensure the licensee obligations are fulfilled. Selected reports may be pursued further if particular concerns are identified, such as unexpected plant behaviours or repeated events. Based on the experiences from these reviews the authority also compiles an annual report with recommendations on priorities for the upcoming year.

The regulatory approach in Sweden is to retrofit facilities to modern requirements and all facilities are expected to meet modern standards. Major upgrades have been completed at Swedish facilities, over the last 10 years, to achieve this target. SSM conducts, and will maintain oversight of licensees' 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 (in SSMFS 2008:17) have significantly improved safety at all nuclear power reactors in Sweden. The main capability that has been improved is their control over conditions that might arise in the event of design basis accidents. The operation of the nuclear power reactors and monitoring of the barriers' surveillance have also been substantially improved by implementing new or upgraded control equipment.

Viewed in relation to all the plants, all of the analysis and modernisation work has now been completed. A concluding assessment of compliance is ongoing at SSM and reviewed plants are deemed to fulfil the intent of the requirements although areas of possible further improvement are highlighted.

Further work regarding enhanced resilience is expected as result of the ongoing implementation of the NAcP, including independent core cooling, see section 6.2.

18.2 Incorporation of proven technologies

18.2.1 Arrangements and regulatory requirements for the use of technologies proven by experience or qualified by testing or analysis

Requirements on proven and verified technology are found in Chapter 2 of the Environmental Act (1998:808) and further detailed by the regulations in Chapter 3 Section 2 in SSMFS2008:1, which requires that design principles and design solutions shall be tested under realistic conditions, or if this is not possible or reasonable, have undergone the necessary testing or evaluation with regard to safety.

The regulation SSMFS2008:1 requires functionally based safety classification and for nuclear power reactors this is further detailed by the regulations in SSMFS2008:17 that states that structures, systems, components and devices of the nuclear power reactor shall be divided into safety classes. According to the general recommendations in SSMFS 2008:17, safety classification may be done according to the principles in the US standards ANSI/ANS 51.1 for PWR and 52.1 for BWR. Classification may also follow IEC standards where applicable, in particular I&C systems for the modernised plants use applicable aspects of IEC61226.

Provisions concerning quality classification of mechanical components in certain nuclear facilities are stipulated in the regulations SSMFS 2008:13.

18.2.2 Measures taken by the licence holders to implement proven technologies

The application of particular standards to fulfil legal and regulatory requirements is a licensee responsibility. The original design of the Swedish NPPs relied on American standards to a large extent, and the Amarican standards still has a strong influence. As applicable, European standards have been developed and assessed by the licensees, and where appropriate, incorporated into the design.

The Swedish licensees also have a common group managing technical requirements which define applicable standards for plant design.

Further information on verification by surveillance, testing and inspection is given in section B14.1.2 and B14.2.7.

18.2.2.1 Analysis, testing and experimental methods to qualify new technologies, such as digital instrumentation and control equipment

Oskarshamn unit 1

Digital technology has been used for quite a long time at Oskarshamn NPP. Below is a brief description of how digital instrumentation and control (I&C) including software were implemented at Oskarshamn unit 1 in safety applications. This extensive project was the first of a kind in Sweden and introduced a number of challenges for both the licensee and the regulator (SSM).

The first project using software in a safety application was the Neutron Flux Monitoring system. It was originally planned to be a part of the unit 1 modernisation project (MOD) but for various reasons it was done as a separate project to be implemented before the MOD project. One of the reasons was that it was a well-defined application and a suitable project to gain experience of how to qualify and implement new technology in a safety application.

The project resulted in a qualification process very much like an ordinary qualification of electrical components. During the project new issues such as software, CCF (common cause failure), failure modes, etc., were highlighted as important areas to be investigated further. As a result of newly-raised questions related to design and qualification, a hardwired Diverse Protection System (DPS) was installed. The reason for this was the difficulties in verifying and validating the new software application to a full/acceptable level. Another reason was that some vital issues were not raised at the beginning of the project and therefore not incorporated in the design process. It was not possible to obtain the verification unless you made a re-design.

The system was developed and type tested according to the specified requirement (IEC 880). The assessment of the extensively performed test in the test field came to the conclusion that the tests could be optimised. Many functions in the software were tested over and over again. Later this system was connected to the new I&C platform installed in the MOD project.

In the MOD project a new strategy was used in presenting the new I&C platform to SSM. An early contact with SSM was established to discuss how the new RPS (Reactor Protection System) should be documented and presented. A plan was developed as regards how it should be documented, and what areas and issues should be in focus. This so-called Safety Demonstration was further developed from a model used by Ringhals NPP in another project that had been carried out there. Regular meetings with SSM were held every 6–8 weeks throughout the whole project. These meetings had specific themes and specific questions that were discussed.

The RPS system was, due to qualification and reliability issues, also installed in combination with a DPS (Diverse Protection System). As the system/platform has not been developed according the specified standard it was qualified during the MOD project (Common Q). Qualification plans for hardware and software were developed and followed. The system was thoroughly tested and verified by type testing but also in the Test field, before it was shipped and installed at Oskarshamn unit 1.

Finally SSM raised four specific questions to be answered before the system was accepted. These questions were focusing the following areas:

- Verification and Validation (V&V) activities during the development process
- How the system requirements has been developed, what hazard analysis has been performed and how they affected the system requirements
- How safety review (according to SSM regulation) was performed as the Safety Analysis (SAR) was preliminary at the time for the review.
- How the test program/instructions were developed and how the tests were traceable back to the requirements.

In the above project, operating experiences from similar nuclear applications, documentation and extra tests were used as compensating factors when requirements were not completely fulfilled.

Ringhals unit 2

In 2010 a major upgrade to the digital instrumentation and control system (I&C) including software was completed in Ringhals unit 2 in the TWICE project. During the project, a completely new and modern control room was installed.

The need for modernisation had already been identified during the 1990s and was mainly driven by ageing equipment, obsolescence, no spare parts available, lack of technical support from the original vendors, and a need to improve the plant's safety level in specified areas to better meet modern requirements on plant safety.

Some of the requirements applied for the TWICE project were:

- The functional classification shall follow the intentions stated in IEC 1226, First edition.
- The cable separation shall, limited by the existing buildings, to the largest extent possible fulfil the requirements stated in IEEE 384 –1992.
- The fire protection shall, limited by the existing buildings, to the largest extent possible fulfil the requirements stated for new nuclear power plants of today.
- Installations of cabinets and equipment, supporting 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 be to a level of functional separation that allows I&C system failures without loss of major plant system functionality and maintenance and modification work to be done on a plant and I&C system/function level without affecting any other major systems/functions.
- The structure shall be to a level of functional diversity to avoid software Common Cause Failures (CCF) to affect functional safety or reliability
- The structure shall not introduce any additional functional dependencies between plant systems/functions.

A brief overview of the design and implementation process (TWICE WP Overview) is visualized in Figure 17.

The implementation was originally due to be done in a phased manner divided into four separate Work Packages WP1-4 over four subsequent outages 2001-2004. Due to experience from the implementation of WP1 2001 the phased approach was found not feasible, and the remaining WP2-4 were instead gathered into a large WP5 to be installed in a "One-shot" approach during a prolonged outage in 2006. The time schedule was further extended and eventually the final implementation took place during a 298 day long outage 2009/2010.

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 equal to the situation before the implementation in a defined number of areas. The method was applied for 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" in 2006, and resulted in implementation of additional possibilities for power supply by DC, and some additional UPSs.

