DECEMBER 2019

European Stress Tests for Nuclear Power Plants
National Action Plan FINLAND

STUK
SÄTEILYTURVAKESKUS
STRÅLSÄKERHETSCENTRALEN
RADIATION AND NUCLEAR SAFETY AUTHORITY

Contents

SUMMARY

There are two nuclear power plants operating in Finland: the Loviisa and Olkiluoto plants. The Loviisa plant comprises two VVER 440-type pressurised water reactor units) operated by Fortum Power and Heat Oy and the Olkiluoto plant two boiling water reactor units operated by Teollisuuden Voima Oyj (TVO). In addition, a new nuclear power plant unit (EPR type pressurised water reactor) is under commissioning by TVO at the Olkiluoto site. At both sites there are the interim storages for spent fuel as well as the final repositories for the intermediate and low-level radioactive waste. Furthermore, one Triga Mark II research reactor located in Espoo and operated by the Technical Research Centre of Finland is under decommissioning.

Following the accident at the Fukushima Dai-ichi nuclear power plant on the 11th of March in 2011 (TEPCO Fukushima Dai-ichi accident), safety assessments were initiated in Finland immediately after Radiation and Nuclear Safety Authority (STUK) received a letter from the Ministry of Employment and the Economy (MEE) on 15 March 2011. The Ministry requested STUK to carry out a study on how the Finnish NPPs have prepared against loss of electric power supply and extreme natural phenomena in order to ensure nuclear safety. STUK requested the licensees to carry out assessments and submitted its report to MEE on 16 May 2011.

Although immediate actions were not considered necessary, STUK required the licensees to carry out additional assessments and present their action plans for safety improvements. Assessments were conducted and reported by the Finnish licensees to STUK on 15 December 2011. After reviewing the results of national assessments STUK made the licensee specific decisions on the additional analyses and safety improvements suggested by the licensees on the 19th July 2012.

Finland participated in the EU Stress Tests for nuclear power plants. The national report was submitted to the European Commission at the end of 2011. The recommendations of the EU peer review (April 2012) were taken into account in the regulatory decisions and in the renewal of national regulations.

In addition, Finland participated in the second Extraordinary Meeting of the Convention of Nuclear Safety (CNS) in August 2012. The report on the national actions in Finland initiated as a result of the TEPCO Fukushima Dai-ichi accident was prepared and introduced in the meeting. All Fukushima-related decisions by STUK, the national report to the European Commission and the report to the Extraordinary CNS have been published on STUK's website.

Based on the results of the assessments conducted in Finland after the Fukushima Dai-ichi accident, it was concluded that no such hazards or deficiencies have been found that would require immediate actions at the Finnish NPPs. However, as presented in this report, areas where nuclear safety can further be enhanced were identified, and accordingly, action plans how to address these areas in the Finnish NPPs and national legislation and regulation were created.

This report is the updated version of the original Finnish National Action Plan addressing the measures initiated and implemented to date on the national level and at the nuclear power plants as a result of the TEPCO Fukushima Dai-ichi accident. The

report discusses national conclusions and activities focusing to six topical areas structured according to the NAcP Guidance by ENSREG Stress Test Action Plan. The first three topics i.e. natural hazards, design issues and severe accident management, are discussed in PART I, in Chapters 1 - 3. PART II discusses the topics of national organizations, emergency preparedness and international co-operation. The relevant text from the EU peer review report "Compilation of recommendations and suggestions" and the topical reports of the second Extraordinary Meeting of the CNS is quoted in the beginning of each Section in *italic*. PART III in Chapter 7 summarizes all activities taken, planned or implemented in a table format including time schedules.

Some of the most significant plant changes which have already been implemented include:

- independent air-cooled cooling units at the Loviisa NPP for decay heat removal from the reactor core and from the spent fuel pools in case of the loss of sea water as an ultimate heat sink

- enhanced protection against high sea water level at the Loviisa NPP

- independent way of pumping water into the RPV in case of total loss of AC systems at the Olkiluoto units 1 and 2

- diverse cooling of the spent fuel pools at the Olkiluoto units 1 and 2

- ensuring operation of the auxiliary feed water system pumps independently of availability of the sea water systems at the Olkiluoto units 1 and 2

There is only one remaining action at the operating NPPs which has not yet been finalized: ensuring the water injection into the spent fuel pools and monitoring the conditions of the pool at the Loviisa NPP. Original target date for implementation was 2018. Due to many overlapping plant modifications (I&C renewal, improvement of secondary circuit safety functions), the licensee had to make the decision to postpone Fukushima modification finalization to 2020. There is also one action concerning Olkiluoto unit 3 under commissioning which will be resolved after the provisional takeover: implementation of the strategy for restoring long-term cooling after an extreme electrical disturbance by replacing selected parts of the electrical systems.

PART I

1 Topic 1: Natural Hazards

Necessary implementation of measures allowing prevention of accidents and limitation of their consequences in case of extreme natural hazards is a finding of the peer review that national regulators should consider. Deterministic methods should form the basis for hazard assessment. Probabilistic methods, including probabilistic safety assessment (PSA), are useful to supplement the deterministic methods.

External natural and human induced hazards are to be taken into account when selecting an NPP site in Finland, as well as in assessing the safety of NPPs. The renewed regulations and YVL Guides published in 2013 include updated requirements on provisions for external hazards, including, e.g, earthquakes, high sea water level, harsh weather conditions and hazards related to transport and industrial activities. The design basis of nuclear facilities shall be determined based on site-specific hazard studies. For new NPP units and other nuclear facilities the new Guides are applied as such. For the operating units the fulfilment of the new requirements has been evaluated and STUK has made separate decisions on the application of the new Guides in 2015. For the Olkiluoto unit 3 under commissioning the evaluation of the fulfilment of the new requirements was carried out and the decisions on the application of the Guides were made in 2016. The new Guides have been applied from 7 March 2019 when the operating licence was granted and became effective.

External conditions in Finland are moderate. No destructive earthquakes or tsunami waves have been observed. Storms are not comparable to tropical cyclones and strong tornadoes are quite rare. Snowstorms are not comparable to the North American blizzards. Nevertheless, the Finnish licensees have used considerable efforts to assess the effects of external events on nuclear facilities during the past twenty years. The assessments cover seismic events, external flooding, extreme weather, frazil ice formation and impurities in the seawater (including algae and oil spills from oil transport accidents).

The national studies and the EU stress tests carried out after the Fukushima Dai-ichi accident did not reveal safety problems requiring immediate action. However, the licensees were required to carry out several additional safety studies and start preliminary planning for some safety improvements.

The required studies and preliminary plans submitted to STUK by the licensees were mainly found acceptable but for some issues more detailed studies and comparison of different alternative actions were required by STUK, for example high sea water level at the Loviisa site and review of the seismic hazard at the current sites.

The lessons learned from the TEPCO Fukushima Dai-ichi accident were taken into account in the renewal of STUK's regulatory guides (YVL guides). External events and "cliff edge" effects shall be considered more extensively in the design of nuclear facilities. More detailed requirements have been set on seismic safety, including seismic monitoring and safe shutdown after an earthquake. The effects of severe, long-standing external events shall be taken into consideration in emergency preparedness and rescue planning (see Sections 3.5, 5.1 and 5.6).

Within the Finnish national nuclear safety research programme SAFIR, there have been research projects on extreme weather phenomena and extreme seawater level variations since 2007 and a few years later seismic issues were added. The planning and implementation of the programme is managed and overseen by STUK. As a result of the TEPCO Fukushima Dai-ichi accident, a reassessment of how the accident should be taken into account was made, and the research projects mentioned here were somewhat redirected. Some additional resources were also allocated to the research of external events especially in the program period SAFIR2014 (2010-2014) The regional effects of long-term climate variability and change, as far as considered potentially relevant to nuclear safety, are included in the SAFIR programme.

The seismic research projects in the SAFIR programme have included sensitivity studies on the effects of the earthquake catalogue on the site specific seismic hazard estimation. Ground motion prediction equations have been developed and evaluated based on the Finnish and Swedish measurement data.

1.1 Hazard frequency and margins

Re-evaluating the hazards posed by external events, such as earthquakes, floods and extreme weather conditions, for each nuclear power plant site through targeted reassessment of safety. The use of a return frequency of 10E-4 per annum (0.1g minimum peak ground acceleration for earthquakes) for plant reviews/back-fitting with respect to external hazards safety cases. Formal assessment of margins for all external hazards including, seismic, flooding and severe weather, and identification of potential improvements.

For quantifiable phenomena, the associated hazard curves have been determined in cooperation with the national expert organizations (Institute of Seismology, Meteorological Institute) and reviewed by STUK using external experts. The estimates are reviewed and, if necessary, updated every few years.

A thorough review of the site-specific hazard curves was started in Finland already shortly before the Fukushima accidents in connection with the projects for building additional nuclear power plant units. Studies on external hazards are also continuously carried out in the national nuclear safety research programme SAFIR.

According to the current regulatory requirements, the design basis earthquake (safe shutdown earthquake) shall be determined so that the probability of exceedance is less than 10^{-5} per year. At the current sites the calculated site-specific peak ground acceleration is less than the minimum value 0.1 g recommended by the IAEA, and the value 0.1 g shall be used. Earthquakes exceeding the design basis have to be analysed in seismic PSA. The updated regulatory guides require more explicitly that earthquakes exceeding the design basis shall be analysed as design extension conditions (DEC C).

The renewed regulatory guides include more specific requirements on protection against other non-seismic external hazards, including external flooding and extreme meteorological phenomena. The frequency requirements for other external events have been harmonised with the seismic requirements. The general design basis of a nuclear facility shall cover external events estimated to occur with a frequency higher than 10^{-5} per year. Events exceeding the design basis shall be analysed as design extension conditions (typically down to frequencies 10^{-7} per year).

The current requirements were not in force when the operating NPP units were built. The capacity of the operating units to withstand exceptional external events has been analysed later with deterministic and probabilistic methods taking into account national and international operating experiences. Based on the analyses, several plant modifications of the plant and operating procedures have been implemented during the life time of the operating units. According to the PSA results, the risk caused to the operating units by external events was a relatively small fraction of the total risk, but the uncertainties were large. Some areas with possibilities for further risk reduction have been identified after the Fukushima accident and measures have been implemented at the plants, for example decreasing the vulnerability of the Olkiluoto units 1 and 2 to loss of the ultimate heat sink (see Section 2.1) and improving the protection of the Loviisa plant against high seawater (see Section 1.2).

Olkiluoto unit 3 fulfils the requirements in effect during the design and mainly also the updated requirements concerning external events. The design basis of Olkiluoto unit 3 for external events has been selected conservatively in the design phase. The design basis covers earthquakes, flooding, extreme weather and other natural hazards as well as human induced hazards. The design values correspond to return periods of up to 100 000 years and much longer for events with “cliff edge” type consequences. As the estimated conditions corresponding to such long return periods involve large uncertainties, considerable physical margins to the largest values observed in the neighbourhood of the site have also been ensured for most natural phenomena.

Assessment of the safety margins end effects of exceeding the design basis values has been done for all identified relevant external hazards (excluding intentional damaging of the plants) in connection with the external events PSAs (Probabilitistic Safety Assessment) which are mandatory for the Finnish NPPs. The external events related PSAs and their input are updated typically at intervals of 3 – 5 years.

Safety margins were assessed by the licensees and reviewed by STUK in connection with the national clarifications and the EU stress tests after the Fukushima Dai-ichi accident. Based on the results, STUK required further clarifications on the following main points:

- seismic resistance of spent fuel pools including situations with water temperature exceeding the design bases;
- seismic resistance of fire fighting systems; and
- plans for improving flooding margin for the Loviisa plant.

For other hazards, the reassessment of the margins within the next few years was considered sufficient.

The ENSREG Peer Review Country Report for Finland included the following recommendation in section 2.1.3: “*During the country visit, it was noted that the updated* *seismic PSA has been prepared for both Loviisa and Olkiluoto NPPs. STUK is currently performing the review. Based on review results, it will be possible to conclude on the qualification status of the critical SSC identified in the seismic PSA. With this regard, STUK should consider additional assessment of critical SSC with respect of PGA = 0.1g (as recommended in the IAEA Safety Guide NS-G-3.3).*"

In the operating units, there are some SSCs (Structures, Systems and Components) with estimated HCLPF (High Confidence Low Probability of Failure) values less than 0.1 g, but the seismic risk has been estimated to be only a small fraction of the total risk. STUK has considered the need for additional assessment of the critical SSCs and the need for safety improvements in connection with the detailed review of the seismic risk analysis. STUK has also considered the external events guidance developed by WENRA according to the ENSREG Stress Test Peer Review Board's recommendation. STUK required Fortum to evaluate the needs and possibilities for improving the supports of the seismically most sensitive main components and carry out a new seismic walk-down at the Loviisa NPP. The licensees also carry out seismic safety improvements for some components in connection with major plant modifications and replacements due to ageing. In accordance with the current regulatory YVL Guides, the licensees have reviewed and updated the site-specific seismic hazard studies.

