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Erja Kainulainen (ed.)

Regulatory oversight of nuclear safety in Finland

Annual report 2019

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Introduction

This report is a report on regulatory oversight in the field of nuclear energy provided by the Radiation and Nuclear Safety Authority (STUK) to the Ministry of Economic Affairs and Employment once a year as required by Section 121 of the Nuclear Energy Decree. The report will also be provided to the Ministry of Social Affairs and Health, the Ministry of the Environment, the Finnish Environment Institute and to the environmental authorities of the nuclear facility municipalities.

The report is a summary of regulatory oversight of safety in the use of nuclear energy performed by STUK and of the related results in 2019. The regulatory oversight concerned the design, construction and operation of nuclear facilities, decommissioning planning, nuclear waste management and nuclear safeguards.

In addition to actual regulatory oversight of safety, the report describes, among other things, the development and implementation of the regulations concerning the use of nuclear energy during the year and the main characteristics of the safety research programmes pertaining to nuclear safety and nuclear waste management in Finland.

The annexes to the report contain significant events at the nuclear power plants and inspection summaries of STUK's inspection programmes. In addition, a summary of the licences accordant with the Nuclear Energy Act granted by STUK in 2019, as required by the Nuclear Energy Decree, is appended to the report.

STUK's Financial Statements and Annual Report 2019 includes an assessment of meeting the performance targets under the performance agreement between the Ministry of Social Affairs and Health and STUK also in view of regulatory oversight in the use of nuclear energy.

Contents

1 Development and implementation of the regulations

Amendments to the Nuclear Energy Act and the Nuclear Energy Decree

The amendments on the security arrangements pertaining to the use of nuclear energy were prepared as part of the Nuclear Energy Act's (990/1987) amendment bill (HE 93/2017), which implemented the requirements of the EU Nuclear Safety Directive's amendment (2014/87/Euratom) and supplemented the implementation of the Spent Fuel and Radioactive Waste Directive (2011/70/Euratom) due to the supplementary questions by the Commission. At the same time, the decommissioning licence was also added to the act as a new licensing phase for nuclear facilities, and changes were made in view of nuclear waste management. However, following the round of opinions in spring 2017, the matters concerning the security arrangements pertaining to the use of nuclear energy were withdrawn from the amendment bill, as there was still a need to continue the basic preparation of the amendment bill of the actand, due to scheduling reasons, the amendments required by the directive had to be implemented as soon as possible, which took place on 1 January 2018.

The preparation of the proposed amendment on the security arrangements pertaining to the use of nuclear energy has continued through cooperation between the Ministry of Economic Affairs and Employment (MEAE) and the Radiation and Nuclear Safety Authority (STUK). The bill proposes to amend the Nuclear Energy Act, the Security Clearance Act and the Mining Act. A round of opinions was arranged on the proposal draft between 15 November 2018 and 16 January 2019. The main objective of the proposal is to improve nuclear and radiation safety by responding to the new identified security threats that cannot be addressed and prevented with the powers of current legislation. The proposal also aims to develop provisions regarding the security arrangements, considering in particular the requirements of the Finnish Constitution and, also, legislation in the private security services. From a constitutional point of view, the objective is to bring regulation to the correct level and to render it sufficiently precise, while taking into account the fulfilment of basic rights and the requirements set for their limitation. In addition, the objective is to harmonise the provisions of the Nuclear Energy Act and the Mining Act with the changed general legislation and to bring legislation fully in line with the Spent Fuel and Radioactive Waste Directive, with regard to which it is necessary to specify the act as regards taking research samples of nuclear waste for research purposes outside the jurisdiction of Finland, which are not intended to be brought back for final disposal. The amendment bill of the act will be submitted for a round of opinions late in 2019 and it will be submitted to the Government in February 2020.