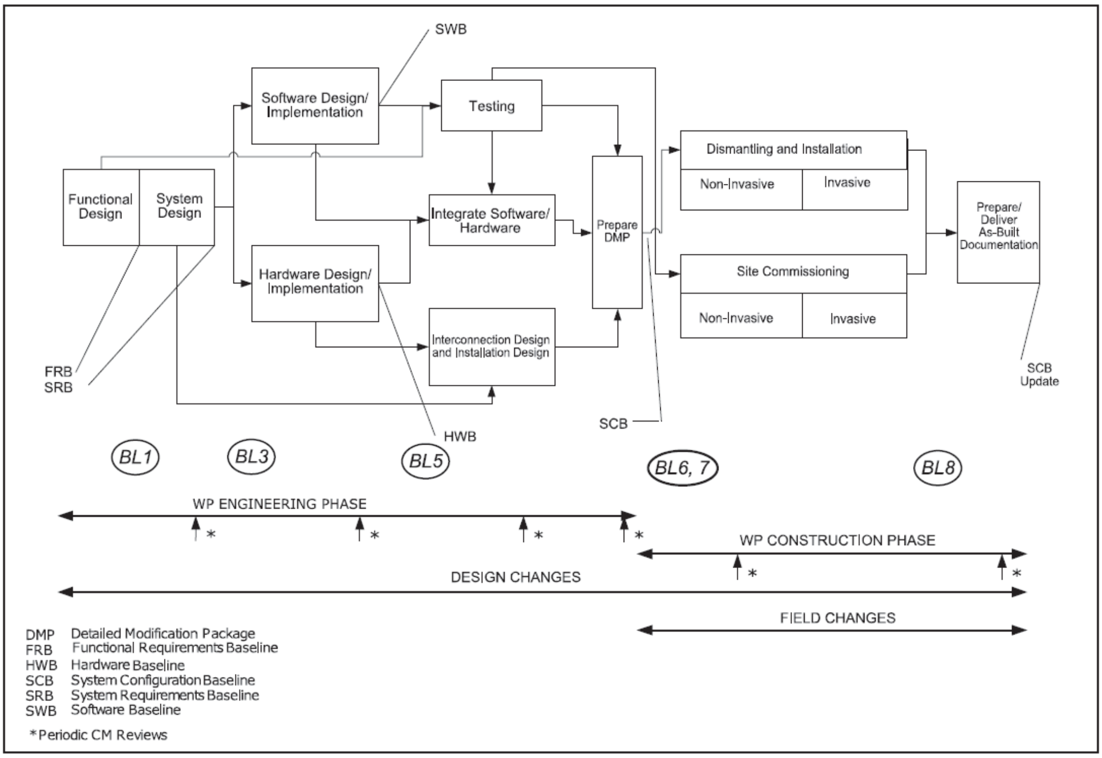

Figure 17: Schematic overview of the TWICE WP process.

Since the Reactor Protection System (RPS) is being implemented on a PE system, a Diversity and defence in depth analysis was performed to determine any areas of the RPS design that were vulnerable to postulated software Common Mode Failures (CMFs). For any areas of vulnerability found, the analysis also specified the automatic and manual functions that must be implemented on a diverse platform. The platform used for the Diverse Actuation System (DAS) implementation must therefore be diverse (hardware and software) to protect against a CMF that affects the Reactor Protection System (RPS).

Compared to the original configuration the new system and technology give possibilities to monitor and present much more information, which initially gave an overload of information and alarm to the operators. Measures for filtering and prioritisation of information were implemented and have solved the problems.

The TWICE project was completed in 2010. After completion, Ringhals unit 2 later went through a major modernisation with increased redundancy and separation of a number of important safety systems, and was completed in 2015. The flexibility and capacity of the TWICE system has been crucial in order to implement the I&C for these later plant modernisations.

18.2.3 Regulatory review and control activities

The regulatory and control activities during the implementation of the above two I&C modernisation projects are descibed above.

Furthermore, regulatory review of design solutions are most commonly carried out as a result of notifications to SSM before implementation of plant modifications or changes in the safety documentation, see section B14.3.5. Further detail on regulatory review and control activities in regards of inspection and testing of plant structures, systems and components is given in section B14.3.3.

18.3 Design for reliable, stable and manageable operation

18.3.1 Overview of arrangements and regulatory requirements for reliable, stable and easily manageable operation, with specific consideration of human factors and the human–machine interface

Requirements regarding the operation of nuclear facilities are summarised in Section 5 SSMFS2008:1. It is required that design solutions shall 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 have been added, e.g. the so-called 30-minute rule. This rule requires that all measures, which need to be taken within 30 minutes from an initiating event involving risk for radioactive release, have to be automated. The rule is implemented in the BWRs, and with some exceptions in the PWRs.

Human factors have long been recognised as an important consideration in design matters and are addressed in Section 9 SSMFS 2008:1. Both licensees and the authority have dedicated functions within the organisation to specifically ensure 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 fuel, materials and human factors.

18.3.2 Implementation measures taken by the licence holder

See sections B12.2 and B19.2.3.

18.3.3 Regulatory review and control activities

The regulator has requirements that any safety significant events or plant modifications must be reported to the authority. The standing group of experts (see section B14.3.5) that makes the first assessment of all notification consist of experts representing all relevant disciplines, including human factor experts.

Further information on regulatory review and control activities in relation to the operation and human factors is provided in sections B12.3 and B19.3.

18.4 Vienna Declaration on Nuclear Safety

This section, in reference to Article 18, describes how Sweden implements the first and second principle of the Vienna Declaration on Nuclear Safety regarding design of the power plants.

Implementation of particular measures to maintain, where appropriate, the integrity of the physical containment to avoid long term off-site contamination is described in section B18.1.4.

18.4 Conclusion

Sweden complies with the obligations of Article 18.

19. 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 organizations 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 last national report

During the current review period, the following developments are of relevance with regard to the obligations of Article 19:

- The number of licensee event reports (category 2 LERs) varies in the range of 8 to55 per year and reactor over the past few years.

19.1 Regulatory requirements

The general safety regulations SSMFS 2008:1 contain legally binding requirements relevant to all obligations of Article 19. These requirements are summarized below.

19.1.1 Initial authorization

As mentioned in section B14.1, a comprehensive deterministic and probabilistic safety analysis is required before the plant is constructed and commissioned. 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.

Documented up-to-date Operational Limits and Conditions (OLC) 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 in SSMFS 2008:1). The OLC shall be subjected to a twofold safety review by the licensee and submitted to SSM for approval. SSM shall be notified by the licensee about any changes which must also be subjected to a safety review.

19.1.2 Approved procedures

Suitable, verified and documented procedures established by the licensee are required for all plant states including accidents. 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. 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.

The procedures for operability verification, as well as procedures and guidelines used in other plant modes other than normal operation shall be subjected to a two-fold 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. Maintenance programmes are to be documented. Inspection and testing of mechanical components shall be carried out in accordance with qualified methods and verified procedures.

19.1.3 Engineering and technical support

The licensee shall ensure that adequate personnel is available with the necessary competence and suitability needed 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. The use of contractors as opposed to own personnel should be carefully considered in order to have capability to develop and sustain adequate in-house expertise. Necessary expertise should always be available in-house for requesting, managing and evaluating work important for safety that is carried out by contractors.