The reassessment of the seismic hazard and seismic risk has turned out to be challenging especially for the Loviisa plant. Recent hazard updates for Loviisa show increased values of ground accelerations especially at long return periods. However, the input data and results of hazard calculations involve large uncertainties. Because in Finland seismic activity is low and seismic design is not required in the general building code, collection of seismic measurement data suitable for seismic hazard studies has been quite limited. A seismic walkdown of the Loviisa plant has been done in 2018 in cooperation with international consultants, and an observation report has been submitted to STUK. Final decisions on safety improvements will be made based on extensive dynamic analyses of safety related buildings and main components including re-evaluation of the boundary conditions.

Reassessment of the seismic hazard has been done also for the Olkiluoto site. The update resulted in some changes of the hazard curve shape, but the effects on seismic risk are small.

1.2 Flooding margin assessments

The analysis of incrementally increased flood levels beyond the design basis and identification of potential improvements. The use of a protected volume approach to demonstrate flood protection for identified rooms or spaces.

Flooding margin assessments have been included in the EU stress tests. The Finnish approach to protection against external flooding is based on the sufficient elevation of the site ground level and water tightness of the nuclear facilities up to the ground level.

In the operating units, some vital parts of systems required for performing the critical safety functions are situated at or below the ground level. Consequently, the safety margins for external flooding exceeding the design basis are small. In Olkiluoto 3 the leakage through outer doors would be slow, but the rise of seawater above the design basis level would soon result in the loss of sea water as the ultimate heat sink due to the flooding of the essential service water pump rooms.

For all Olkiluoto NPP units, it is considered extremely improbable that the seawater level design basis is exceeded (less than 10^{-9}/year). The design water level is +3.5 m and the observed maximum value in the region is about +1.04 m (N60 reference system).

The protected volume approach is currently used in special cases, for example, for the Olkiluoto units 1 and 2 emergency core cooling equipment rooms, but the protection is intended for preventing spreading of internal flooding due to pipe breaks.

The licensee of the Olkiluoto NPP was requested to carry out a more detailed assessment on the effects of exceptionally high seawater level on the cooling systems of the spent fuel interim storage and their electric power supply. Cooling system pumps are situated at the +0.5 m level. The spent fuel interim storage is designed as watertight up the seawater level +1.2 m. At higher seawater levels some seepage of water through the soil to the drainage system is anticipated. According to the licensee, the seepage would be stable and slow, and the water could be removed with submersible pumps up to seawater level of +3,5 m.

Based on the findings of the EU stress tests, the leak tightness of the seam between the seawater pumping station and seawater pipe culvert at the level +2.5 m has been ensured to prevent fast flooding of the interim storage of spent fuel.

For the Loviisa plant the safety margin against flooding is smaller than for the Olkiluoto units. The design value for external flooding during operation is about +3.0 m and the observed maximum value is +1.75 m. The annual frequency of exceeding the +3.0 m design basis was at that time estimated as $4 \cdot 10^{-7}$/year. The licensee was required to submit plans to improve protection against external flooding by the end of 2013. The licensee has been examining site area protection with levees and the protected volume approach and also their combination to improve of the flooding resistance of the Loviisa plant.

To ensure adequate design basis for the improved flood protection, Loviisa NPP contracted updating of the seawater level extreme value distribution by the Finnish Meteorological Institute. According to the results the expected seawater levels at low frequencies of occurrence are higher than previously estimated. The exceedance frequency of the critical +3.0 m level was estimated as about $5 \cdot 10^{-6}$/year taking into consideration also the effect of waves. The design basis seawater level for the improvements was set as +4,1 m., corresponding to exceedance frequency of less than 10^{-8}/year.

The improved flood protection of the Loviisa plant is based on the protected volume concept. The selected technical solution is local protection of the additional emergency feed water system and the back-up system for residual heat removal. The new protections of the additional emergency feed water system are installed in case exceptionally high seawater level is forecasted. Active measures are acceptable for protection against design extension floods, because high sea water can be predicted with sufficient warning time. To ensure cooling of the spent fuel pools, a separate water injection connection to fuel pools and was added. The improvements were implemented gradually in 2015 – 2019.

In addition, Loviisa NPP has in 2012-2018 gradually improved flood protection during certain annual outage states with open hatches in the condenser cooling seawater system, the design water level was increased from +2.1 m first to +2.45 m and later to +2.95 m. It should be noted that the annual shutdowns are scheduled for summer and early autumn whereas high seawater levels occur mostly in winter.

The ENSREG Peer Review Country Report for Finland included the following recommendation in section 2.3.3: "*An assessment of the drainage system capacity in case of high seawater level should be considered."* Prevention of flooding through the drainage system has been included in the improved protection against external flooding at the Loviisa NPP. Modifications of the drainage water system around the Olkiluoto interim storage for spent fuel has been implemented.

1.3 Secondary effects of earthquakes

The possible secondary effects of seismic events, such as flood or fire arising as a result of the event, in future assessments.

The licensees were required to analyze and present the conclusions on the seismic resistance of the fire fighting systems by the end of 2012. The use of fire fighting water for other safety functions besides fire extinguishing has also been considered in the analysis. Seismic qualification of fire fighting systems has not been required previously as in Finland the possibility of consequential fires due to an earthquake is considered very small.

Other consequential effects are not considered possible at the Finnish sites due to geographical and geological reasons. As the nuclear facilities are founded on bedrock, the site topography is relatively flat and there are no dams in the vicinity, soil liquefaction and subsidence, landslides and dam failures are not relevant hazards. The same applies to severe tsunami type flooding as there are no active fault zones under the Baltic Sea and, on the other hand, due to the shallowness of the sea the formation of high tsunami waves is not considered physically possible.

1.4 Seismic monitoring

The installation of seismic monitoring systems with related procedures and training.

Seismic monitoring instrumentation with sensors in the basemat and in structures at higher elevations has been installed in Olkiluoto unit 3 but the currently operating units do not have seismic monitoring systems. For the Olkiluoto units 1 and 2 the measurements at unit 3 can be used as a basis for inspections and other actions after an earthquake. At the Loviisa site there is no seismic measuring system. Decision on installation of a seismic monitoring system will be made when the seismic hazard assessment and seismic risk assessment have been completed. Currently the instructions on actions after an earthquake at the Loviisa plant is based on sensory observations and information from the Institute of Seismology seismic observation network. The vibration measurement systems of the turbines and primary circulation pumps may also provide useful information in connection with a seismic event.

1.5 Early warning notifications

The implementation of advanced warning systems for deteriorating weather, as well as the provision of appropriate procedures to be followed by operators when warnings are made.

The operating procedures of the Finnish NPPs require the operating personnel to contact the Meteorological Institute under circumstances with increased possibility of hazardous meteorological or marine phenomena. Authorities also distribute warnings on extreme natural phenomena.

Long term climate variability and change is monitored by the licensees and safety authorities in cooperation with expert organizations in ongoing research programs.

1.6 Qualified walkdowns

The development of standards to address qualified plant walkdowns with regard to earthquake, flooding and extreme weather – to provide a more systematic search for non-conformities and correct them (e.g. appropriate storage of equipment, particularly for temporary and mobile plant and tools used to mitigate beyond design basis (BDB) external events).

Plant walkdowns are a mandatory part of verifying the seismic design before commissioning of NPPs or major plant modifications. In addition, plant walkdowns are an established practice in conducting and reviewing probabilistic safety assessment for external and internal hazards.

In the new regulatory guides requirements are presented concerning performing walkdowns, but more rigorous guidance for qualified walkdowns has not been developed by STUK. The licensees are required to submit plans for walkdown for STUK's acceptance. Existing international guides published by, for example EPRI, have been applied.

The licensees have used plant walkdowns in developing action plans due to the TEPCO Fukushima Dai-ichi accident. Some walkdowns have also been performed by STUK. Walkdowns have also been done in connection with the review of the plant modification plans submitted by the licensees.

TVO has carried out seismic walkdowns for the fire extinguishing water systems of Olkiluoto. A seismic walkdown and a flooding walkdown were conducted at Olkiluoto 3 in connection with commissioning. A seismic walkdown was conducted for the Loviisa NPP in 2018.

2 Topic 2: Loss of Electrical Power and Loss of Ultimate Heat Sink (Design Issues)

The systems needed for residual heat removal from the reactor, containment and fuel pools require external power at both Finnish NPPs. At both sites, the ultimate heat sink is the sea. Depending on the design features of the plant, the time margins to withstand station blackout and loss of ultimate heat sink vary. A reliable supply of electrical power to the systems providing for basic safety functions at the Finnish NPPs is ensured by the Defence-in-Depth concept. As a result of multiple and diversified electrical power sources at different levels, the probability of loss of all electrical supply systems is considered very low at the Finnish NPPs.

However, as a result of the studies made after the TEPCO Fukushima Dai-ichi accident, further changes were implemented at both NPPs. Main changes are aimed at decreasing the dependency on plant's normal electricity supply and distribution systems as well as on the sea water cooled systems for residual heat removal from the reactor, containment and spent fuel pools.

2.1 Alternate cooling and heat sink

The provision of alternative means of cooling including alternate heat sinks. The enhancement of safety in shutdown states and mid-loop operation. The enhancement of the functional separation and independence of safety systems. The provision for a bunkered or "hardened" system to provide an additional level of protection with trained staff and procedures designed to cope with a wide variety of extreme events including those beyond the design basis.

At the Loviisa NPP, the availability of an alternate heat sink depends on the plant state and feed water availability. If the primary circuit can be pressurized (i.e. reactor vessel head is in place), the atmosphere can be used as an alternate heat sink as long as there is enough water available for dumping steam into the atmosphere from the secondary circuit. There is a separated diesel driven auxiliary emergency feed water system with two pumps which feed water to the steam generators in case of loss of AC power. It is also possible to transfer heat to the spent fuel cooling system and hence to the intermediate cooling system, giving time for restoring the ultimate heat sink.

The licensee at the Loviisa NPP carried out a plant modification to ensure the decay heat removal in case of loss of seawater by implementing an alternative ultimate heat sink. The modification consisted of two air-cooled cooling units per plant unit powered by an air-cooled diesel-generator. The other cooling unit removes decay heat from the reactor and the other one ensures the decay heat removal from the spent fuel pools inside and outside of the containment. The cooling unit is connected to the intermediate cooling circuit, and it backs up the seawater cooled heat exchangers. The modifications will create a possibility to closed-loop operation also in case of loss of ultimate heat sink. The plant modification was implemented in 2014.

In addition, the licensee has evaluated measures needed to secure the availability of the auxiliary emergency feed water system in the case of a loss of electrical power, water supply for the diesel driven auxiliary emergency feed water pumps, and the electricity supply for the instrumentation needed in accidents. Battery discharge time of the diesels of the auxiliary emergency feed water system was increased to 72 hours during 2012 and 2013.

At the Olkiluoto units 1 and 2, sea water is the primary ultimate heat sink and an alternative heat sink exists only partially. Both units can evaporate residual heat from the reactor core to the atmosphere by conducting the steam produced inside the reactor pressure vessel to the condensation pool through the safety relief valves, by letting the condensation pool boil, and by venting the steam from the containment to the atmosphere through the filtered venting system. However, the systems required to pump water into the reactor pressure vessel are either dependent on the sea water using component cooling systems or on the condensation pool water, which means that the complete loss of sea water as the ultimate heat sink will eventually prevent the supply of water to the reactor pressure vessel.

The licensee has modified the current residual heat removal chain to decrease the dependency on the sea water cooling. The modification of the auxiliary feed water system ensures the cooling of the components by demineralized water in addition to the sea water based cooling chain. By this modification the system will remain operational for a significant period of time even during the loss of the primary ultimate heat sink (sea water). The installations were originally scheduled for 2014 – 2015, but due to vibrations in the recirculation lines, some further studies and modifications were needed. Currently, all four redundancies of unit 1 and two redundancies of unit 2 are modified.

In addition, an independent way of pumping water to the reactor pressure vessel in case of loss of AC power was designed by the licensee. The arrangement consists of two systems, high- and low-pressure systems. The low-pressure system circulates water to the core from the firefighting water system with additional booster pumps through the reactor spray system. The system has a dedicated diesel aggregate. The high-pressure system, the Auxiliary Coolant Injection System (ACIS) consists of steam driven turbine pump, which circulates water from the demineralized water tank to the core. The installation and commissioning of the new systems was completed in 2018.