The Nuclear Energy Decree (161/1988) was amended at the beginning of 2018 due to changes made to the Nuclear Energy Act and the new Act on Environmental Impact Assessment Procedure (252/2017). Specifying provisions were added to the decree regarding

the decommissioning licence procedure and oversight of the Radiation and Nuclear Safety Authority and the minimum contents of the national nuclear waste management programme. Changes due to the new Radiation Act and the Nuclear Energy Act, which entered into force in mid-December 2018 as an annexed act to the Radiation act, and implemented the EU Basic Safety Standards Directive, BSS (2013/59/Euratom), were not included in the decree at the same time. At the end of 2019, MEAE started the preparations for updating the Nuclear Energy Decree, with priority given to the implementation of the amendments and additions resulting from the BSS Directive. In the same connection, also other necessary amendments will be introduced to the decree, which result from amending the security arrangements pertaining to the use of nuclear energy, and from other amendments that will enter into force at the same time.

In autumn 2018, the Ministry of Economic Affairs and Employment (MEAE) launched an assessment of the reform needs of the Nuclear Energy Act, and set up a working group on 18 October 2019 to prepare an overall reform of the Nuclear Energy Act. The term of the working group chaired by MEAE is from 21 October 2019 to 18 June 2020. In addition to MEAE, the working group members present the Ministry of Social Affairs and Health, the Ministry of the Environment, STUK and the LUT University. Permanent expert members present companies that are engaged in the production of nuclear energy and have a legal obligation to manage nuclear waste. The objective of the reform is to bring the regulation regarding the use of nuclear energy in nuclear facilities- up-to-date, clear and consistent as whole and ensure that regulations meet the new requirements of the Finnish Constitution and EU legislation and any foreseeable needs.

Update of STUK's regulations issued by virtue of the Nuclear Energy Act

The Radiation and Nuclear Safety Authority issues further regulations, which are binding to the licensees, in accordance with Section 7q on the technical details of the general safety objectives laid down in Chapter 2a of the Nuclear Energy Act (990/1987). STUK issued five regulations concerning the safety of nuclear facilities for the first time in early 2016. Until that time, these regulations had been issued as government decrees.

As a result of the reform of the radiation legislation and the amendments to the Nuclear Energy Act, STUK updated its Regulations on the Safety of a Nuclear Power Plant (STUK Y/1/2016), on the Emergency Arrangements of a Nuclear Power Plant (STUK Y/2/2016) and on the Safety of Disposal of Nuclear Waste (STUK Y/4/2016) and they entered into force on 15 December 2018. The Regulations on the Security in the Use of Nuclear Energy (STUK Y/3/2016) and on the Safety of Mining and Milling Operations Aimed at Producing Uranium or Thorium

(STUK Y/5/2016) remained unchanged at that time. The update of the Regulation on the Security in the Use of Nuclear Energy was launched in autumn 2019, when the contents of the proposed amendment under preparation had been confirmed. The objective is to publish the regulation in summer 2020. The update of Guide YVL A.11 concerning the security of a nuclear facility will be scheduled for completion at the same time as the regulation. The update of the regulation (STUK Y/5/2016) and preparation of the corresponding Guide YVL D.6 are to be carried out almost with the same schedule as STUK's regulations on security.

Update and implementation of the YVL Guides

As part of the update of the nuclear safety regulations, STUK's nuclear safety guides (YVL Guides) have also been updated. There are a total of 47 YVL Guides. The round of updates does not apply to the new guides YVL D.6 "Production of uranium and thorium in the mining and milling industry" and YVL E.13 "Ventilation and air conditioning equipment of a nuclear facility" which will be published in 2020. The round of updates of the YVL Guides involved mainly clarifications, changes to the regulation references and minor changes to the requirements. The update also took into account feedback received from the licensees in the implementation of the YVL Guides. In the update of the YVL Guides, a particular goal was also to reduce the administrative burden.

In 2019, STUK published 32 updated YVL Guides with their explanatory memorandums in Finnish and English: in February-March Guides YVL A.2, A.3, A.5, A.7, A.8, A.9, A.10, B.4, C.1, C.3, C.4, C.6, E.1, E.5, E.7 and E.12; in May Guides YVL D.1 and D.2; in June Guides YVL A.6, B.1, B.2 and B.6; in September Guides YVL B.3, B.5, E.2 and E.11; and in November–December Guides YVL A.4, B.7, B.8, C.2, D.4 and E.3. The remaining YVL Guides being updated will be published in 2020. In 2019, approximately 100 persons took part in the update project of the regulations and YVL Guides at STUK, corresponding to approximately three man-years.