19.1.4 Reporting of incidents in a timely manner

SSMFS 2008:1 contains a chapter on reporting requirements and an appendix specifying these requirements for various types of events (Chapter 7 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 important for plant safety. Specifications are provided about the contents 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 regulations specifies events and conditions that require different responses depending on the category of event they belong to. Three following categories 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 corrected and which, without measures, could lead to a more severe condition, and which is 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 two-fold 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 is found to function unexpectedly, or in cases where it is difficult to determine the seriousness of an identified deficiency.

19.1.5 Programmes for collection and analysis of operating experience

The licensee shall ensure that experience of importance for safety from own activities, and from similar activities at other relevant facilities, is continuously analysed, acted upon and communicated to the personnel concerned. Furthermore, all events and detected conditions that affect safety must be investigated systematically in order to determine sequences and causes, as well as to establish the measures needed in order to restore safety margins and prevent recurrence. The results of the investigations shall be disseminated within the organisation and are to contribute to the development of safety work at the facility. Results of investigations shall also be reported to SSM (see above). SSM ensures that events are reported to suitable international organisations and other regulatory bodies.

19.1.6 Generation of radioactive waste, conditioning and disposal

As of 1 November 2012, requirements are in effect regarding handling, processing and storage. These 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 that 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 analysis report.

- 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.

19.2 Measures taken by licence holders

19.2.1 Initial authorization

No nuclear units have been commissioned in Sweden since 1985, when Forsmark 3 and Oskarshamn 3 went into commercial operation and no more units are currently planned or under construction.

As described in Chapter 14, 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 SSM following completion of the different operational tests, and reporting results of the startup stages. Permission for commercial operation was granted when the operational tests were completed satisfactorily and reported, and FSAR and technical specifications had been accepted.

19.2.2 Operational limits and conditions

The operational limits and conditions of the reactor units are included in an operational document named STF in Sweden (Säkerhetstekniska driftförutsättningar, or technical specifications). This document is considered 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. STFs for the oldest BWRs were produced in close cooperation between nuclear utilities. Consequently, the structure of the documents is similar for all STFs produced in the country. STFs for PWRs follow the Westinghouse Owners Group (WOG) approach. The scope and content of Swedish STFs are similar to those used in other European countries.

The original STF for each unit is derived from the safety analyses in the FSAR, where the behaviour of the unit, when different transients and abnormal events occurred, was 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 tests, or from operational experience. Suggestions for changes in the STF are subjected to a twofold safety review and are 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 and further efforts are underway to describe all SAR conditions 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, certain electrical systems and feedwater systems. For these, requirements for operability have been included to a varied extent in STFs.

The STF of the Westinghouse PWRs at Ringhals have 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. The new STFs have been approved by SSM.

19.2.3 Operability verification

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 to verify complete system function are being used more frequently, instead of component testing. After some events in the plants, major efforts have been invested in improving procedures and tools for verification of operability.

19.2.4 Approved procedures

All activities that directly affect the operation of the plants are governed by procedures of different kinds. Normal 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, though not always as detailed as operating procedures, where activities are described step by step in sequences. Signing of steps carried out in the procedures is mandatory in most cases in order to confirm their completion and to facilitate verification. Temporary modifications and special conditions are controlled in the form of operation notices (“DM” – *driftmeddelanden*) 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, or, particularly in the case of maintenance procedures, when new experience is obtained.

As far as possible, full-scale simulators of the units are used when verifying a new or revised operating procedure.

19.2.5 Response to anticipated operational occurrences and accidents

Emergency procedures have been developed in order to deal with anticipated operational occurrences and accident conditions. Emergency procedures are complemented with 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) which exist in 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 raising an alarm. The structure of procedures is illustrated by Figure 18.

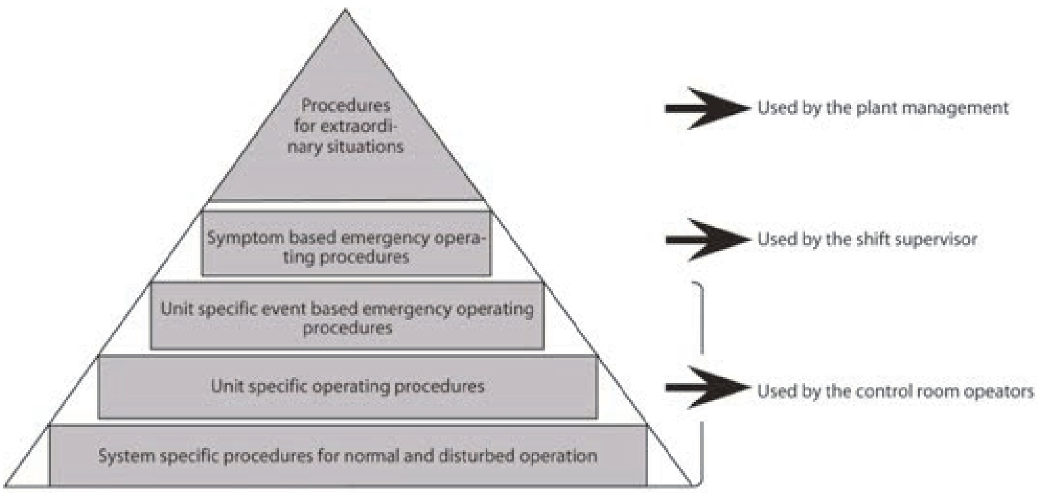

Figure 18: Overview of the main procedures applied during emergency situations. Other documents exist as reference to the main procedures. The level of the detail and the number of procedures decreases with the height of the pyramid.

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.

19.2.6 Engineering and technical support

The nuclear power plants are staffed with personnel to be able to account for the responsibilities of the licensees. All licensees have these competences 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 internal consultants. The group has been incorporated as a line organisation function, Projects & Services, since January 2013.

19.2.7 Incident reporting

Incidents significant for safety are reported in accordance with the non-routine reporting requirements in the STFs. These have been updated to comply with the latest regulations of SSM, SSMFS 2008:1. 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 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 to warrant prompt reporting (Level 2 or higher) according to the INES scale. During the period 2013–15, one event on the INES scale was reported, rated as Level 1.

The other type of LER, called category 2, is used for less severe events. This type of event is mentioned in the daily report, which is sent to the regulatory body; this is followed up by a final report within 30 days (see section 19.3.4).

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.

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

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.

19.2.8 Operating experience analysis and feedback

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 on events. The reports include events not meeting 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 scram and other event reports from Swedish NPPs, as well as from Finnish BWRs in addition to international information, are performed by Norderf, who provides Nordic NPPs with external operational experience from the nuclear industry worldwide. Norderf consists of representatives from TVO (Finland), Swedish nuclear power companies and 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 placed in a common 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 and NucNet, and the information is collected, reviewed, screened and sorted by KSU. The events are graded on a scale of three.
- Norderf assesses all events, including scram reports, from Nordic BWR reactors, and when appropriate, also related to PWR reactors. International events, classified from 1 to 3 by KSU, are also assessed by Norderf as belonging to 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 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, which is operated by KSU. 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, 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.

19.2.9 Operating experience feedback function at Ringhals

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 following them up. 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. The result is brought upstream to the central OPEX group. This group is staffed by appointed representatives 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 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.

19.2.10 Operating experience feedback function at Forsmark

The OEF function at Forsmark is located in the Engineering Unit. The department's OEF function is composed of two groups: Internal and External Operating Experience, and MTO.