At the Olkiluoto unit 3, the ultimate heat sink is the sea. In case of the total loss of the availability of sea water for cooling, the residual heat from the reactor core would be released to the atmosphere via the steam generators. During refueling outage, the containment filtered venting could be used. The spent fuel pools could be cooled by evaporation. In case of extreme electrical disturbance, the strategy is to replace parts of the electrical systems to restore long-term cooling. Short-term measures for maintaining coolability have been designed. Final implementation will take place after provisional takeover.

Both licensees have investigated their cooling water reserves at site, considering also situations where all plants in same site are in emergency including spent fuel pools.

The experiences from the TEPCO Fukushima Dai-ichi accident have also been taken into consideration in the renewal of the legislation and Finnish regulatory guides. The new regulatory guides include new requirements concerning Defence-in-Depth level 3b which is aiming at managing design extension conditions (DEC). DEC C category includes rare and extreme external hazards. There is a requirement, which requires the decay heat removal from the reactor and the containment, and the spent fuel pool storages also in rare and extreme conditions (DEC C) for 8 hours without material replenishment (especially diesel fuel and emergency cooling water reserve) or need to charge batteries. Decay heat removal shall be possible for 72 hours without any external help outside the plant.

The above modifications related to residual heat removal systems are reviewed considering this requirement on the protected autonomous systems.

2.2 AC power supplies

The enhancement of the on-site and off-site power supplies. Examples include adding layers of emergency power and adding independent and dedicated backup sources. Implementation of operational or preparatory actions with respect to the availability of operational consumables (e.g. ensuring the supply of fuel and lubrication oil).

At the Loviisa NPP, the current AC power supply systems include connections to the 400 kV and 110 kV power grids, the main generator (house load operation), four emergency diesel generators (EDG) per unit, the diverse diesel power plant and the dedicated connection to a nearby hydropower plant, two SAM (severe accident management) diesel generators, and the possibility to supply electricity from the neighbouring NPP unit. No modifications are planned to the current design concerning AC power supply.

At the Olkiluoto units 1 and 2, the current AC power supply systems include connections to the 400 kV and 110 kV power grids, the main generator (house load operation), four emergency diesel generators per unit, the gas turbine, the dedicated connection to a nearby hydropower plant, and the possibility to supply electricity from the neighbouring NPP unit. The licensee has been preparing and implementing for several years the renewal of all the eight emergency diesel generators. Several plans, surveys and studies were prepared for this project resulting in an investment decision and renewal project. The EDG renewal includes several safety improvements. The new EDGs will be equipped with two diverse component cooling systems. The primary EDG cooling will be provided by the sea water based cooling system, similar to present EDGs units. Additionally, an alternative, automatically activated air-based cooling system will be installed to cope with the loss of sea water situations. This will provide extra protection against external hazards, internal hazards such as fires, as well as component failures. One extra diesel generator for supplying water to reactor in case of a loss of other AC power is also under construction. Current schedule for the completion of the renewal project is 2023.

At the Olkiluoto unit 3, the current AC power supply systems include connections to the 400 kV and 110 kV power grids, the main generator (house load operation), four emergency diesel generators, two station black out diesel generators, the gas turbine and the possibility to supply electricity from the neighbouring NPP unit. No modifications are planned to the current design concerning AC power supply.

At the Loviisa NPP, there is enough diesel fuel in the emergency diesel generator tanks for at least 72 hours of operation, and with realistic loads in case of an accident, the duration is evaluated twice as long. At the Olkiluoto NPP, there is enough diesel fuel for more than one week of operation of EDGs, if fuel transfer between different tanks is considered. Currently the emergency diesel generators (EDGs) at the Loviisa and Olkiluoto NPPs use conventional diesel fuel, which is available only in limited scope. The licensees together with the diesel engine manufacturers have carried out investigations of replacing conventional diesel with widely available biodiesel. Based on these investigations, biodiesel can be used in exceptional circumstances.

In 2012 the licensee of the Loviisa NPP purchased a container to transfer diesel fuel at the site. The purpose of this container is to make fuel transfer between the tanks on-site easier and faster. In addition, the licensee has in 2015 built a new fuel storage tank, from which it is possible to deliver fuel to the diesel generators' day tanks.

Both licensees have considered the need for additional mobile power supply equipment (see Section 2.5).

2.3 DC power supplies

The enhancement of the DC power supply. Examples include improving the battery discharge time by upgrading the existing battery, changing/diversifying battery type, providing spare/replacement batteries, implementing well-prepared loadshedding/staggering strategies, performing real load testing and on-line monitoring of the status of the batteries and preparing dedicated recharging options (e. g. using portable generators). Study of RCP pump seal leakage following long term AC power failure. Ensure that the state in which isolation valves fail and remain, when motive and control power is lost, is carefully considered to maximise safety.

At the Loviisa NPP, the depletion times of certain DC batteries was estimated to be rather short and the duration of DC power supply was enhanced, and the current depletion time is at least 2 h. Especially the function of the reactor coolant pump seal water system must be ensured. The licensee submitted a plan regarding these improvements to STUK at the end of 2012 and batteries with increased capacity were installed by 2014.

It is possible to charge the batteries using the AC power sources. The licensee has installed two new separate underground cable connections from the new diesel power plant to the 6.3 kV diesel busbars in 2012–2013, which furthermore ensures and enhances battery charging possibilities.

At the Olkiluoto units 1 and 2, the depletion times of DC batteries are well above 10 h, in some cases tens of hours. It is possible to charge the batteries using the AC power sources. The DC batteries supplying the severe accident monitoring systems can be charged by mobile generators. The licensee has investigated and implemented the possibilities for fixed connection points for recharging of all safety important batteries using transportable power generators (see Section 2.5).

At the Olkiluoto unit 3, there are separate and diversified 2 hours' and 12 hours' battery backed power supply systems. The first set of batteries supplies all electrical equipment which require uninterruptible power in the nuclear island and the second set of batteries supplies loads which are important in case of a severe accident. Thus, the licensee evaluates that there is no need for upgrading the battery capacity.

2.4 Spent fuel pools

The improvement of the robustness of the spent fuel pool (SFP). Examples include reassessment/upgrading SFP structural integrity, installation of qualified and power-independent monitoring, provisions for redundant and diverse sources of additional coolant resistant to external hazards (with procedures and drills), design of pools that prevents drainage, the use of racks made of borated steel to enable cooling with fresh (unborated) water without having to worry about possible recriticality, redundant and independent SFP cooling systems, provision for additional heat exchangers, an external connection for refilling of the SFP and the possibility of venting steam in a case of boiling in the SFP. The performance of further studies in areas where there are uncertainties, e.g. the integrity of the SFP and its liner in the event of boiling or external impact.

Regarding spent fuel pools, the approach in Finland is to "practically eliminate" the possibility of fuel damage. The licensees have evaluated alternative means of decay heat removal from the spent fuel storage pools in case of loss of existing systems, and to supply coolant to the spent fuel storage pools (including potential need for new instrumentation).

At the Loviisa NPP, independent air-cooled cooling units with no connections to seawater systems were implemented in 2014 (see Section 2.1). The cooling units will take care of the decay heat removal of reactors and spent fuel storage pools inside and outside the containment in case the ultimate heat sink is lost. The licensee has also planned additional water injection capabilities into the pools in both spent fuel building and in the in-containment pool. Boiling of the pool water can be used as an alternative means to remove decay heat. Water injection will be provided through new internal connections or mobile water injection systems in order to recover the loss of water from the pools. The plant modifications concerning water injection to the fuel pools will be completed in 2020. Original target date for implementation was 2018. Due to many overlapping plant modifications (I&C renewal, improvement of secondary circuit safety functions), the licensee had to make the decision to postpone Fukushima modification finalization to 2020.

Furthermore, the licensee continues to improve EOPs (Emergency Operating Procedure) and SAM Guidelines to support heat removal from spent fuel pools by pool boiling and supplying additional water to the pools (see Section 3.3). Licensee has also studied the seismic resistance of the spent fuel pools as well as the influence of pool water boiling to the pool structures (see Section 1.1).

At the Olkiluoto units 1 and 2, the licensee has evaluated that water injection into the pool and boiling of the pool water could be used as an alternative means to remove decay heat from the pools inside the reactor building. To improve monitoring of the water temperature and level in the spent fuel pools inside the reactor building all spent fuel pools were equipped with a temperature and level measurement system which enables measuring water level from the normal level down to the top of the fuel assemblies. The measuring system will be visible outside the containment and independent from the power supply. Possibility for adding makeup water from the firefighting system to the pools from safe locations is provided. Installations of new pipeline junctions was finalized in 2015. The pool water level indications were also routed to those locations. External junctions to the interim spent fuel storage pool (outside the reactor buildings) water system have been installed during the enlargement project of spent fuel storage. Feed of water to the spent fuel storage pools is possible from a fire-fighting vehicle or from diesel-powered pumping crates procured in 2014.

In Olkiluoto 3, possibility for decay heat removal from the spent fuel pools in the fuel building using water injection (from demineralized water storage) into the pool and boiling of the pool water is part of the original design concept as an alternative means to remove decay heat. During detailed design and construction, additional water sources that can be used for pool filling were added to the design. Current water reserves fulfill the 72-hour requirement.

2.5 Mobile devices

The provision of mobile pumps, power supplies and air compressors with prepared quick connections, procedures, and staff training with drills. The equipment should be stored in locations that are safe and secure even in the event of general devastation caused by events significantly beyond the design basis. The enhancement of the capability for addressing accidents occurring simultaneously on all plants of the site. The establishment of regular programs for inspections to ensure that a variety of additional equipment and mobile devices are properly installed and maintained.

Finnish regulations require fixed installed systems for residual heat removal from the fuel in the reactor for a period of three days, independently of the off-site supply of electricity and water in a situation caused by a rare external event or a disruption in the on-site electrical distribution system. Also, for severe accident management, there shall be fixed installed systems that are independent of the systems designed for normal operation, anticipated operational occurrences and postulated accidents. Diverse residual heat removal of spent fuel from storage pools can after a grace period rely on mobile equipment with fixed supply connections. Autonomy requirement is the same as in case of residual heat removal from the reactor.

The licensee of the Loviisa NPP evaluated the possibilities to utilize mobile power supply and mobile pumps to support safety functions. Based on the studies, additional mobile devices were not evaluated to be necessary after the other plant improvements (related mostly to provisions to high sea water level) are implemented. In addition, using additional mobile power supply and mobile pumps as short-term measures would not fulfil national regulations. The project for mobile devices was terminated in 2017.

At the Olkiluoto units 1 and 2, the licensee started the investigation of needs and targets for mobile power supply in autumn 2011. Investigation included also the renewal of the present mobile SAM diesel generators. Currently there are four new mobile aggregates and two old mobile aggregates. Enhancing the charging of batteries was also found feasible to improve the availability of DC power. The licensee investigated the possibilities for fixed connection points for recharging of the safety important batteries and other important consumers (e.g. weather tower and spare part storage) using transportable power generators, and the fixed connection points have been made. Mobile pumps used for residual heat removal from the reactor and the spent fuel pools at the Olkiluoto units 1 and 2 were discussed in Sections 2.1 and 2.4.

The above modifications related to mobile devices are reviewed taking into account the new YVL Guide requirement on the protected autonomous systems for the decay heat removal as discussed in Section 2.1.

3 Topic 3: Severe Accident Management (On-Site)

A comprehensive severe accident management (SAM) strategy has been developed and implemented both at Olkiluoto 1&2 and Loviisa 1&2 plant units. Development of the strategies started after the TMI and Chernobyl accidents. These strategies are based on ensuring the containment integrity which is required in the existing national regulations. STUK has reviewed these strategies and has made inspections in all stages of implementation.

Severe accidents have been considered in the original design of Olkiluoto 3. STUK has reviewed the overall SAM strategy and the approach has been accepted. No changes to this approach are expected based on current knowledge from the TEPCO Fukushima Dai-ichi accident.

As a result of the studies made after the TEPCO Fukushima Dai-ichi accident, no major changes at the plants are considered necessary. However, licensees were expected to consider all plant stages in the SAM procedures as well as any implications on them possibly arising from simultaneous multi-unit accidents. In addition, there were many actions related to the update of the emergency plans.

3.1 Severe accident management hardware provisions

WENRA reference levels

The incorporation of the WENRA reference levels related to severe accident management (SAM) into their national legal frameworks, and ensure their implementation in the installations as soon as possible.

In Finland, the Radiation and Nuclear Safety Authority Regulation on the Safety of a Nuclear Power Plant Y/1/2018 (Regulation STUK Y/1/2018) and the regulatory guides (YVL Guides) include requirements for severe accident management which are in compliance with the WENRA Reference Levels Issue F. In particular, the Finnish regulations include requirements on dedicated, safety-classified and single-failure tolerant SAM systems and measurements. Based on the current knowledge from the TEPCO Fukushima Dai-ichi accident, no specific changes to the regulatory guides are foreseen related to the severe accident management systems.