The published YVL Guides apply to new nuclear facilities as such. With regard to operating nuclear facilities and those under construction, the YVL Guides will be brought into effect through STUK's separate implementing decisions. For the implementation of the updated YVL Guides, STUK has requested, via requests for clarifications sent after the publications of the guides, the licensees and licence applicants to submit a reasoned assessment of the fulfilment of the requirements presented in the YVL Guides and, if the requirements are not fully met, to present a proposal for improvement measures and their timing. Processing of the fulfilment assessments submitted by the licensees started at STUK in late 2019, and the implementation decisions to be taken based on them will be completed mainly in 2020.

2 Results of regulatory oversight of nuclear facilities in 2019

2.1 Loviisa 1 and 2

STUK oversaw the safety of the Loviisa nuclear power plant and assessed its organisation in different areas by reviewing materials provided by the licensee, carrying out inspections in line with the periodic inspection programme and the YVL Guides, and by overseeing operations at the plant. On the basis of this regulatory oversight, STUK can state that as regards radiation exposure, the activities of the Loviisa nuclear power plant were safe to the employees, the population and the environment.

During the annual outages in 2019, the plant modifications involved final work on the I&C update project ELSA, the modification of the cooling pipes of the emergency diesel generators, the improvement of the cleaning system of the primary circuit and final work on the changes made on the basis of the Fukushima accident, which were also overseen by STUK.

The descriptions of the annual outages and the most significant events are presented in more detail in Appendix 2, and the summaries of the inspections in accordance with the periodic inspection programme are presented in Appendix 3.

2.1.1 Safe operation of the plant

Radiation safety of the plant, personnel and environment

The collective occupational radiation dose of the employees in 2019 was 0.25 manSv at Loviisa 1 and 0.25 manSv at Loviisa 2. Most of this accumulated from work completed during the annual outage of the plant (0.22 manSv at Loviisa 1 and 0.23 manSv at Loviisa 2).

Fortum has continued work to reduce the doses at the Loviisa power plant. This involves the further development of work methods and systems and the minimisation of parts containing highly activated substances in accordance with the ALARA principle. During the 2019 annual outages, the long-planned improvement of reactor water cleaning circulation was implemented, allowing active impurities to be removed from the primary circuit also during the annual outage – previously it was only possible during power operation.

Highly activated elements include nickel, cobalt, silver and antimony, the activation products of which (^{58}Co, ^{60}Co, ^{110m}Ag and ^{124Sb}) may raise radiation levels at the facility. According to the ALARA principle, the use of these elements must be avoided, when possible, in locations where activation may occur or the elements may be released into the reactor coolant circuit. These locations include structural materials, welds and seals of the reactor circuit.

According to the Government Decree on Ionising Radiation (1034/2018), the effective radiation dose to persons engaged in radiation work must not exceed 20 mSv per year. The actual individual radiation doses remained clearly below this limit. The largest individual dose

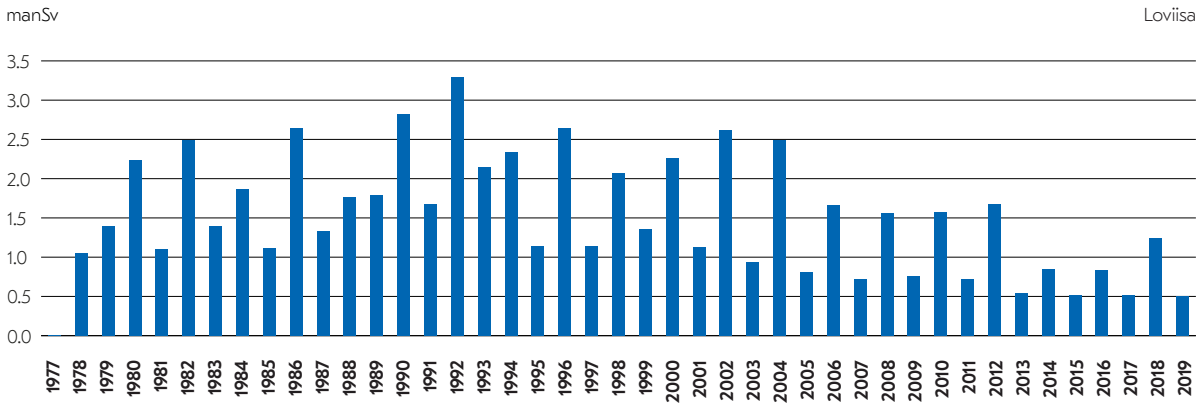

FIGURE 1. Collective occupational doses since the start of operation of the Loviisa nuclear power plant.