Internal OE

The main task of the group is to manage all OEF in a systematic and structured way. This includes implementation of a process for CAP (see figure). In order to assist in handling and processing of OE matters, all main departments at FKA have OE coordinators who are responsible for ensuring that matters are dealt with as specified by the CAP process and ensuring that actions are taken within their unit. The OEF department has two OE coordinators: one for the Maintenance Unit and one for Plant Operations units 1, 2 and 3.

External group

The overall objective is to enhance reactor safety by making use of external events and lessons learned. A group with members designated based upon their technical skills and position in the organisation meets every other week to evaluate incoming external experiences. The group's other main task is to provide and assist the entire organisation with adequate knowledge for performing root cause analysis (see Figure 19) for events affecting the interplay between Man, Technology and Organisation (MTO).

The main task of the WANO SOER coordinator is to assist in and follow up ongoing work with recommendations and actions for the SOER.

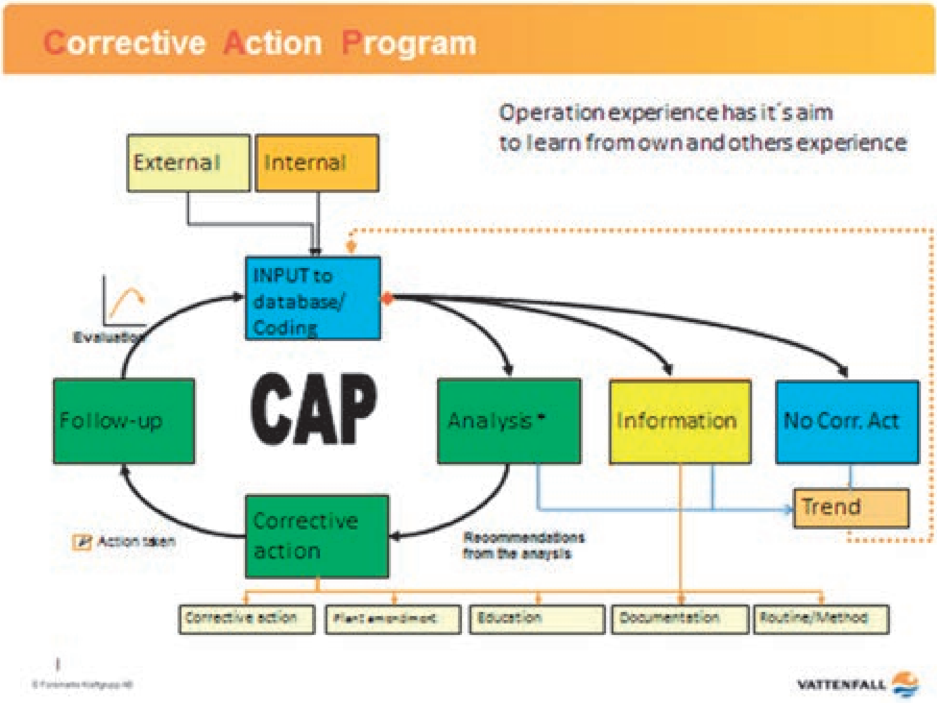

Figure 19: CAP-process.

19.2.11 Operating experience feedback function at Oskarshamn

All departments and sections at Oskarshamn are responsible for applying experience feedback in daily work within their own operations. Departments and sections at OKG principally obtain experience feedback from engineers 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. 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 excluding any issues based on dissimilarities found, but instead looking to identify associated similarities and details.

Corrective action programme (CAP)

OKG works with a CAP for management of events, nonconformities and suggested improvements. These are referred to collectively as 'observations'. The main objective of observations is not only to identify appropriate measures for reducing the risk of recurrence, but also to eliminate the risk of more serious events taking place.

All employees at OKG have training on reporting observations. Managers and other key personnel have training on actively managing observations, performing analyses and executing proposed actions. Experiences from the plant are shared through the CAP process by CAP coordinators assigned to each production unit.

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. Nearly ten people work with coordination, training and assisting the organisation in the process.

19.2.12 Operating experience for training 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.

19.2.13 Management of spent nuclear fuel and radioactive waste

Spent fuel

Spent fuel is stored in fuel pools at Swedish nuclear power plants, usually for an average of two years while awaiting transport. This is done by the m/s Sigrid, which ships the spent fuel to Clab, a central interim storage facility located at the Oskarshamn plant. This transportation is a routine operation.

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.

Intermediate-level waste

This type of waste is dominated by filters and spent ion exchange resins, which are commonly solidified with cement or bitumen in steel drums, or in moulds of reinforced concrete or carbon steel. The cement or bitumen immobilises the waste, while the moulds contain the waste forms, and in the case of concrete moulds also provide 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.

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.

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 1m
- Position during intermediate storage

Production and storage of radioactive waste at the plants is 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 awaiting transportation to the SFR repository, located near the Forsmark nuclear power plant. Prior to shipping to SFR, the types of waste packages must receive approval by SSM with regard to safety during transport and for disposal (waste acceptance).

19.3 Regulatory control

19.3.1 Operational limits and conditions

Notifications on changes in STFs and exemptions from STFs are reviewed as described in section 14.3. SSM is of the opinion that STFs are updated regularly at all the plants.

19.3.2 Procedures

Operational, emergency and maintenance procedures are normally not reviewed by SSM. SSM only asks for a procedure to be submitted for review in connection with event investigations or specific inspections.

19.3.3 Engineering and technical support

Except for the independent safety review functions and involvement in the national competence situation as reported in Chapter 11, SSM has not thus far 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.

19.3.4 Incident reporting

The number of licensee event reports (category 2 LERs) has varied in the range of 8 to 55 per year and reactor over the past few years. The total number is approximately between 219 and 354 LERs each year.

For more serious incidents, SSM has a procedure for making on-site rapid investigations. This procedure has been used in a few cases over the past few years. Licensee reporting has improved over the past few years and in most cases, provides the necessary information, together with SSM verifications on-site, for making needed regulatory decisions.

19.3.5 Experience feedback analysis

All reports from licensees are screened each week by a group of six to eight persons from the reactor safety department. 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 department 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.

All LERs and scram reports from Swedish nuclear power reactors have been registered in a database at SSM (‘ASKEN’) since the 1970s. All events are indexed and searchable and can easily be trended across many parameters.

19.3.6 Radioactive waste

Inspection of on-site management of radioactive waste is carried out by SSM 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 for disposal in SFR.

19.4 Vienna Declaration on Nuclear Safety

This section, in reference to Article 19, describes how Sweden implements the first and second principle of the Vienna Declaration on Safety regarding design of the nuclear power plants.

19.5 Conclusion

Sweden complies with the obligations of Article 19.

C. APPENDICES

Appendix 1: Nuclear safety and radiation protection regulations

Regulations concerning safety in nuclear facilities (SSMFS 2008:1)

These regulations were developed for nuclear power reactors but are applicable, in a graded way, on all licensed nuclear facilities. Minor amendments regarding the requirements on safety program, safety analysis, safety analysis reports and technical specifications were made in the SSM regulations. The regulations aim at specifying measures needed for preventing and mitigating radiological accidents, preventing illegal handling of nuclear material and nuclear waste and for conducting an efficient supervision:

- Application of multiple barriers and defence-in-depth
- Handling of detected deficiencies in barriers and the defence-in-depth
- Organisation, management and control of safety significant activities
- Actions and resources for maintaining and development of safety
- Physical protection and emergency preparedness
- Basic design principles
- Assessment, review and reporting of safety
- Operations of the facility
- On-site management of nuclear materials and waste
- Reporting to SSM of deficiencies, incidents and accidents
- Documentation and archiving of safety documentation
- Final closure and decommissioning

General advice on the interpretation of most of the requirements is given.