The development of SAM strategy at the Finnish NPPs in the late 1980's led to a number of hardware changes. SAM strategy is based on the following SAM safety functions whose purpose is to ensure containment integrity and isolation:

- containment isolation,
- RCS depressurisation,
- in-vessel retention of corium by reactor pressure vessel external cooling (Loviisa NPP) or prevention of basemat melt through (Olkiluoto NPP),
- hydrogen management, and
- management of containment pressure by containment external spray (Loviisa NPP) or by containment filtered venting system (Olkiluoto NPP).

In addition, sub-criticality and fuel pool cooling have to be ensured during a severe accident. All these issues are part of the SAM Guidelines.

Fixed severe accident management systems have been installed both at Loviisa and Olkiluoto operating NPPs. At the Loviisa NPP, the following modifications were made already prior to the Fukushima Dai-ichi accident:

- new manually actuated RCS depressurisation capability for SAM through motor-operated relief valves (two parallel lines with two similar valves in each line), installed 1996;
- modified hydrogen management scheme concentrating on two functions: ensuring containment atmosphere mixing to decrease the local hydrogen concentrations (a dedicated system for opening the ice-condenser doors to ensure adequate flow paths installed in 2001-2002) and controlled removal of hydrogen (passive autocatalytic recombiners (PARs) and a new glow plug system installed in 2003);
- containment external spray system installed in 1990-1991 to remove the heat from the containment in a severe accident when other means of decay heat removal from the containment are not operable (filtered venting system was not seen feasible for Loviisa NPP, as steel shell containments are vulnerable to subatmospheric pressures, which may arise after large amounts of non-condensable gases have escaped the containment);
- modifications carried out in 2000-2001 to enable in-vessel retention of corium by external cooling of the RPV: enable lowering of the lower neutron and thermal shield to allow free passage of water in contact with the RPV bottom, slight changes of thermal insulations and ventilation channels in order to ensure effective natural circulation of water, and construction of a strainer facility in the reactor cavity in order to screen out possible impurities from the coolant flow and thereby prevent clogging of the narrow flow paths around the RPV;
- creation of a dedicated independent SAM I&C, in particular, new measurements for monitoring containment conditions and thus the status of the SAM safety functions; and
- dedicated AC power supply system to provide power supply from an independent source for all essential SAM instruments and equipment and a dedicated SAM control room.

At the Loviisa NPP, the design basis for all SAM safety functions is that the actions can be done, when the other supplies have been lost, with dedicated independent SAM electrical systems and dedicated independent SAM I&C from SAM control room or main control room.

There is a system for hydrogen concentration monitoring in the containment at the Loviisa NPP. The measurements are not qualified for hydrogen burning conditions, but some additional protections were added as part of the SAM project. Measurement results are used as supporting information to monitor threat to the containment integrity, and when evaluating whether it is safe to use the glow plug system, in case it has not been switched on already.

At the Olkiluoto NPP units 1 and 2, the following modifications were done:

- protection of the penetrations in the lower drywell against direct contact with the molten corium;
- containment overpressure protection;
- containment filtered venting system;
- lower drywell flooding from wetwell;
- system for filling the containment with water from an external source (the fire water reservoir); and
- a dedicated instrumentation system for monitoring the conditions inside the reactor containment in connection with severe accidents.

The main provisions for severe accident management were installed at the Olkiluoto units 1 and 2 during the SAM project which was finished in 1989. Some additional measures (e.g. pH control inside the containment) were carried out during the plant modernisation project in 1998. All the accident management actions at Olkiluoto units 1 and 2 can be performed without the need for AC power, either manually or by using battery backed power sources.

There is a system for measuring hydrogen contents in the containment at the Olkiluoto units 1 and 2, but the system can't operate if the containment pressure exceeds 2.0 bar. In that case, a sample can be taken from the drywell by means of a syringe.

The SAM strategies and their implementation at Loviisa and Olkiluoto NPPs follow the requirements set in the Regulation STUK Y/1/2018 and the YVL Guides. The approach and the plant modifications have been approved by STUK. Since the systems for management and mitigation of severe accidents have already been implemented at Loviisa and Olkiluoto operating units and the corresponding procedures are in place, no further measures for this purpose are foreseen at the moment. However, the soundness and adequacy of the accident management schemes is being constantly assessed against the latest knowledge and experience obtained from different international sources.

The overall SAM strategy and approach of OL3 has been accepted. No such hazards or deficiencies that would require changes to this approach have been found, and STUK has not set any further requirements on the SAM approach of OL3.

<u>Review of SAM hardware provisions following severe external events</u>

Adequate hardware provisions that will survive external hazards (e.g. by means of qualification against extreme external hazards, storage in a safe location) and the severe accident environment (e.g. engineering substantiation and/or qualification against high pressures, temperatures, radiation levels, etc), in place, to perform the selected strategies.

The systematic review of SAM provisions focusing on the availability and appropriate operation of plant equipment in the relevant circumstances, taking account of accident initiating events, in particular extreme external hazards and the potential harsh working environment.

In Finland, the SAM systems are not required to be seismically qualified because earthquake risks are low. The philosophy is to seismically qualify the systems used for severe accident prevention (systems for design basis accidents).

However, SAM systems at Olkiluoto units 1 and 2 are designed to withstand earthquakes (peak ground acceleration of 0.1 g). At the Loviisa NPP, the SAM systems are not designed to withstand earthquakes. Seismic analyses of these systems are not included in level 2 PSA and therefore there is no confirmation on the sufficient operability of these systems after an earthquake.

The availability of dedicated SAM systems and components in the severe accident environmental conditions has been verified as part of the qualification process, as required by regulatory guides. When creating the new SAM strategy at the Loviisa NPP in 1990's, the new qualification criteria were introduced for the equipment inside the containment fulfilling SAM safety functions. This resulted in some cabling modifications in order to survive the harsh environmental condition due to a severe accident. At the Olkiluoto units 1 and 2, the containment monitoring system has been designed to operate under severe accident conditions. The system has no radiation or temperature sensitive components inside the containment.

The experiences from the Fukushima Dai-ichi accident have also been taken into consideration in the renewal of the Finnish regulatory guides (YVL Guides). For example, there is a new requirement for the arrangements that enable the decay heat removal from the reactor out of the containment and arrangements to ensure sufficient cooling of the fuel in fuel storages. In spite that there are fixed severe accident management systems installed both at Loviisa and Olkiluoto operating NPPs, STUK required the licensees to investigate needs and possibilities to use mobile power supply and mobile pumps in accidents.

At the Loviisa NPP, the licensee investigated possibilities to implement additional injection points for mobile pumps to provide more flexibility to the water supply of the containment external spray. However, using mobile devices was not evaluated to be necessary after the other plant improvements (related mostly to provisions to high sea water level) are implemented. The project for mobile devices was terminated in 2017.

<u>Presence of hydrogen in unexpected places</u>

The preparation for the potential for migration of hydrogen, with adequate countermeasures, into spaces beyond where it is produced in the primary containment, as well as hydrogen production in SFPs.

Hydrogen leakages out of the containment during severe accidents has been analysed for all units, and the results show that design leakages do not cause a threat to the containment integrity. For spent fuel pools, the approach in Finland is to "practically eliminate" the possibility of fuel damage (see Section 2.4). The possibility of top venting of reactor hall has been added at the Olkiluoto units 1 and 2 for the steam and hydrogen release in case of fuel pool boiling. The design process of the modification for the top venting facility was started in 2013 and implementation was completed in 2019. Provisions for venting hydrogen in the spent fuel storage building was evaluated as unnecessary. Controlling the released steam is enough and can be done with existing methods.

3.2 Level 2 probabilistic safety assessments (PSAs)

A comprehensive Level 2 PSA as a tool for the identification of plant vulnerabilities, quantification of potential releases, determination of candidate high-level actions and their effects and prioritizing the order of proposed safety improvements.

The effectiveness of the severe accident management is further evaluated by the level 2 PSA studies, which show the possibility to carry out and the success of SAM measures in spectrum of initiating events and severe accident sequences.

The current level 2 PSA for Loviisa units 1 and 2 covers full, low and non-power states and it includes accident sequences initiated by internal events, internal hazards such as flooding, fire and heavy load drop, and external hazards such as extreme weather phenomena (incl. marine oil spills). Currently, seismic events are not included in level 2 PSA. The fraction of seismic events in core damage frequency has been estimated to be small, but updates of the seismic hazard studies and the seismic PRA are underway. Level 1 and level 2 PSA studies are unit-specific. The unit-specific Level 2 PSA risk metrics also include accident scenarios related to the fuel pool of the unit. The PSA for the spent fuel storage includes a simplified assessment of large release risk and early release risk.

At the Olkiluoto units 1 and 2, level 2 PSA includes all level 1 core damage sequences, i.e. the analysis includes power operation, plant start-ups, shutdowns as well as refuelling outages. The initiating events considered include internal initiating events, internal hazards such as flooding and fires, and external hazards such as extreme weather phenomena, seismic phenomena and marine oil spills. Events related to spent fuel storage are planned to be included during the ongoing storage extension project. Level 1 PRAs are unit-specific, but level 2 modelling is common to OL1 and OL2. Due to modifications at Olkiluoto units, their total core damage frequencies have reduced below 1E-5, which is the limit for new units and recommendation or target value for existing units.

Both at the Loviisa and Olkiluoto operating NPPs, the frequency of large releases is higher than the limits set in STUK's regulatory guide YVL A.7. The frequency limits as such, apply for new NPP units to be built in Finland, and for old units the principle of continuous improvement of nuclear safety is applied.

For Olkiluoto unit 3, full-scope level 1 and level 2 PSA has been performed. Risk integration has been performed over all plant damage states. STUK has approved the PSA for OL3, currently with minor comments. Both the core damage frequency and large release frequency of OL3 are below safety goals defined in Regulatory Guide A.7.

In 2017, a new amendment was added to YVL A.7 concerning new units: *accident sequences, in which the containment function fails or is lost in the early phase of a severe accident, shall have only a small contribution to the reactor core damage frequency*. This requirement is currently fulfilled by Loviisa 1 and 2 and Olkiluoto 3.

3.3 Enhancement of severe accident management guidelines (SAMGs)

The enhancement of SAMGs taking into account additional scenarios, including, a significantly damaged infrastructure, including the disruption of plant level, corporate-level and national-level communication, long-duration accidents (several days) and accidents affecting multiple units and nearby industrial facilities at the same time. The extension of existing SAMGs to all plant states (full and low-power, shutdown), including accidents initiated in SFPs. The performance of further studies to improve SAMGs. The validation of the enhanced SAMGs.

At the Loviisa NPP, immediate SAM measures are carried out within the Emergency Operation Procedures (EOP). After carrying out immediate actions successfully, the operators concentrate on monitoring the SAM safety functions with SAM procedures. The SAM procedures focus on monitoring the leak tightness of the containment barrier, and on the long-term issues. At the Loviisa NPP, licensee will continue improving EOPs and SAM procedures to support heat removal from spent fuel pools by pool boiling and supplying additional water to the pools. New EOPs for shutdown states, which cover the immediate recovery of SAM systems, have been developed in 2012.

At the Loviisa NPP, the SAM handbook contains background material for better understanding of the SAM strategy, SAM safety functions and accident phenomenology related to these safety functions, fuel storages, criticality issues and radiation protection during a severe accident. Relevant severe accident analysis results, experimental results, and thorough description of the SAM systems have been included. The handbook is used primarily by the emergency preparedness organization during the accident, and more generally also for training purposes.

Olkiluoto units 1 and 2 have event-oriented operating procedures for events within the scope of the design. To cope with emergency conditions beyond design, including severe accidents, a set of symptom-based emergency operating procedures is available. The focus of the severe accident EOPs is on ensuring the containment integrity. The symptom-oriented accident management procedures (included in EOPs) apply to shutdown states, as well, although the prevention of core damage is essential in situations with open containment. The licensee has improved EOPs to support heat removal from spent fuel pools by pool boiling and supplying additional water to the pools along the implementation of the related plant modification.

At the Olkiluoto unit 3, event-based and symptom-based procedures (EOPs) will be used for emergency operation. In case of severe accidents, a separate severe accident management guidance document is provided for the emergency organization management team to help assess the accident conditions and determine what coping strategies need to be implemented.

EOPs and SAM Guidelines are verified and validated for units 1 and 2. For Olkiluoto unit 3 this work is still ongoing as commissioning has been delayed.