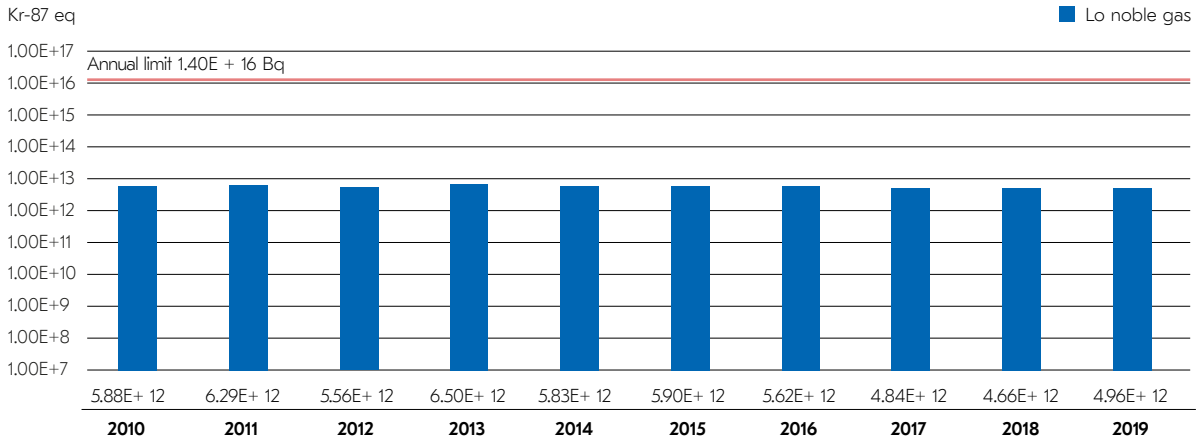

FIGURE 2. Noble gas releases to the atmosphere (Kr-87 eq), Loviisa.

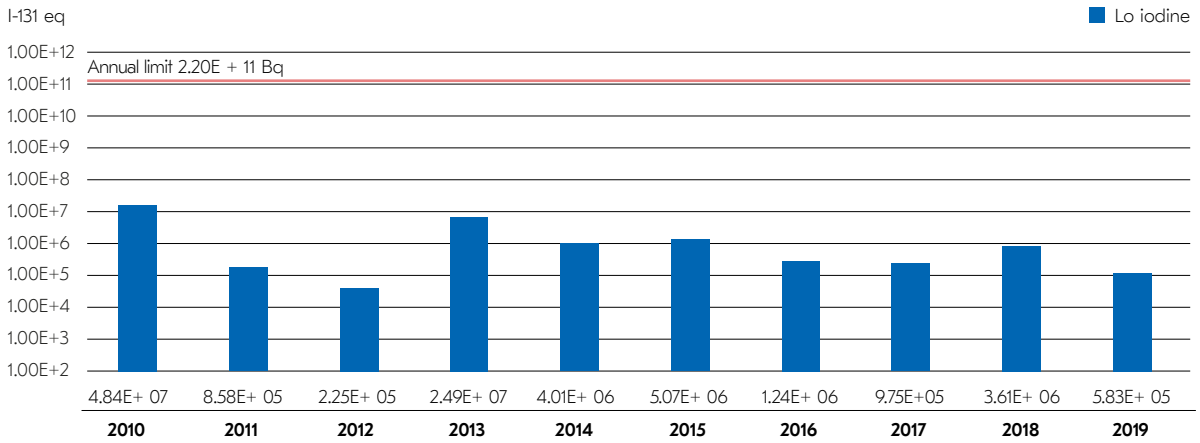

FIGURE 3. Iodine isotope releases to the atmosphere (I-131 eq), Loviisa.

received at the Loviisa power plant was 6.8 mSv, and resulted from mechanical work on the improvement of rector water cleaning circulation.