In 2012, changes were made to SSMFS 2008:1. These include some new requirements and amendments, mainly in the areas of nuclear waste and decommissioning, justified by a desire to bring together provisions currently found in several of SSM's regulations. Some of the changes were also made in order to obtain better agreement with the reference levels developed within the framework of WENRA cooperation.

Regulations on control of nuclear material (SSMFS 2008:3)

These regulations with general advice include requirements on measures needed to prevent the spread of nuclear weapons and illegal possession of nuclear material, disposed spent nuclear fuel, nuclear equipment and associated software and techniques. The requirements cover organizational aspects, competence and the authority of staff, procedures concerning international control (IAEA, EC, and ESA) descriptions of the facility, nuclear material control system, reporting, notification, and filing procedures. The regulations also stipulate requirements regarding nuclear research, manufacture of nuclear equipment, and import and export control.

General advice on the interpretation of Section 5 in the Act on Nuclear Activities (1984:3) on the use of contractors (SSMFS 2008:6)

SSM has issued general advice on the interpretation of Section 5 in the Act on Nuclear Activities regarding the use of contractors. Contractors are defined as every physical or legal person to whom the licensee hands over an activity (provides a contracted service). This means that companies belonging to the same corporation as the licensee, as well as staffing agencies, are regarded as contractors. If a contractor is approved by SSM and a permit is issued (see section B7.1), although the overall responsibility for safety rests with the licensee, the contractor has legal duties and obligations for the nuclear activities defined by the contract and permit. SSM can decide on safety conditions for the contract. A contractor cannot, without an additional permit, use a subcontractor for activities within the contract. A subcontractor is not allowed to engage a sub-subcontractor (fourth party).

Regulations on exemption from the requirement on approval of contractors (SSMFS 2008:7)

The Act on Nuclear Activities (1984:3) provides rules regarding the allowed use of contractors (see also section B7.1). In general, a licensee cannot contract out an activity included in the nuclear licence without a permit by the Government or SSM. However, if the licensee controls and follows up on the contractor's work, for certain activities the permit procedure can be replaced by a notification to the regulatory body. SSM is authorized by the Government to specify the prerequisites for such exemptions.

The regulations contain a list of activities that can be contracted out without a permit. This list includes building and construction work, decommissioning activities, maintenance and inspection work, training, qualified expert tasks that cannot reasonably be done with own staff and filing (archives) of safety documentation. It is pointed out that exempted activities must not be all or major parts of the licensed nuclear activity. Furthermore, exempted activities must not include security measures or activities for storage and disposal of nuclear materials or wastes.

The regulations specify that exempted activities must be conducted under the management and control of the licensee. If SSM finds, after notification, that a contract includes activities of principal importance, the authority can decide that the contract must not be awarded without a permit by the Government or SSM.

Regulations on physical protection of nuclear facilities (SSMFS 2008:12)

These non-classified regulations with general advice contain requirements on the organisation of the physical protection, clearance of staff, tasks for the security staff, central alarm station, perimeter protection, protection of buildings, protection of compartments vital for safety, access control for persons and vehicles, protection of control rooms, communication equipment, search for illegal items, handling of information about the physical protection and IT security. Design details about the physical protection shall be reported in a classified attachment to the SAR of the facility.

Regulations concerning mechanical components in certain nuclear facilities (SSMFS 2008:13)

These regulations contain requirements for the use of mechanical equipment, requirements on limits and conditions, damage control, and accreditation of control organizations and laboratories, requirements on in-service inspection and control, requirements in connection with repair, exchange and modification of structures and components, requirements on compliance control and annual reporting to SSM. The regulations contain rather precise requirements for design specifications and their assessment when plants are to be modified. The regulations contain stringent requirements for the assessment of the safety impact of continued operation with components that are degraded to a certain level. The general advice focuses on important aspects to be considered when applying different qualitative and quantitative risk oriented approaches (see section B14.1).

Regulations on emergency preparedness at nuclear facilities (SSMFS 2014:2)

These regulations apply to the planning of emergency preparedness and radiation protection measures in the case of an emergency or a threat of an emergency in nuclear facilities of emergency preparedness categories I, II or III according to the IAEA Safety Requirements No. GSR Part 7: *Preparedness and Response for a Nuclear or Radiological Emergency*. The regulations address alarm criteria and alerting, emergency facilities, evacuation plans, training and exercises and other issues related to emergency preparedness (e.g. iodine prophylaxis, personal protective equipment, monitoring, ventilation filters, meteorological data).

Regulations on design and construction of nuclear power reactors (SSMFS 2008:17)

The regulations with general advice contain specific requirements for nuclear power reactors on design principles and the implementation of the defence-in-depth concept, withstanding of failures and other internal and external events, withstanding of environmental conditions, requirements on the main and the emergency control room, safety classification, event classification, requirements on the design and operation of the reactor core.

Transitional rules to the regulations stipulate that measures to comply with certain paragraphs shall be implemented at the latest at time points decided by SSM. The reason for this is that the licensees must be given time to investigate in depth, specify, procure, install, test, and safety review the back fitting measures needed to comply with the regulations. SSM has reviewed and decided on these plans (see section B6.2).

Regulations on protection of human health and the environment from discharges of radioactive substances from certain nuclear facilities (SSMFS 2008:23)

These regulations are applicable to releases of radioactive substances from nuclear facilities that are directly related to the normal operation at each facility. The limitation of releases of radioactive substances from nuclear facilities shall be based on the optimisation of radiation protection and shall be achieved by using the best available technique. The optimisation of radiation protection shall include all facilities located within the same geographically delimited area. The effective dose to an individual in the critical group from one year of releases of radioactive substances to air and water from all facilities located in the same geographically delimited area shall not exceed 0.1 millisievert (mSv).

Regulations on radiation protection managers at nuclear facilities (SSMFS 2008:24)

These regulations require any licence holder shall appoint a radiation protection manager[14] at the facility, with formal and good knowledge in radiation protection competences, in order to promote active radiation protection work and check on the implementation of the radiation protection legislation (laws, regulations, licence conditions). Furthermore, this control function also includes the tasks: to advice on competence and staffing issues, to oversee the optimisation of radiation protection, to control that the required reporting to SSM is carried out. SSM formally approves the appointment of the radiation protection manager and his/her substitute.

Regulations on radiation protection of workers at nuclear facilities (SSMFS 2008:26)

These regulations apply to the radiation protection of workers at nuclear facilities. They contain provisions on the optimisation of radiation protection; procedures for information and education; local radiation protection instructions and their content; procedures for controlled areas; monitoring of work places; individual dose monitoring and exposure assessments; the calibration of, and instructions for, instruments and equipment; procedures connected to work with fuel elements; and documentation, reporting and archiving of radiation dose data.

Regulations on the competence of operations personnel at reactor facilities (SSMFS 2008:32)

These regulations and general advice include requirements on competence analysis, competence assessment, authorization by the licensee, recruitment and training for a position, and retraining of operations personnel belonging to the categories operations management, control room personnel and field operators. If an individual satisfies all requirements regarding competence and suitability, the licensee may issue an authorization valid for three years. Every year, an intermediate follow up shall be done in order to check that the essential

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14 This radiation protection manager should not be confused with the appointed managers in the line organisation. This person should have an independent, controlling function, and at Ringhals and Forsmark NPPs this person is named "radiation protection controller".

competence is maintained. The regulations require the use of full scale simulators for operational training.