3.4 SAM training and exercises

Regular and realistic exercises aimed at checking the adequacy of SAM procedures and organisational measures, including extended aspects such as the need for corporate and *nation level coordinated arrangements and long-duration events. Training exercises should include the use of equipment and the consideration of multi-unit accidents and long-duration events. The use of the existing NPP simulators is considered as being a useful tool but needs to be enhanced to cover all possible accident scenarios.*

Control room operators are required to participate in the simulator training every year. Emergency operating procedures are evaluated as a part of these simulator trainings.

All individuals working at the power plant receive basic emergency preparedness training. Evacuation exercises for personnel are arranged annually at the power plant. Individuals assigned to the emergency preparedness organization receive task-specific basic training before being assigned to the task. Those in the emergency preparedness organization receive annual refresher training and advanced training.

Official emergency exercises are held annually at the both Finnish NPPs. Every third year a nationwide emergency exercise of the plant is held. The training simulator is used when practicing the accidents, but the simulators are not fully capable of extending the simulation into the severe accident domain at the moment. When there is need to practice severe accidents then table top training is used together with the training simulator at the Loviisa NPP. At the Olkiluoto NPP, a PC-simulator has been developed to illustrate severe accident phenomena.

As a lesson learned from the TEPCO Fukushima Dai-ichi accident, more consideration has been given to training exercises with multi-unit accidents and long-duration events as well as to exercises related to the spent fuel pools.

3.5 Emergency preparedness and response (on-site)

The enhancement of the capability for addressing accidents occurring simultaneously on all plants of the site. Examples include assuring preparedness and sufficient supplies, adding mobile devices and fire trucks and increasing the number of trained and qualified staff.

The Government Decree on Emergency Response Arrangements at Nuclear Power Plants was renewed in 2013, and in the renewal a requirement to take the possibility of several reactor units' simultaneous accident into account in the emergency planning was introduced. Another new requirement in the Decree concerned the Reserve Emergency Centres which shall be located outside the power plant area. Currently, the Government Decree has been replaced by Radiation and Nuclear Safety Authority Regulation on the Emergency Arrangements of a Nuclear Power Plant Y/2/2018 which has similar requirements. Accordingly, the regulatory guides set up by STUK have been revised in 2013 and again in 2019. Required changes in the emergency plans and organisations need to be trained and exercised after implementation.

STUK requested the licensees to update the emergency plans and organisation taking into account an accident influencing multiple reactor units. Especially responsibilities, communication possibilities and the possible extension and prolongation of the situation must be considered. The emergency plans have been updated at the both NPPs during 2013 to consider a multi-unit accident and there have been multi-unit exercises since

2014. The final organisational issues for Olkiluoto unit 3 are completed, and unit 3 is included in Olkiluoto site emergency plans.

Both licensees were also requested to evaluate the suitability of emergency preparedness personnel to their duties. At the Olkiluoto NPP, the licensee has been requested to ensure the support resources needed for maintenance. Maintenance personnel need to be trained and regularly participate in exercises. The licensee has also updated the emergency plan with regard to radiation measurement patrols. Those persons who are nominated to the patrolling duties in extended emergencies will also be trained for their tasks.

Improved communications

The improvement of communication systems, both internal and external, including transfer of severe accident related plant parameters and radiological data to all emergency and technical support centre and regulatory premises.

In addition to the normal commercial telephone and data transfer connections (both wired and wireless), the emergency command centres are connected to the Finnish authorities' telecommunication network (VIRVE). Strengthening of the power supplies of the authorities' network base stations will be provided with mobile power engines for the net operator. There is also a satellite telephone connection dedicated to the emergency situations both in Loviisa and in Olkiluoto.

External and internal communication systems at Loviisa NPP are backed up by the emergency diesels. Mobile communication equipment can also be recharged from the SAM diesel secured network.

Olkiluoto units 1 and 2 have their own connection facilities to support the operation of the internal telephone connections within the units. In case of a loss of off-site power licensee's internal telephone connections will operate on battery backup for 24 hours, and the external landline network and mobile telephone network are estimated to operate for a little less than 24 hours. The battery backup arrangements of the mobile telephone network are dependent on the emergency response arrangements of the telephone operators.

Olkiluoto unit 3 will have a range of equipment for plant communication inside the buildings, between the buildings and with offsite locations. The communication systems are continuously supplied from the emergency power supply system. With the exception of the combined telephone and LAN system, each communication system is independent of the others, so that any failure in one will not cause problems in the others.

For the assessment of the safety status of the Finnish NPPs, relevant plant parameters and radiological data can be transferred with a real time computerised data system to emergency centres, technical support centres and the emergency response centre of STUK.

At the Olkiluoto NPP, the meteorological measurements in the power plant weather mast have the UPS secured capacity for 12 hours' operation without the normal AC-power. In addition, there is a possibility to connect an external power generator to the mast. External environment radiation monitors in Olkiluoto have local batteries for one to two weeks' operation without the normal AC-power. The central units of the environment radiation monitoring system are equipped with UPS and they can be connected to an external power generator.

At the Loviisa NPP, the meteorological measurements in the power plant weather mast have the battery back-up for eight hours. The licensee has renewed the weather mast at site and added an additional mast in another location near the site. The environment radiation monitoring system in Loviisa has been renewed. The design basis of the new measurements is at least three months' autonomic operation in emergency situations with long-term batteries.

<u>Large volumes of contaminated water</u>

The conceptual preparations of solutions for post-accident contamination and the treatment of potentially large volumes of contaminated water.

The design of Finnish NPPs aims at maintaining the radioactive material inside the containment, and thus there should not be any need for treating large amounts contaminated water outside the containment. No preparations for possible solutions have been initiated at this stage.

<u>On-site accessibility and habitability</u>

The provision for radiation protection of operators and all other staff involved in the SAM and emergency arrangements. The provision of an on-site emergency center protected against severe natural hazards and radioactive releases, allowing operators to stay onsite to manage a severe accident. The enhancement of the main control room (MCR), the emergency control room (ECR) and emergency control centre (ECC) to ensure continued operability and adequate habitability conditions in the event of a station black-out (SBO) and in the event of the loss of DC.

Analysis of radiological conditions related to the habitability of control rooms and emergency centres as well as the accessibility for local manual actions during a severe accident has been done and appropriate modifications have already earlier been implemented at the operating Finnish NPPs. Habitability and accessibility analyses have been done also for Olkiluoto unit 3.

At the Loviisa NPP, the main control rooms have filtered ventilation systems, but they are not designed against radiation from large amounts of radioactive material being outside the containment. In case the main control room is unavailable, e.g. due to a fire, the main control room of the neighboring unit can be used as an emergency control room to operate the unit in question to safe state. If both main control rooms are lost at the same time, e.g. due to high radiation levels, the shifts of the both units will be evacuated into the SAM control room. This SAM control room is common to both plant units, and there are separate monitoring and operation facilities for SAM systems for both units. The massive concrete structure of the SAM building, filtered ventilation and the possibility to use the underground pathways ensure the SAM control room being accessible and operable during a severe accident.

The emergency centre of Loviisa NPP is located in a shelter. The emergency centre has its own emergency diesel generator that provides the required energy if the electricity cannot be provided in the normal ways. The amount of diesel fuel is estimated to be enough for approximately 300 hours without refuelling. The emergency centre is shielded against direct radiation by thick concrete walls and filtered ventilation. If for some reason the emergency centre loses its ability to operate, the emergency preparedness organization can operate to the appropriate extent in the SAM control room. In addition to the emergency centres at site, the licensee has an opportunity to use rescue service facilities of town Porvoo. The material needed in management of emergency situation has been gathered in these facilities.

At the Olkiluoto units 1 and 2, the main control rooms (MCR) are shielded against radiation and have filtered emergency ventilation systems. The emergency control rooms at the Olkiluoto units 1 and 2 are completed. Each plant unit has an emergency centre, and there is a common sheltered reserve centre. The management of the emergency organization activates one emergency centre and normally the technical support group will occupy the reserve emergency centre. All emergency centres are shielded against radiation and have filtered emergency ventilation systems. In addition to the emergency centres at site, the licensee has an opportunity to use shelter facilities of town Rauma. The material needed in management or emergency situation has been gathered in these facilities.

At the Olkiluoto unit 3, the main control room and the emergency control room, as well as the emergency centre, are shielded against radiation and have filtered emergency ventilation systems.

Personal radiation protection gears are stored in several storages at the Finnish NPPs, like at the boundaries of the controlled area. The protective gears and measuring instruments for the radiation measuring patrols are also readily available. Iodine pills are stored e.g. in the emergency centres.

As a lesson learned from the TEPCO Fukushima Dai-ichi accident, STUK requested the licensees to provide plans for access control and radiation monitoring of the staff and decontamination measures for personnel, vehicles and materials in case of the normal provisions at the plant site are not available (e.g. in extreme natural hazards or fallout). Emergency plans have been updated and the new procedures have been exercised during the annual exercises. Loviisa-14 exercise in 2014 handled a two-unit emergency and OLKI-14 large scale exercise handled an intermediate phase of a nuclear emergency and fallout situation.

<u>Support to local operators</u>

Rescue teams and adequate equipment to be quickly brought on site in order to provide support to local operators in case of a severe situation. Assess operation in the event of widespread damage, for example, the need of different equipment to clear the route to the most critical locations and equipment.

Based on the advance planning, the regional rescue service participates in the Finnish power plant's rescue operations. Additionally, they have heavy duty clearing equipment. In an accident situation, based on their resources, they can prioritise their duties to provide assistance to the nuclear power plant and to clear access routes in and around the plant. Based on legislation, they have the option to present an official request for help from any authority to clear roads and to arrange alternative modes of transportation, such as boat and air transportation. In an accident situation, the rescue authority also has the right to requisition of private equipment.

After the TEPCO Fukushima Dai-ichi accident, STUK requested the licensees to provide plans to restore the access routes to the site. The plans have been finalised in 2013.

PART II

4 Topic 4: National Organizations

The main stakeholders in Finland having a role or responsibilities with regard to nuclear and radiation safety are the Parliament, the Government, the Ministry of Employment and the Economy, the Ministry of Social Affairs and Health, the Ministry of the Interior, regional Rescue Authorities, licensees operating nuclear facilities and licensees using radiation, the Radiation and Nuclear Safety Authority (STUK), the Technical Research Centre of Finland (VTT), and the Universities.

As a result of the studies made after the TEPCO Fukushima Dai-ichi accident, no major changes are considered necessary in this area so far. However, prompt and flexible means to engage TSO resources and tools also in accident situations to support regulatory recommendations have been considered resulting in the conclusion that the engagement of present TSO resources i.e. VTT resources would be practically realistic in long-lasting accident situations.

4.1 National infrastructure and framework for safety

Review and revision of nuclear Laws, Regulations and Guides. Where the Regulatory Body (RB) is constituted of more than one entity, it is important to ensure efficient coordination. Emphasis on the need for comprehensive periodic reviews of safety, using state-of-the-art techniques.

Policies and strategies for radiation and nuclear safety are expressed in Finland through legislation. Among the safety principles, the Nuclear Energy Act stipulates governmental and regulatory framework, licensing procedures, provisions for human and financial resources, framework for research and development, principles for continuous development and requirements to promote safety culture and management of safety. In addition, provisions for nuclear waste management are set down in the Act. A comprehensive periodic safety review is also enacted by the Act.

According to the Nuclear Energy Act (Section 54), the overall authority in the field of nuclear energy is the Ministry of Employment and the Economy. It prepares for example licensing decisions for the Government. According to the Radiation Act (section 5), the overall authority in the field of the use of radiation and other radiation practices is the Ministry of Social affairs and Health. According to Section 6 of the Radiation Act and Section 55 of the Nuclear Energy Act, STUK is responsible for the regulatory control of the safety of the use of radiation and nuclear energy. The rights and responsibilities of STUK are provided in the Radiation and Nuclear Energy Acts.

Many other governmental and local organizations, as well as the municipalities, have their own functions based on separate legislation as regards the construction and operation of facilities and conducting activities. Typical areas calling for coordination are environmental issues, security arrangements as well as emergency preparedness. In the areas of rescue services and security the Ministry of the Interior (MI) is the overall authority. In the IRRS mission carried out in Finland in October 2012, a suggestion was given that the relevant Ministries and STUK should develop Memoranda of Understanding for implementing their roles, responsibilities and cooperation with a view to ensuring that STUK is accountable while clearly maintaining its regulatory independence.

The responsibility for the safety rests with the licensee as prescribed in the Radiation and Nuclear Energy Acts. Accordingly, it is the licensee's obligation to assure safe use of radiation and nuclear energy. Furthermore, it shall be the licensee's obligation to assure such physical protection and emergency planning and other arrangements, necessary to ensure limitation of nuclear damage, which do not rest with the authorities. It is the responsibility of the regulatory body to verify that the licensees fulfil the regulations.