Radioactive releases into the air and sea remained clearly below the set limits. The calculated radiation dose of the most exposed individual in the vicinity of the plant was less than 1% of the limit of 100 microsieverts set in the Nuclear Energy Decree.

A total of approximately 390 samples were collected and analysed from the land and marine environment surrounding the Loviisa power plant in 2019. The measured concentrations were so low that they are insignificant in terms of radiation safety of the environment or people. The exposure to radioactivity of residents in the vicinity of the nuclear power plant was also measured. No radioactive substances originating from the Loviisa power plant were detected in them.

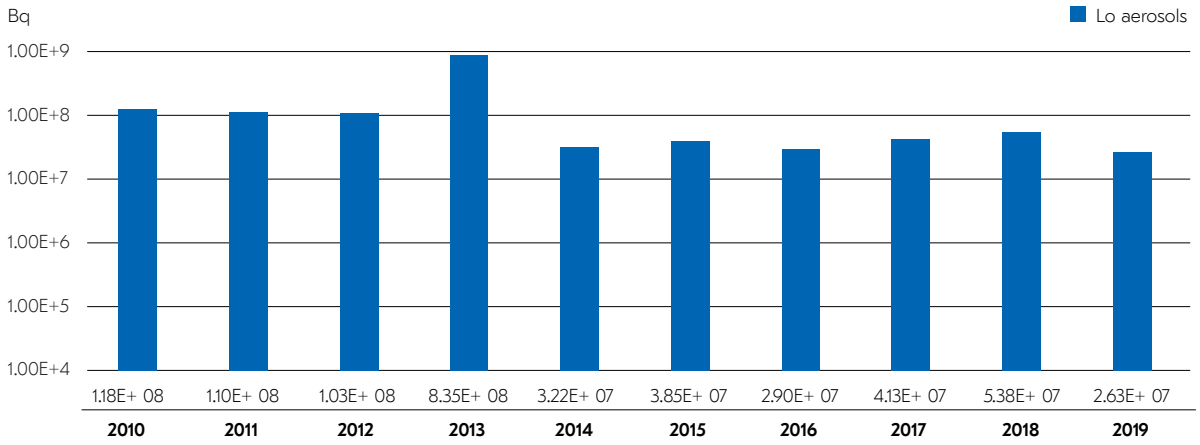

FIGURE 4. Aerosol releases to the atmosphere (Bq), Loviisa.

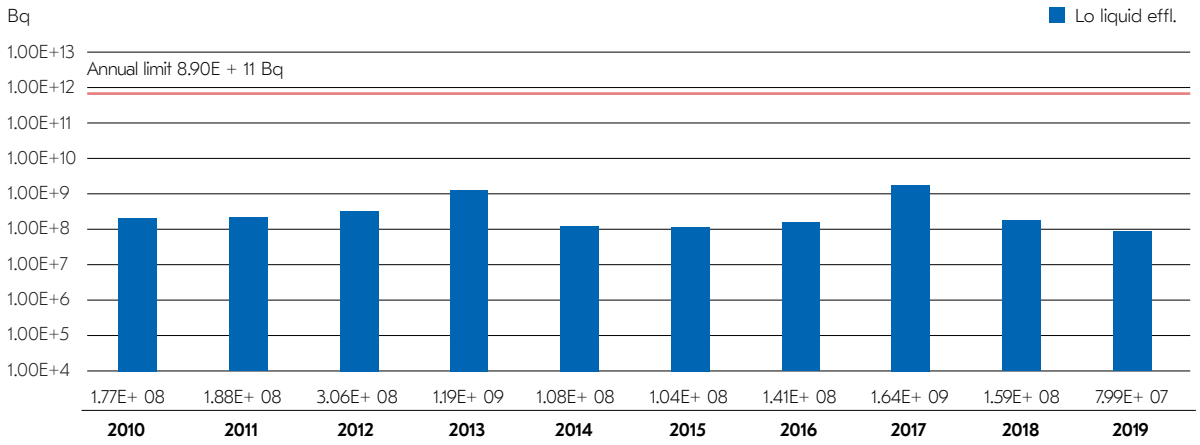

FIGURE 5. Gamma activity of the liquid effluents (Bq), Loviisa.