Regulations on archiving at nuclear facilities (SSMFS 2008:38)

These regulations apply to the archiving of documents that are drawn up or received in connection with the operations of a nuclear facility, record-keeping and the archives. They specify which documents and records that must be filed and how long they must be kept. They refer to requirements and general advice by the Swedish National Archives on the selection of materials and data carriers, transfers etc. They contain some provisions on the design of archives at the nuclear facilities. If the nuclear facility is decommissioned and the activities ceases, the archives shall be transferred to the National Archives or the regional state archives of Sweden.

Regulations concerning clearance of materials, rooms, buildings and land in practices involving ionising radiation (SSMFS 2011:2)

The regulations stipulate requirements on procedures for clearance of material, rooms, buildings and land. The regulations also stipulate nuclide specific clearance levels for different objects subject to clearance. Among others, the regulations contain requirements on written procedures, competence of the responsible personnel, recording of measurement results and reporting to SSM. Clearance levels are given for clearance of materials for reuse or for disposal as conventional waste, as well as for clearance of rooms or buildings after cessation of practices or decommissioning of facilities. The clearance levels are based on recommendations from the European Commission (reports RP 113 and RP 122 part 1).

Regulations on basic requirements for the protection of workers and the public in connection with work with ionising radiation (SSMFS 2008:51)

The regulations are general and apply to the exposure of workers and the public in both planned and emergency exposure situations. They are based on European provisions in the EU BSS[15]. They contain fundamental requirements on the licensee/operator for justification of the activities, optimisation of the radiation protection and limitation of individual doses (dose limits). They address the categorisation of workers and work places; stipulate Swedish dose limits for workers (including apprentices) and the public, and address the required information and protection of pregnant or breast-feeding women. The regulations address dose-limitation in connection with emergency exposure situations. The regulations give rules for measurements and registration of individual radiation doses and how these should be reported to the national dose register. The regulations contain provisions on medical surveillance, classification and medical records of workers. The regulations contain rules for the accreditation of laboratories for individual dose monitoring and performance requirements of individual dose meters. The regulations refer to the European technical

15 Council Directive 96/29/Euratom of 13 May 1996, laying down basic safety standards for the health protection of the general public and workers against the dangers of ionising radiation [O. J. L-159 of 29.06.1996].

recommendations for monitoring individuals exposed to external radiation (EUR 14852 EN, 1994).

Regulations concerning outside workers who work with ionising radiation (SSMFS 2008:52)

These regulations apply to outside workers of category A, working within controlled areas in Sweden and when Swedish workers of category A perform similar tasks in other countries. The regulations put obligations on both the licensee (e.g. operator of a nuclear facility) and the outside workers undertaking. The EU Directive (90/641/Euratom) which these regulations are based on require that the EU Member State's competent authorities, in Sweden SSM, can issue individual radiological monitoring documents to outside workers, as necessary. The regulations stipulate the necessary procedures to be followed and data to be available when such "dose passports" are issued by the authority.

General advice concerning the competence of Radiation protection experts (SSMFS 2008:29)

These general advice were issued following the "Communication from the Commission concerning the implementation of Council Directive 96/29/Euratom of 13 May 1996 laying down basic safety standards for the protection of the health of the workers and the general public against the dangers arising from ionising radiation". These recommendations covers the competence needed as well as gives advice on basic and additional training for Radiation protection experts ("qualified expert" according to the communication).

Regulations on the protection of human health and the environment in connection with the final management of spent nuclear fuel and nuclear waste (SSMFS 2008:37)

These regulations apply to the disposal of spent nuclear fuel and nuclear waste. They are not applicable to landfills for low-level nuclear waste. The basic requirement is that human health and the environment shall be protected from detrimental effects of ionising radiation, during operation as well as after closure. Another important requirement is that impacts on human health and the environment outside Sweden's borders are not permitted to be more severe than those accepted in Sweden. The regulations contain provisions on areas such as BAT and optimisation, the risk criterion and most exposed group, time periods for the risk analysis and demonstration of compliance for different time periods.

Regulations on safety in connection with the disposal of nuclear material and nuclear waste (SSMFS 2008:21)

These regulations, in force since 2002, contain specific requirements on design, construction, safety analysis and safety reports for disposal facilities in view of the period after closure of the facility. For the period before closure, the general safety regulations (SSMFS 2008:1) apply. The regulations concerning long-term safety for the disposal of spent nuclear fuel and nuclear waste specifically cover:

- qualitative requirements on the barrier system,

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

Appendix 2: Major past and currently implemented modifications at Swedish NPPs

1. Measures implemented during the reporting period 2013–15

1.1 Oskarshamn NPP

Oskarshamn unit 1 and unit 2

- Reinforcement of the control room ceiling to withstand an earthquake (2014)
- Analysis of natural phenomena, including necessary plant modifications (2014)
- Analysis of the requirement on two different parameters to identify the need of initiation of the reactor protection system, including necessary plant modifications (2014)
- Automation of the boron system for reactor shut-down (2014)
- Analysis of dependencies between the hydraulic scram system and the pressure relief system, including necessary plant modifications (2015/2014)

Oskarshamn unit 1 and unit 3

- Update of the environmental qualification inside the containment, including measures if necessary (2014)

Oskarshamn unit 1

- Update of the environmental qualification outside the containment, including measures if necessary (2014)

Oskarshamn unit 2

- Replacement of all safety classified electrical and I&C systems (including reactor protection systems) to strengthen the separation of operation and safety systems and the physical separation of the different subdivisions in the safety classified electrical and I&C systems (2014)
- Installation of a new digital reactor protection system (RPS) and a diversified non digital reactor protection system (DPS), control room modernization and installation of a new emergency control room (identical to the main control room from a safety aspect) (2014)
- Installation of diversified relief valves (ADS) for the RPV (verified for two phase flow) (2014)
- Installation of new diversified residual heat removal systems (two trains) (2014)
- Installation of four new emergency diesel generators. Two of them diversified from the other two and with diversified cooling systems (2014)

- Installation of diversified detection of plant initiating events (2014)
- Installation of a new emergency control room (2014)
- Implementation of new electrical, I&C and process systems as well as modifying existing process systems due to earthquake (2014)
- Improvement of the fire protection (2014)
- Analysis of strong wind, snow, tornado and tornado induced missiles including necessary plant modifications (2014)
- Reinforcement of the reactor building to withstand flooding (2014)
- Measures due to risk of turbine missiles (2014)
- New main control room and emergency control room including e.g. new safety panel and safety desk and advanced operational readiness monitoring of safety systems (2014).