Nuclear power plant operating licences are granted in Finland for a fixed term but the length of the licence is not defined in the legislation. According to the Finnish regulatory guides, the licensees shall carry out a periodic safety review (PSR) at least every ten years. The Finnish PSR process and scope are in line with the IAEA guidance (NS-G-2.10). PSR is seen as a very important tool for promoting the continuous safety improvement approach. The last periodic safety review was finalized for Loviisa NPP in 2017. Olkiluoto units 1 and 2 renewed their operating licences in 2018.

4.2 Functions and responsibilities of the regulatory body

Effective independence of the RB is essential, including the following aspects: transparency in communicating its regulatory decisions to the public, competent and sufficient human resources, adequate legal powers (e.g. suspend operation), and financial resources. Importance of inviting IRRS missions, and to effectively implement the findings, make the findings and their means of resolution publicly available, and invite follow-up missions.

The current Act on STUK was given in 1983 and the Decree in 1997. The duties of STUK are described in the legislation. STUK is administratively under the Ministry of Social Affairs and Health. The regulatory control of the safe use of radiation and nuclear energy is independently carried out by STUK. No Ministry can take for its decision-making a matter that has been defined by law to be on the responsibility of STUK. STUK has no responsibilities or duties which would be in conflict with regulatory control.

STUK has three Advisory Commissions: The Advisory Commission on Nuclear Safety, the Advisory Commission on Nuclear Security, and STUK´s Advisory Commission. In addition, there is an Advisory Commission for Radiation Safety, which is working in connection to the Ministry of Social Affairs and Health.

Based on Section 7r of the Nuclear Energy Act and Section 70 of the Radiation Act STUK has been authorized to issue the detailed safety requirements (YVL and ST Guides). The experiences from the TEPCO Fukushima Dai-ichi accident have also been taken into consideration in the renewal of the YVL Guides.

STUK receives about one third of its financial resources through the government budget. The costs of regulatory oversight are charged in full to the licensees. The model of financing has been applied since 2000 and has ensured that any decreases in government budget have not had direct influence on regulatory oversight activities. Therefore, STUK has been able to plan and allocate its resources (including recruitments) flexibly and according to the needs and on the areas of safety significance.

STUK trains its personnel continuously. Training programmes are established on organizational as well as on individual level reflecting the tasks and responsibilities of the staff members. Individual needs for training are indentified in the course of work and annual planning. A specific self-assessment tool is used to explore the level of knowledge, skills and abilities available and necessary for regulatory functions.

In addition to competence and resources of STUK's own staff, STUK uses technical support organizations as well as other consultants to support regulatory activities. However, also in these areas STUK's expertise has to be wide and deep enough to enable STUK to make the regulatory decisions.

The technical services for research on nuclear safety during normal operation and accident situations as well as in the case of radiological emergencies are mainly provided by the VTT Technical Research Centre of Finland and to some extent also by Finnish universities. STUK and licensees in Finland order safety related research from VTT to support normal operation as well as to support knowledge on the behaviour of the plant in accident conditions. Based on the experience of the TEPCO Fukushima Dai-ichi accident follow-up in March 2011, the possibilities to engage VTT support promptly and flexibly also in accident situations has been considered, as discussed in the introductory paragraphs of Chapter 4.

The Integrated Regulatory Review Service (IRRS) mission was conducted at the request of the Government of Finland from 15 – 26 October 2012. The mission team found that STUK is a competent and highly credible regulator and is open and transparent. It also concluded that STUK is very active in promoting experience sharing both nationally and internationally. The IRRS team identified also areas for further improvement to enhance overall performance of the regulatory system, including:

- although STUK operates in practice as an independent regulatory body, the government should strengthen the legislative framework by establishing the regulator as a body separate in law from other arms of government
- Finnish legislative framework should be further developed to cover authorization for the decommissioning of nuclear facilities and the final closure of nuclear waste repositories
- STUK can further enhance the effectiveness of its inspection activities by enhancing the focus of inspection on the most safety-significant areas and developing a formal qualification programme for inspectors.

Based on the recommendations and suggestions an Action Plan was prepared by STUK. The follow-up mission was conducted in 2015.

4.3 Openness, transparency and communication

Active stakeholder engagement in the decision making process builds public confidence. International bilateral cooperation can be beneficial (e.g. joint regulatory inspections). The transparency of the operators activities needs to be enhanced.

The Decree on STUK defines STUK's tasks. One of the tasks is to inform about radiation and nuclear safety matters and participate on training activities in the area. STUK utilizes internet to inform public and interested stakeholders about nuclear and radiation safety in general, risks related to radiation and use of nuclear energy, safety requirements, roles and responsibilities of STUK, STUK's organisation, current activities and operating experience, significant regulatory decisions taken, events and publications and safety research. STUK web pages can be found (www.stuk.fi) in Finnish, Swedish and in English. STUK has also made itself available in social media (Facebook and Twitter). In addition to internet STUK utilizes also other means to communicate with public and interested stakeholders, such as meetings, seminars, and training courses.

STUK consults interested parties (public, advisory bodies, licensees, ministries, other authorities etc.) in e.g. in licensing steps (when issuing safety assessments), when drafting new regulations, and in the areas related to other authorities (e.g. security, emergency preparedness).

Finland has several bilateral agreements for exchange of information on nuclear facilities and on notification of a nuclear and radiation emergency, e.g. with Sweden, Norway, Russia, Ukraine, Denmark and Germany. In addition, STUK has done bilateral arrangements with several foreign regulatory bodies, which cover generally exchange of information on safety regulations, operational experiences, waste management etc. Such arrangements have been made with NRC (USA), ASN (France), FANR (United Arab Emirates), NSSC and KINS (Republic of Korea), TAEK (Turkey), ENSI (Switzerland), NISA (Japan), SUJB (Czech Republic), AERB (India) and Rostechnadzor (Russian Federation).

4.4 Human and organizational factors and competence for safety

There is a need to further develop human resource capacity and competence across all organizations in the field of nuclear safety. Governmental level commitment is needed to ensure that a long-term approach is developed for capacity building.

The competence of the licensees as well as the vendor and main subcontractors is one of the key review areas in the licensing processes for the use of radiation and nuclear energy. During the lifetime of the facilities, the competence remains a key subject to the regulatory control by STUK. STUK has currently updated the legislation and regulatory guides and has set goals and requirements on the resources needed to be available for the licensee during normal operation as well as during emergencies.

The Nuclear Energy Act was amended in 2003 to ensure funding for a long-term nuclear safety and nuclear waste management research in Finland. Money is collected annually from the licence holders to a special fund. The research projects are selected so that they support and develop the competences in nuclear safety and to create preparedness for the regulator to be able to respond on emerging and urgent safety issues. These national safety research programmes called SAFIR (Nuclear Safety of NPPs) and KYT (Nuclear Waste Management) have an important role in the competence building of all essential organizations involved in nuclear energy. In 2011, research needs originating from the TEPCO Fukushima Dai-ichi accident were studied, and an appendix addressing the topics for further research (e.g. spent fuel pool accidents) was added to the research programme.

Due to planned expansion of the use of nuclear energy, a comprehensive study has been conducted twice in Finland in the last 10 years to explore the need of experts and education of experts in Finland to meet the needs from the organizations in the field. The first study was completed in March 2012 and the second in 2019. (http://urn.fi/URN:ISBN:978-952-327-410-5)

5 Topic 5: Emergency Preparedness and Response and Post-Accident Management (Off-Site)

The requirements for off-site plans and activities in a radiation emergency are provided in the Decree of the Ministry of the Interior issued in 2011. Off-site emergency plans are prepared by regional rescue authorities. Legislation and plans define clearly the roles and responsibilities of stakeholders having a role in an emergency. Emergency exercises are conducted annually between the licensee and STUK. Every third year all authorities will have a joint exercise covering each site.

As a result of the studies made after the TEPCO Fukushima Dai-ichi accident, a few needs for improvements were identified in this area:

- a need to ensure accessibility to the site in case of extreme weather conditions,
- a need to provide a sufficient amount of radiation protection equipment and radiation monitoring capabilities for rescue services and communication capabilities.
- a need to ensure that the resources of rescue authorities can be reasonably coordinated between radiological and other emergencies, should they happen simultaneously. The arrangements for coordination of activities and sharing of resources between different regional rescue authorities have been discussed and agreed upon by the rescue authorities whose regions contain NPPs.

5.1 National off-site emergency preparedness organization

Review and improvements to aspects of national emergency preparedness and response. Expansion of the set of scenarios on which the plan was based – multiple units on a site, multiple sites, initiating event impacts in more than one country.

The Finnish concept of off-site nuclear emergency response has been developed since 1976, when the first public authorities' off-site emergency plan was prepared. The development has been a continuous process since then.

The primary safety principle in Finland is that of remote nuclear power plant (NPP) siting, meaning also restrictions on land use within about 5 km radius from the nuclear power plant. In off-site emergency planning another planning zone is applied for an area within a radius of about 20 km. A detailed off-site emergency response plan is required in this area including rapid alerting and evacuation possibility of the population if necessary. The plan is to be prepared by the regional rescue service authority. For the areas outside 20 km radius, the requirements imposed by a potential nuclear accident have to be taken into account in the general emergency planning and arrangements. Thus, the nuclear and radiation accident preparedness covers the whole country in Finland. There are no plans to increase these 5 km and 20 km zones at the moment, but the training and exercising will target the outer regions also. The national protection strategy (VAL Guides) include extendability of protective actions beyond the emergency planning zones. The guides are also applicable in case of accident in neighboring country.

In addition to actual emergency rescue planning, the authorities are also required to be prepared for long-term actions following a nuclear accident. These include e.g. decontamination of environment, management of waste containing radioactive substances, radiation monitoring and surveys, health control of the population, measures concerning agricultural and other production and measures to ensure uncontaminated food and feeding stuffs.

A close local co-operation between the regional rescue services, regional police departments, NPP licensees and the Radiation and Nuclear Safety Authority (STUK) has taken place since several years. Earlier, a National Nuclear Power Plant Emergency Preparedness Forum was planned to be launched in order to co-ordinate this work. However, after the initial proposals, the Forum's field of responsibility was found to be mostly over-lapping with other existing co-operation and co-ordination bodies. Therefore, it has been decided that creation of new group is not the best way to address the issue. Instead, the membership and responsibilities of existing groups have been adjusted.

5.2 Intervention levels

Develop reference levels for the application of immediate countermeasures such as sheltering, iodine distribution and evacuation. Develop radiological reference levels for rescue and emergency response personnel in extreme events. Development of reference level for trans-border processing of goods and services such as container transport. Re-examination of approach and associated limits to govern the "remediation" phase. Improvement of the approach to establish contamination monitoring protocols and locations during the recovery. Develop criteria for the return to evacuated area and criteria for return to normal from emergency state.

STUK has prepared so called VAL Guides, which contain the protection strategy in Finland. VAL Guides contain protective measures and operational intervention levels in early and intermediate phases of a nuclear or radiological emergency, for various types of emergencies (such as fallout from nuclear detonation, severe accident in a NPP, malicious acts, contamination due to radioactive substances etc.). VAL Guides contain reference levels of exposure during the first year and factors, other than radiation, affecting choice of protective measures and protective measures to be considered during nuclear or radiological emergencies and transition to recovery. VAL Guides have been put into force by the Ministry of the Interior in 2013 and are being updated during 2019.

VAL Guides include principles and dose limits for protection of workers in the early and intermediate phases of a nuclear or radiological emergency. Indicative operational intervention levels for different protection measures of emergency workers are presented as well as intervention levels for workers involved in urgent protection measures, mitigating the consequences of the accident and other necessary work.

Environmental measurements are carried out by STUK, rescue service and Defence Forces. In Finland, there is a network of environment and foodstuffs laboratories which have the capability to measure gamma radioactivity levels in the food and environmental samples. STUK coordinates operation and provides technical support if needed. In addition, STUK has delivered regional hospitals monitoring equipment for monitoring iodine in thyroid. This measuring capability is meant for screening the public for contamination of iodine.

STUK provides guidance and advice and collects measurement results made by different authorities to prepare an overview picture of the radiation levels in contaminated area. This information is needed to focus monitoring to the areas of interest. The food industry has its own quality control and measuring procedures to make sure that food is safe to consumers. STUK has finalised its monitoring strategy for nuclear or radiological emergencies. Ministry of Interior, in cooperation with STUK, rescue services and other authorities is preparing a national measurement strategy. This strategy complements the national protection strategy and describes what measurements would be needed in case of a nuclear or radiological accident, what are the national measurement capabilities of all organizations, and how are those planned to be improved.

5.3 Information to the public

According to the Rescue Act and the Decree of the Ministry of the Interior concerning informing public during nuclear or radiological emergencies, the authority in charge is responsible for informing public on protective measures and other activities to be carried out. Authorities at governmental, provincial, and municipal level provide information on their own activities and give instructions regarding their own sphere of responsibility. In case of a nuclear power plant accident there are many organisations providing information. Thus, special attention needs to be paid to coordination of timing and content.

Further improvement of arrangements for the coordination of information to the public and media during emergencies is needed to ensure that the messages issued by different authorities are consistent. A coordination group for preparedness of authorities with public information responsibilities during nuclear or radiological emergencies has been working since 2018.

In an accident situation the principal information route to the public is FM radio, TV and internet. The first outdoor warning to the public close the NPP is given by general warning signal via sirens or loudspeakers. By arrangement with broadcasting companies, urgent RDS-notifications can be transmitted promptly over the FM-radio and TV.

5.4 Training of personnel, emergency drills

Increasing the scope of off-site exercise programs. Exercising all interface points (national, regional, municipal,...). Increasing emphasis on drilling with neighbouring countries. Performing of longer term exercises to reflect the challenges of extreme events. Train intervention personnel for potentially severe accident conditions. Rapid intervention team to provide support to sites. Education of the public and the media in aspects related to emergencies (e.g. radiation does and their effects).

The off-site emergency plan prepared by the regional rescue service authority includes a training program. The training shall comprise co-operation between authorities as well as training in the special tasks of each authority in a nuclear power plant accident.

Every third year a full-scale command post exercise is organised for each domestic nuclear power plants. In these exercises all established emergency arrangements are tested including mobile monitoring. In addition to the licensee and the regional rescue authority in question, a large number of authorities on local, regional and national level take part in the exercise. In each exercise there is a representation of private sector, too. In addition, representatives of media are invited to take part in the exercise. Scenarios of these exercises are usually severe on-site situations, and real time weather is used. Exercises exceeding 24 hours are also held, with the next one being planned for late 2020.

Neighbouring countries (the Nordic countries and Russia) are invited to take part in Finnish exercises. Correspondingly Finland takes part in exercises organised by neighbouring countries. Finland also regularly takes part in the exercises organised annually by the EC and every fourth year by the IAEA. Thus, cooperation and communication and coordination of actions internationally are tested at regular intervals. Requests and provision of international assistance is often included in the objectives of the international exercises. Based on an initiative from political level, Finland hosted an international exercise in spring 2013 in which the IAEA and the Nordic and Baltic countries participated. In 2014, the IAEA took part in the Loviisa exercise with multi-unit scenario for testing communication with STUK and IAEA's capabilities to assess on-site and off-site situation in Loviisa NPP based on the information received from STUK. In 2019, the IAEA took part in the Olkiluoto exercise for testing communication with STUK and IAEA's capabilities to assess on-site and off-site situation in Olkiluoto NPP based on the information received from STUK.

Permanent coordination groups (SVPP) have been established for both Loviisa and Olkiluoto NPPs in order to ensure coordinated and consistent emergency plans, to improve and develop emergency planning and arrangements and to share lessons learned from the exercises, regulations and other information. An extensive emergency training is also coordinated by these groups. Members of these groups are the regional rescue service and police authorities, STUK and the licensee (NPP). SVPP groups organise annual joint training for the staff of licensee, STUK and the regional rescue and police authorities. In addition, each organisation organises training according to their detailed training programme.

5.5 Monitoring of the radiation situation 24/7

STUK monitors constantly the radiation situation throughout the country. The aim is to identify potential radiation hazards quickly and to take efficient measures to protect the population against the harmful health effects of radiation. In addition to STUK, the Ministry of the Interior, the Finnish Meteorological Institute, and the Finnish Defence Forces and their organizations participate in radiation monitoring.

The dose rate of external radiation is measured by a monitoring network maintained by STUK and local rescue authorities. The network comprises about 270 automatic stations. Additionally, real-time airborne spectrometric measuring stations are situated e.g. at a distance of 20-30 km from the NPPs. All signals of abnormal detections in either external dose rate network or spectrometric measuring stations are received by STUK expert of duty who is obliged to activate necessary actions to verify abnormal detection and activate emergency response if it is not the case of e.g. malfunction of the monitor. Actions shall be activated within 15 minutes on 24/7 basis.

The monitoring network is going to be completely renewed during 2020-2021. The number and location of measurement locations are planned to be kept same, but the measurement system and underlying technological solutions are going to be replaced with more modern systems.

5.6 External risks, including extreme weather conditions

Enhancing radiation monitoring and communication systems by additional diversification / redundancy. Hardening of support infrastructure (Emergency Response Centers, Sheltering facilities, essential support facilities (like Corporate Offices) with back-up power, environmental radiological filtering, etc.

In Finland, main natural external threats of NPPs and the society at the same time are e.g. extreme low and high temperatures in extended periods, storms in different seasons of the year (incl. snow storms) and elevated sea water levels. Examples of other external threats are e.g. oil transport accident on the Baltic Sea, collapse of the electrical grid or data network. The risks of these situations are regularly evaluated both for NPPs and for all important functions of the society. Often there is a possibility to enhance the regional preparedness based on the predicted circumstances.

After the TEPCO Fukushima Dai-ichi accident, evaluations to enhance the off-site actions were initiated between STUK, the licensees and regional rescue services. Ensuring the accessibility of the NPP site was considered an essential part to support the accident management on-site. Thus, the clearance of the roads leading to the site e.g. after extreme storms was assessed, and further enforcements to support were considered. Furthermore, the sufficiency of the amount of radiation protection equipment and radiation monitoring capabilities for rescue services was checked and necessary supplements have been provided, when necessary.

Even though there are several independent telecommunication systems available during normal situations, the need for strengthening the power supply to the Finnish authorities' communication network base stations is provided with the mobile power sources. As the ultimate back-up, the satellite telephones have been already installed in the emergency centres of the Finnish NPPs and STUK respectively.

A transportable, insulated and heated container for personnel protective equipment and radiation measuring instrument has been purchased and has been operational at the Eastern Uusimaa Emergency Services Department since 2015 to quickly provide a certain amount of equipment in such a case when the normal storages in the NPP are unavailable e.g. due to the external hazards or fallout. The container can be transported by a truck and it can be connected to the electricity grid or to the movable power engine. There is an ongoing project to procure similar containers for Satakunta-region closer to Olkiluoto NPP and possibly elsewhere in country in case of radiological emergencies.

Finnish authorities have a Natural Disaster Warning System (LUOVA), which is coordinated and run by the Finnish Meteorological Institute. It secures information gathering and transfer to competent safety authorities about regional storms, tornados, significant snowfall, significant lightning, rural and urban flooding, and sea level rise. Also, European events like nearby forest fire, wide and sudden snow storms, storms etc are monitored, and followed. Global seismic and tsunami events are reported without delay. This guarantees in advance warning and continuous situation assessment for the authorities and the population potentially concerned.

Future development of NPP off-site emergency planning shall consider all aspects of coordinated resource allocation when there might be serious limitations of communication and transport as well as a simultaneous situation requiring urgent health and property saving actions and NPP emergency actions to protect the population in the same region. Additionally, the construction of NPPs on the new sites where there is no NPP today sets new challenges to the authorities.

6 Topic 6: International Co-operation

Finland has signed the international conventions and treaties aiming at a safe and peaceful use of nuclear energy and is committed to transparency and enhancing nuclear safety internationally through international co-operation and implementation of the IAEA Action Plan. Finland participates actively in the work of international organizations such as the IAEA, the OECD/NEA and the EC.

Utilization of operating experience feedback is seen as a very important tool to improve safety worldwide. Finland believes that the international operating experience process should be improved to ensure that lessons are learned from operating experience and measures are taken to avoid recurrence of significant events.

6.1 Strengthening international peer review processes

Strengthening the peer reviews process of CNS and of missions (IAEA, WANO and Industry).

The transparency and international co-operation are one of the corner stones in the Finnish nuclear safety policy. Finland has signed the international conventions and treaties aiming on safe and peaceful use of nuclear energy. After the TEPCO Fukushima Dai-ichi accident, Finland signed among 130 other countries in the General Conference in September 2011 the IAEA Action Plan.

Finland regularly hosts international peer reviews and also offers its experts for the reviews in other countries. Finland also supports activities to improve peer review services and has already participated in the development of IAEA's peer review services (e.g. IRRS and the OSART missions for construction).

The latest peer reviews are the following:

- IAEA carried out an OSART safety review in Loviisa in March 2007, with a follow-up review in July 2008.
- WANO peer review to Loviisa was performed in March 2010.
- WANO peer review was carried out at the Olkiluoto nuclear power plant during the year 2006. A follow-up was carried out in August 2009.
- IAEA's International Physical Protection Advisory Service (IPPAS) mission was carried out in Finland in 2009. The follow up mission was hosted in April 2012.
- In 2009 STUK organized a Peer Review of STUK's waste management related activities. All EU member states were invited and representatives from 11 countries participated in the peer review.
- In 2011 STUK hosted a peer review of the emergency preparedness with the OECD NEA countries.
- STUK participated in the work carried out by the working group of European authorities (European Pilot Study on Demonstrating the Safety of Geological Disposal), which resulted in a recommendation for safety case content for final disposal at different stages of final disposal. The recommendations were published in 2011.

- Finland had IRRT mission in 2001 and the follow-up mission in 2003. IRRS mission was carried out to the regulatory body in October 2012 and the follow-up mission was in 2015.
- WANO peer review to Loviisa was performed in March 2015.
- WANO peer review to Olkiluoto was performed in March 2016.
- IAEA carried out an OSART safety review in Olkiluoto in March 2017
- IAEA carried out a pre-OSART (Operational Safety Review Team) mission to Olkiluoto 3 NPP in 2018.
- IAEA carried out an OSART safety review in Loviisa in March 2018.

Finland continues the hosting and participation in the international peer reviews and will report the findings of these peer reviews as well as progress of the action plans in the CNS report. As a result of the TEPCO Fukushima Dai-ichi accident there is no need for changes in this activity in Finland.

6.2 Co-operation with international organizations and working groups

Optimisation of the Global Safety Regime.

In Finland international co-operation and transparency belong to the cornerstones of the development of the national safety policy and regulations as well as operation of the nuclear facilities. All of the involved organizations including ministries, the regulatory body, the utilities and research organizations take actively part into international co-operation at relevant forums, e.g. IAEA, EU, OECD/NEA, WENRA, VVER forum, NERS, ETSON, WANO, ENISS, and EUR. Each of these organizations aim to enhance nuclear safety and they have made initiatives in respect to lessons learned from the TEPCO Fukushima Dai-ichi accident in March 2011. Information about the ongoing work is shared nationally and within the involved organizations. As a result of the IRRS mission in October 2012, the IRRS team gave Finland a good practice on active contribution to the global improvement of radiation and nuclear safety through participation in relevant international activities and devoting high quality expertise to this activity. Finland is committed to do so also in the future.

Finland acknowledges that the growing number of international meetings, assessments, peer reviews and expanding mandates is placing high demands on existing human resources. It is also acknowledged that it is the task of the member countries to give directions to the international organizations to focus resources on most significant areas and to avoid overlapping activities and actions by various organizations. While participating in the international co-operation, Finland will act actively and initiatively to ensure on its part that resources are allocated with a graded approach to most significant areas and avoiding also overlapping activities.

6.3 Strengthening communication mechanisms through regional and bilateral cooperation

Countries should cooperate with neighbouring and regional countries and exchange information on their civil nuclear power programmes.

Finland has bilateral agreements with neighbouring countries and also with some other countries having a nuclear program. The bilateral agreements include provisions to exchange information on the design and operation of nuclear facilities as well as on regulatory frameworks and approaches. As an example, STUK has continued bilateral co-operation in the form of meetings and conferences with the nuclear safety regulatory authorities of Sweden, Russia, France and the USA, among others. In the field of emergency preparedness Finland has bilateral and international agreements on exchange of information.

As a result of the TEPCO Fukushima Dai-ichi accident there has been no need to for any new agreement to mechanism of communication. However, there has been a need to enhance the exchange of information during the event and coordination of the protective measures recommended by the regulatory body. This topic is discussed in a working group of HERCA (Heads of European Radiological Protection Competent Authorities) for which Finland also participates.

Within the Nordic co-operation STUK has published in 2014 the Nordic Flagbook "Protective Measures in Early and Intermediate Phases of a Nuclear or Radiological Emergency". (http://www.stuk.fi/sateilyvaara/en_GB/index_uusi/_files/92026761818687300/default/nordic_flagbook_february2014.pdf). The publication gives common guidelines and recommendations for the practical application of protective measures for the Nordic authorities responsible for radiation protection in the event of a nuclear of radiological emergency.