Oskarshamn unit 3

- Fire hazards analysis (2010–13)

1.2 Forsmark NPP

Forsmark unit 3

- Analysis of the requirement on two different parameters to identify the need of initiation of the reactor protection system, including necessary plant modifications (2013)

1.3 Ringhals NPP

Ringhals unit 1–4

- Strategy for long-term cooling of a severely damaged core, including necessary plant modifications (2014–15)
- Update of the environmental qualification outside the containment, including necessary plant modifications (2015)

Ringhals unit 1 and unit 4

- Analysis of earthquake, including necessary plant modifications (2011–13)

Ringhals unit 2 and unit 4

- Interconnection of RH and SP systems (2014)

Ringhals unit 3and unit 4

- Analysis of the emergency control post, including necessary plant modifications (2013)
- Analysis of local loads (R3-4: 2013), including necessary plant modifications (2015)
- Analysis of natural phenomena, including necessary plant modifications(2013)
- Measures regarding dependency of miniature circuit breakers (2014)

- Emergency Diesel Generators modernization, power increase and major overhaul of diesel generators (2014, 2015)

Ringhals unit 1

- Separation of operation and safety systems within the switchgear (2013)
- Change to two phase flow relief valves (2014)
- Measures to vent incondensable gases from the reactor vessel (2015)
- Improvement of the back panels in the control room (2013)

Ringhals unit 2

- Measures to make the auxiliary feed-water system independent, including a new water supply (2013; application to extend completion time until 2015)
- Physical separation within the ventilation system in the auxiliary systems building (2014)
- Analysis of the physical separation within the power system in the auxiliary systems building and the containment, including necessary plant modifications (2014)
- Separation within component cooling system (2014)
- Supports for several containment isolation valves (2014)
- Fire hazards analysis, including necessary plant modifications (2014)
- Incore and Flux measurement (2015)

2 Modifications implemented 1995–2013

2.1 Oskarshamn NPP

Oskarshamn unit 1

The major renovation of Oskarshamn unit 1 in the early 1990s showed that the reactor pressure vessel was in good condition and capable of operating for more than its 40-year design lifetime. The utility OKG therefore decided to further modernize the unit in order to ensure safe and economical operation for at least another 20 years. Projects performed included:

- further checking of the reactor pressure vessel and main circulation pipes, and exchange of reactor internals (moderator vessel, moderator vessel head and steam separators)
- further safety improvements in the core cooling systems, electric power system (two additional trains) and the I & C system (introducing digitalised systems for neutron flux monitoring and the reactor protection system) including modernization of the control room
- improvement of the turbine (main exchange of HP and LP turbines) to increase availability and thermal efficiency, adding at least 20 MWe to the power output.

This modernization programme was implemented during extended outages and completed in 1999.

By 2002 the following further measures were completed, and the corresponding functions and systems ready for operation:

- a new safety concept based on the safety requirements for modern nuclear power plants
- new and modernized systems for performing safety functions
- a modified concept for the reactor protection system and safety I&C including a new emergency control room
- a modified concept for electrical power supply, and
- a new emergency control building, as well as some modifications to existing buildings.

The modernization of the safety systems was achieved by a functional group concept consisting of three diversified possibilities for emergency core cooling and residual heat removal. The first group comprises the unique auxiliary condenser and a new independent demineralised water supply line connected to the demineralised water storage tank. The second group comprises the twofold auxiliary feed-water system, the four power-operated relief valves and the two-train containment heat removal system, while the third group consists of the two-train low-pressure emergency core cooling system (100% each) and the two-train containment heat removal chain. The installations and components of the third group are designed and qualified to withstand seismic loads.

The emergency power supply system consists of four separated safety trains. Two of them are powered by two new diesel generator sets, while the other two are powered by the re-qualified existing diesel generator sets.

The new I&C system for safety systems and the new reactor protection system are of a fourfold redundant design with total physical and functional separation.

A completely new emergency control building was erected to house the new systems and components. The following main components were installed in the building:

- two diesel generators including auxiliary systems and fuel tanks, completely physically separated
- two secondary cooling water pumps and heat exchangers for safety systems
- two auxiliary feed-water booster pumps
- a pump for supplying demineralised water to the auxiliary condenser basin
- switch gears, batteries and bus bars for the redundant safety trains
- a physically separated four-train reactor protection system and other I&C equipment
- a redundant ventilation system
- A monitoring system was installed to detect core instability/power oscillations
- Recombiners installed in the turbine off-gas system to reduce radioactive discharge to the environment
- Ventilation valves installed on top of the reactor to evacuate non-condensable gases following a loss of coolant accident

The reactor building has been designed to withstand all types of external events, including the seismic loads defined for Oskarshamn unit 1. Installations and electrical and mechanical equipment in the building have also been designed and qualified to withstand seismic loads.

The original main control room is completely modernized in areas in which new equipment has been installed, whereas existing control equipment and panels have been maintained to which no changes have been made. A safety desk has been installed having the same function as a safety display panel. The emergency control room contains a replica of the safety desk and the control functions. Upgraded cooling of the condensation pool was performed in 2004 at the same time as a diversified power supply for the programmable reactor protection system was implemented.

During the previous review period the following modifications were made at Oskarshamn unit 1:

- Enhancement of the fire separation in the reactor building.
- Replacement of obsolete valves in the blading and feed heater systems.
- Valve replacements in the residual heat removal system.
- Reactor core sprinkler system - Installation of additional shut off valves in the pressure boundary to non-essential part
- Valve replacements in the fire protection water system.
- Environmental qualification of equipment
- Reinforced roof in the main control room
- Digital control equipment system – Improvements in the operator interface
- Measures taken concerning the feed water distributors in the reactor pressure vessel
- Measures taken concerning the supports of the coolant water pipes for diesel generators A and B
- Reconstruction of pressure surveillance and pressure regulation in the water tanks belonging to the scram system.
- Measures taken regarding the decontamination pipes for the isolation condenser
- New starting motors to the emergency diesel generators sub A and B to improve reliability

Oskarshamn unit 2

The modernization project at O2 started as a pre-study in 1996 based on an inventory of known weaknesses and experience from operation of the unit. The modernization measures include a chemical decontamination of the reactor pressure vessel (RPV) and the primary systems, as in Oskarshamn unit 1, in order to reduce the dose rates, followed by tests of the RPV and its internal parts.

Examples of early completed measures are

- replacement of piping, penetrations and valves in the primary systems within the reactor containment
- replacement of reactor internals, i.e. steam separators, and core spray nozzles and piping

- changes in the reactor protection system including addition of a new condition for reactor scram
- improvements of some fire protection systems
- improvements to reduce risks for hydrogen explosions in piping systems
- upgrading of feed water control system to programmable I&C equipment.
- separation of safety and non-safety related equipment in some I&C systems.

The PLEX project (physical changes starting in 2007) included modifications to comply with SSMFS 2008:17 regulations as well as replacement of critical components in order to achieve a 60-year life. The 2007, 2009 and 2013-2016 outages were the periods of time for performance of the main work.

- Modernization of the feed water system inside the containment involving the exchange of inboard isolation valves, installation of pipe break valves and cyclone filters
- New turbine I&C including operator interface in the control room
- Environmental qualification of components outside the containment
- Modernization and power uprate project began erecting buildings intended for new safety I&C, bus bars, auxiliary power diesels and diversified cooling chain
- Recombiners installed in the turbine off-gas system to reduce radioactive discharges to the environment
- Ventilation valves installed on top of the reactor to evacuate non-condensable gases following a loss of coolant accident
- Replacement of the low pressure turbines
- Deep water intake construction implemented and commissioned
- Preparatory work performed for the new diversified cooling chain
- Completed erection of new buildings
- Installation of new safety I&C, bus bars and auxiliary power diesels
- Install of the new diversified residual heat removal
- Verification of the operability of long shaft pumps during accident condition in low pressure core cooling system and residual heat removal system based on events in PWR in France. The verification was performed at the Barsebäck plant by electrically heating up the condensation pool there.

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.

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).

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 1–2)
- replacement of 6 kV switchboards (units 1 and 2).

Forsmark unit 1

- 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 sec.
- 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 (unit 1)
- new low pressure turbines (unit 1-2005).