With regard to assistance on embarking countries, Finland is a member of the IAEA's Regulatory Co-operation Forum (RCF) which coordinates and implements assistance to newcomer countries. In addition, Finland has provided support to embarking countries via EC's INSC programme.

6.4 Effectiveness of experience feedback mechanisms

Information exchange and feedback should be enhanced by using the established mechanisms (e.g. IRS, INES) and organisations (e.g. WANO). The current focus is on reporting events and not necessarily on learning from the events. Effectiveness of Operating Experience Feedback should be assessed and its implementation should be included in peer reviews.

Finland promotes learning from the operating experience by several means. The evaluation of foreign operational occurrences and incidents is based on the reports of the IRS Reporting System (IAEA/NEA) and on the reports of other national regulatory bodies. IRS reports are also evaluated by the licensees. Reports for the IRS System on safety-significant occurrences at Finnish nuclear power plants are written by STUK.

STUK has also participated in co-operation between international organizations such as the IAEA, the OECD/NEA and the EU, which exchange information on safety issues and operating events. Other forums that STUK uses to obtain information are WENRA, the VVER Forum and the NERS Forum as well as some bilateral agreements.

At the Loviisa NPP, the main external operating experience information to be handled comes from WANO (World Association of Nuclear Operators) Moscow Centre which links all the VVER reactor operators. Additional information and reports are received from the VVER Club, IAEA, OECD/NEA and NRC (U.S. Nuclear Regulatory Commission) and the Olkiluoto NPP.

At the Olkiluoto NPP, the main sources of information of the operating experience feedback group are ERFATOM (the owner's group for Nordic BWR operators), KSU (Swedish nuclear training centre), WANO and the Swedish Forsmark NPP. Information is also coming directly from several sources (IAEA and OECD/NEA, IRS), Loviisa NPP (e.g. operating experience meetings and reports), vendors (Westinghouse Atom, Alstom Power Sweden AB), component manufacturers, the WANO Network, BWROG (BWR Owners Group) and BWR Forum (FANP).

As a result of the TEPCO Fukushima Dai-ichi accident there has been no need to for any new forum for the exchange of operating experience. However, there is need to improve the effectiveness of the lessons learned process globally. This could be achieved by requiring licensees' and regulators to report corrective actions taken in the country as a result of significant events. In addition, utilization of international operating experience feedback should be an essential part of the international peer review missions.

6.5 Utilization of IAEA safety standards

Strengthening and expanded use of IAEA Safety Standards. The IAEA Safety Standards should be taken into account in developing national nuclear safety regulations. These Safety Standards have a role to play in seeking continuous improvements to safety at existing nuclear power plants.

According to the Finnish nuclear safety policy the Finnish nuclear legislation and regulations aim at high safety level at the Finnish nuclear facilities. Continuous improvement is one of the fundamental principles of the Finnish nuclear safety policy. The legislation and the regulations are kept up to date and all the stakeholders are committed to practices typical to high reliability organizations. The IAEA safety standards are used as a reference when developing the Finnish regulations.

STUK takes actively part in the preparation of the IAEA safety standards. Finland is represented in all of the safety standard committees, the commission on safety standards and the Standing Advisory Group on Safeguards Implementation (SAGSI).

PART III

7 Implementation of Activities

This Section concludes all activities taken, planned or already implemented in a table format including time schedules. References are given to Sections 2-7 regarding more detailed description of the related responses and conclusions.

Table 1. National level activities.

No.	Action/Activity	Related Section	Status	Schedule
Topics 1-4 – Natural Hazards, Design Issues, Severe Accident Management and National Organisations				
1	Including new issues (extreme external hazards, spent fuel pool issues) in the national research programme	Sections 1 and 4.4	Implemented	2012-2014
2	Implementing the new requirements to Finnish Regulatory Guides (YVL Guides)	Sections 1, 2.1 and 3.5	Implemented	12/2013
3	Preparations to implement rapid support from TSOs to the authority in emergencies	Section 4	Implemented	2013
Topic 5 – Emergency Preparedness and Response and Post-Accident Management (Off-Site)				
4	National Nuclear Power Plant Emergency Preparedness Forum to be launched in order to co-ordinate issues related to: –long term accidents of several NPP units, –recovery phase actions, –emergency measures outside the planning zones, –scope of the emergency exercises, –radiation monitoring capability during prolonged emergency situations, –communication capability during prolonged emergency situations, –availability of the emergency centres with respect to power supply, filtration of the intake air and the distance from the NPPs, –public information, information between the authorities, –clearance of the roads, alternative transport ways and means, –decontamination resources and facilities, –supply of contractor staff during the emergencies, –warning the population	Section 5.1	Canceled *	-
5	Further improvement of arrangements for the coordination of information to the public and media during emergencies is needed. Guidelines for co-	Section 5.3	Implemented	2015

	operation among authorities have been written in a guidebook published in November 2012.			
6	Emergency exercises exceeding 24 hours or exercises containing aspects of recovery have not been organised systematically, and should be included in the exercise calendar.	Section 5.3	Implemented	2014
7	Ensuring sufficient amount of radiation protection equipment and radiation monitoring devices for rescue services	Section 5.6	Implemented	2014
	Topic 6 – International Co-operation			
8	Participation in the IAEA-ISSC work	Section 6.2	Implemented	According to the work of the IAEA-ISSC
9	Participation in the WENRA RHWG work	Section 6.2	Implemented	According to the WENRA RHWG
10	Participation in the CNRA and CNRA STG on Fukushima	Section 6.2	Implemented	According to the CNRA and STG
11	Participation in the MDEP STC and EPR design specific working group	Section 6.2	Implemented	According to the MDEP STC and EPRWG
12	Participation in EU Stress Tests	Introduction	Implemented	06/2012

* After the initial proposals, the Forum's field of responsibility was found to be mostly overlapping with other existing co-operation and co-ordination bodies. Therefore, it has been decided that creation of new group is not the best way to address the issue. Instead, the membership and responsibilities of existing groups have been adjusted. For example, Ministry of the Interior is now also member in both of the regional groups.

Table 2. Measures at the Loviisa NPP units 1 and 2.

No.	Action/Activity	Related recommendation	Status	Schedule
	Topic 1 – Natural Hazards			
101	Evaluation of fragility of the spent fuel pools at high temperature and at high pressure	Section 1.1	Implemented	09/2012
102	Updating the seismic fragility analyses of - the spent fuel pools - fire fighting systems	Sections 1.1 and 1.3	 Implemented Implemented	 09/2012 03/2013
103	Improving preparedness for high seawater level	Sections 1.1 and 1.2	Implemented	2019
104	Analysis of consequences of beyond design basis low and high temperature	Section 1.1	Implemented	12/2011
105	Analysis of consequences of tornados and downbursts on plant structures and systems	Section 1.1	Implemented	12/2011
	Topic 2 – Design Issues			
106	Implementation of an alternative ultimate heat sink	Section 2.1	Implemented	2014

107	Securing the availability of the auxiliary emergency feed water system	Section 2.1	Implemented	2013
108	Acquiring a container to transfer diesel fuel at site	Section 2.2	Implemented	2012
109	Enhancing the battery power sources	Section 2.3	Implemented	2014
110	Acquiring mobile power supply and mobile pumps	Section 2.5	Canceled **	-
111	Connecting the additional diesel power engine to the plant switchgears by a dedicated cable	Section 2.3	Implemented	10/2012
112	Evaluation of demineralised water reservoirs	Section 2.1	Implemented	12/2011
113	Evaluation of demineralised water usage in an accident concerning all units and spent fuel pools at the site	Section 2.1	Implemented	5/2013
114	Enhancing the diesel fuel transfer capabilities on-site; acquiring a new diesel fuel storage tank at site	Section 2.2	Implemented	2015
115	Evaluation of suitability of biodiesel for the diesel engines	Section 2.2	Implemented	2012
116	Ensuring the water injection into the spent fuel pools and monitoring the conditions of the pool	Sections 2.4 and 3.3	In progress	2020
Topic 3 – Severe Accident Management				
117	Capability of dealing with multi-unit severe accidents; updating of emergency plans and organisation	Section 3.5	Implemented	2013
118	Improving the containment decay heat removal in case of multi-unit accidents. Alternative means investigated.	Section 3.1	Canceled **	-
119	Plans for restoring the access routes to the site	Section 3.5	Implemented	12/2013
120	Evaluation of suitability of emergency preparedness personnel to their duties	Section 3.5	Implemented	2013
121	Plans for access control and radiation monitoring of the staff and decontamination measures in extreme natural hazards	Section 3.5	Implemented	12/2013

** The utility evaluated that using mobile devices would no longer bring additional benefits after other plant improvements (e.g. provisions to high sea water level, action no. 103) are implemented. The project for mobile devices was terminated in 2017.

Table 3. Measures at the Olkiluoto NPP units 1 and 2.

No.	Action/Activity	Related recommendation	Status	Schedule
Topic 1 – Natural Hazards				
201	Updating the seismic fragility analyses of the spent fuel pools and fire fighting systems	Sections 1.1 and 1.3	Implemented	2/2013
202	Improvement against exceptionally high seawater level on the cooling systems of the spent fuel interim storage	Section 1.2	Implemented	2013
203	Analysis of consequences of beyond design basis low and high temperature	Section 1.1	Implemented	12/2011
204	Analysis of consequences of tornados and downbursts on plant structures and systems	Section 1.1	Implemented	12/2011
Topic 2 – Design Issues				

205	Implementation of an independent way of pumping water into the RPV	Section 2.1	Implemented	2018
206	Implementation of modification to prevent overheating of the auxiliary feed water system (independent of sea water cooling)	Section 2.1	Implemented ***	2018
207	Evaluation of suitability of biodiesel for the diesel engines	Section 2.2	Implemented	2012
208	Implementation of mobile power supply (including recharge of DC batteries)	Section 2.5	Implemented	2014
209	Evaluation of demineralised water reservoirs	Section 2.1	Implemented	12/2011
210	Evaluation of demineralised water usage in an accident concerning all units and spent fuel pools at the site	Section 2.1	Implemented	2012
211	Ensuring the water injection into the spent fuel pools and monitoring the conditions of the pool	Sections 2.4 and 3.3	Implemented	2017
Topic 3 – Severe Accident Management				
212	Capability of dealing with multi-unit severe accidents; updating the emergency plans and organisation	Section 3.5	Implemented	10/2013
213	Reactor building top venting for steam escape; hydrogen possibly formed could be exhausted through this route as well	Sections 2.4 and 3.1	Implemented	2019
214	Plans for restoring the access routes to the site	Section 3.5	Implemented	12/2013
215	Enhancement of the emergency plan on radiation measurement patrols	Section 3.5	Implemented	03/2013
216	Enhancement of adequacy of the maintenance personnel in case of emergency	Section 3.5	Implemented	3/2013
217	Evaluation of suitability of emergency preparedness personnel to their duties	Section 3.5	Implemented	03/2013
218	Plans for access control and radiation monitoring of the staff and decontamination measures in extreme natural hazards	Section 3.5	Implemented	12/2013
219	Improvement of communication capabilities	Section 3.5	Implemented	12/2012

*** The new recirculation line modification was implemented at Olkiluoto 1 in 2014. Abnormal vibration and pressure oscillations were observed during the testing of one subsystem. This did not influence operation of the pump, however, and the fault would not have prevented the supply of water to the reactor in case of need. The reasons for oscillations have been investigated and improvements to the design have been made. Currently, all four redundancies of unit 1 and two redundancies of unit 2 are modified. Some final issues need to be resolved before last two redundancies of unit 2 are modified.

Table 4. Measures at the Olkiluoto NPP unit 3.

No.	Action/Activity	Related recommendation	Status	Schedule
Topic 1 – Natural Hazards				
301	Analysis of consequences of beyond design basis low and high temperature	Section 1.1	Implemented	12/2011

302	Analysis of consequences of tornados and downbursts on plant structures and systems	Section 1.1	Implemented	12/2011
Topic 2 – Design Issues				
303	Evaluating modifications required for restoring long-term cooling after extreme electrical disturbance	Section 2.1	In progress	After provisional take-over
304	Ensuring the water injection into the spent fuel pools with mobile pumps	Section 2.4	Canceled ****	-
Topic 3 – Severe Accident Management				
305	Capability of dealing with multi-unit severe accidents; updating the emergency plans and organisation (in connection with Olkiluoto units 1 and 2)	Section 3.5	Implemented	2019

**** Dedicated mobile pumps were evaluated as unnecessary in 2012 because of means already implemented. Pumps procured for units 1 and 2 (action no 211) could be used for unit 3 if needed.