Forsmark unit 2

- 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 sec.
- 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 installed in 2009
- replacement of electrical control boards in the main control room (unit 2)
- modification of the reactor pressure vessel head sprinkler (unit 2)
- modernization of the power measurement system (unit 2)
- modification of the cooling chain for increased capacity and separation of power supply connections (unit 2)
- new low pressure turbines (unit 2-2006).

Forsmark unit 3

- 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 sec.
- 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 (unit 3)
- new low pressure turbines (unit 3-2004).

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 in fire protection systems
- Fire system modernizations
- Upgrading and modernizing Ringhals NPP's Command Center

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

- 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.

Ringhals unit 1

- separation of electric power supply of core cooling systems (R1)
- introduction of alarm for core instability (R1)
- exchange of control rod indication and manoeuvring system (R1)
- verification and improvement of piping supports (R1)
- the SPRINT project (replacement of primary system piping) (R1)
- 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.

Ringhals unit 2

- completions for the Twice-project, replacement I & C equipment including the main control room (R2)
- a fourth level measurement channel installed in the steam generators (R2)
- modernization of 110 V DC systems with new switchboards (R2)
- replacement of toroid plates (R2)
- pressurizer relief valves replaced/modified (R2)

- replacements and improvement in the electrical supply systems for improved separation and safety (R2)
- 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.

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

Vienna Declaration on Nuclear Safety

On principles for the implementation of the objective of the Convention on Nuclear Safety to prevent accidents and mitigate radiological consequences

Adopted by the Contracting Parties meeting at the Diplomatic Conference of the Convention on Nuclear Safety
Vienna, Austria

9 February 2015

THE CONTRACTING PARTIES
TO
THE CONVENTION ON NUCLEAR SAFETY

(i) *taking into account* the significant number of efforts and initiatives taken place after the accident at the Fukushima Dai-ichi Nuclear Power Plant on a national, regional and international level, to enhance nuclear safety;

(ii) *noting* changes adopted in the Guidance Documents INFCIRC/571, 572 and 573 to strengthen the review process of the Convention on Nuclear Safety (hereinafter referred to as CNS);

(iii) *recalling* the observations of the Contracting Parties of the CNS at the 2nd Extraordinary Meeting in 2012, confirmed at the 6th Review Meeting in 2014, that the displacement of people and the land contamination after a nuclear accident call for all national regulators to identify provisions to prevent and mitigate the potential for severe accidents with off-site consequences;

(iv) *reaffirming* the fundamental safety principles provided by the CNS and the commitment it entails to the continuous improvement of the implementation of these principles;

(v) *aware of* the world-wide Action Plan on Nuclear Safety endorsed by all Member States of the International Atomic Energy Agency in September 2011; and,

(vi) *having considered* the proposal by the Swiss Confederation to amend Article 18 of the CNS presented at the 6th Review Meeting of the CNS;

have adopted the following principles to guide them, as appropriate, in the implementation of the objective of the CNS to prevent accidents with radiological consequences and mitigate such consequences should they occur:

1. New nuclear power plants are to be designed, sited, and constructed, consistent with the objective of preventing accidents in the commissioning and operation and, should an accident occur, mitigating possible releases of radionuclides causing long-term off site contamination and avoiding early radioactive releases or radioactive releases large enough to require long-term protective measures and actions.

2. Comprehensive and systematic safety assessments are to be carried out periodically and regularly for existing installations throughout their lifetime in order to identify safety improvements that are oriented to meet the above objective. Reasonably practicable or achievable safety improvements are to be implemented in a timely manner.

3. National requirements and regulations for addressing this objective throughout the lifetime of nuclear power plants are to take into account the relevant IAEA Safety Standards and, as appropriate, other good practices as identified inter alia in the Review Meetings of the CNS.

The Contracting Parties to the CNS further decide that:

(1) The agenda of the 7th Review Meeting of the CNS shall under its process include a peer review of the incorporation of appropriate technical criteria and standards used by Contracting Parties for addressing these principles in national requirements and regulations, which should lead the CNS to a process of consideration of key areas to be agreed at Review Meetings for subsequent Review Meetings.

(2) With immediate effect, these principles should be reflected in the actions of Contracting Parties, in particular when preparing their reports on the implementation of the CNS, with special focus on Article 18 as well as other relevant Articles, including Articles 6, 14, 17 and 19, starting with the national reports to be submitted by Contracting Parties for consideration during the 7th Review Meeting of the CNS.

(3) Each national report should include inter alia an overview of implementation measures, planned programs and measures for the safety improvements identified for existing nuclear installations.

(4) Contracting Parties are committing to ensuring that the safety objectives set out above form an integral part of considerations during future Review Meetings and will be used as a reference to help strengthening the peer review process of the CNS.

The Contracting Parties to the CNS request the IAEA Director General to:

a. *transmit* this Declaration to the IAEA Commission on Safety Standards for its consideration with the four safety standards committees under its aegis, of the technical elements contained therein with a view to incorporating them as appropriate into the relevant IAEA Safety Standards; and

b. *publish* this Declaration as an INFCIRC for its widest dissemination including to States which are not Contracting Parties to the CNS, and the public in general.

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Kronologisk förteckning

1. Kontroller och inspektioner i Sverige av Europeiska byrån för bedrägeribekämpning. Fi.
2. Några frågor om offentlighet och sekretess. Ju.
3. Uppföljning av återvändandedirektivet och direktivet om varaktigt bosatta tredjelandsmedborgares ställning. Ju.
4. Effektivare hyres- och arrendenämnder. Ju.
5. Mer tydlighet och aktivitet i sjuk- och aktivitetsersättningen. S.
6. Entreprenörsansvar och svenska kollektivavtals- villkor vid utstationering. A.
7. Tolktjänst för vardagstolkning. S.
8. Hälsoväxling för aktivare rehabilitering och omställning på arbetsplatserna. S.
9. Ny lag om tilläggsavgift i kollektivtrafik. N.
10. Nya regler för europeiska småmål – lättare att pröva tvister inom EU. Ju.
11. Anpassningar av svensk rätt till EU-förordningen om kliniska läkemedelsprövningar. S.
12. Etisk granskning av klinisk läkemedelsprövning. U.
13. Nya möjligheter till operativt polissamarbete med andra stater. Ju.
14. Förtydliganden av lönestöden för personer med funktionsnedsättning som medför nedsatt arbetsförmåga. Byte av benämningar på lönebidrag, utvecklingsanställning och trygghetsanställning. A.
15. Normgivningen inom åklagarväsendet m.m. Ju.
16. Ersättning vid expropriation av bostäder. Ju.
17. Otillåtna bosättningar. Ju.
18. Ytterligare åtgärder för att genomföra EU-direktiv om mänskliga vävnader och celler. S.
19. Jämställda pensioner? S.
20. Strada. Transportstyrelsens olycksdatabas. N.
21. Ändringar i fråga om sysselsättning för asylsökande och kommunplacering av ensamkommande barn. A.
22. Polisens tillgång till information om vissa it-incidenter. Ju.
23. Vissa frågor om kommersiell radio. Ku.
24. Validering med mervärde. U.
25. Miljöbedömningar. M.
26. Utvidgat skydd mot diskriminering i form av bristande tillgänglighet. Ku.
27. Frågor kring 2009 års renskötselkonvention. N.
28. Driftsformer för universitetssjukhus. S.
29. Privata sjukvårdsförsäkringar inom offentligt finansierad hälso- och sjukvård. S.
30. Sweden's seventh national report under the Convention on Nuclear Safety. Sweden's implementation of the obligations of the Convention. M.

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