Operational events and operating experience feedback

Fortum identifies events at the plant and initiates event investigations to determine the causes and to improve the plant and the operations. A testament to this is the fact that Fortum reported the results of 18 event analyses and investigations to STUK in 2019. Some of the events are events that took place in 2018. Two event investigations examined a theme that emerged at several events (management of preventive maintenance required by the Operational Limits and Conditions (OLC)) or for which Fortum wanted to form an overall picture of the situation and the targets for development (loose pieces in annual outage 2018). Other event analyses and investigations concerned individual events. Most of the events revealed areas for improvement in procedures and activities. For example, one event surfaced shortcomings in the design and implementation of the updated cooling water lines of the emergency diesel generators. Fortum will investigate this event in two phases: the latter phase (root cause analysis) will be completed in early 2020. This event is described in more detail in Appendix 2.

By reviewing the results of the event analyses and investigations, STUK verified that Fortum had investigated the underlying causes of the events and initiated the necessary actions to correct technical faults and deficiencies in its operations and prevent reoccurrence of the events. STUK did not entirely share the view of Fortum on the nature of two events (according to STUK's view, situations in violation of the OLC). The view differences will be discussed between STUK and the licensee in order to mutually learn from them. In one case, STUK submitted its own observations to be taken into account in the more extensive investigation launched by Fortum. In other respects, STUK considered the event analyses and investigations of Fortum sufficient.

STUK inspected the effects of event investigations in 2018 because deviations relating to the same area had recurred. STUK concluded, based on the inspection, that Fortum had not comprehensively analysed the reasons for the recurrence although problems had been clarified and corrected through event investigations. Based on the inspection, STUK required that Fortum improve learning from their operating experience. STUK also intensified regulatory oversight with regard to this topic and continued it for the whole year of 2019. At the end of the year, it was too early to assess the effectiveness of the measures launched by Fortum.

Annual outages and maintenance operations

The annual outages of the plant units were implemented as planned in terms of nuclear and radiation safety. In addition to refuelling and modifications, a large number of maintenance measures and inspections are carried out during each annual outage to ensure the safe and reliable operation of the power plant.

In the short annual outages of 2019, the most important modification as far as STUK was concerned was the modification of the cooling pipes installed in 2018 for the Loviisa 2 emergency diesel generators. In summer 2019, leaks were observed in the piping of one diesel at Loviisa 2 resulting from excessive vibration of the diesel cooling piping, which is why Fortum investigated the operational condition of all Loviisa 2 diesel cooling pipes with analyses and tests, and planned and implemented the necessary repairs before the start-up of the plant unit. STUK verified Fortum's measures, processed Fortum's reports and approved the corrections made. The plant did not receive STUK's authorisation for start-up until there was absolute

certainty that all diesels at Loviisa 2 were fully operational in case of a long-term 72-hour need. Originally, the intent was to make the same modification of the diesel cooling pipes at Loviisa 1 that was made at Loviisa 2 in 2018. Due to the findings made at Loviisa 2 and the modifications made during the annual outage in 2019, the modification work of Loviisa 1 was transferred to the annual outage of 2020, so that operating experience can be gathered from Loviisa 2's design solutions and the plans updated.

More information on the annual outages is available in Appendix 2, and a summary of the part of the periodic inspection programme is included in Appendix 3.

Operational waste management

The processing, storage and disposal of low and intermediate level waste (operational waste) at the Loviisa power plant were carried out as planned. The volume and activity of operational waste in relation to reactor power remained low compared with most other countries. Development projects at the power plant have progressed, for example, the management and storage of liquid waste and the solidification of liquid waste. The development projects aim at improving operational efficiency and reducing the amount of solidified waste needing final disposal. In connection with this topic, STUK carried out an operational oversight inspection targeting the solidification of liquid waste in the spring, covering the solidification procedures, operating experience and development projects concerning the solidification of liquid waste. No cause for remarks was found in the inspection.

In October, STUK carried out a periodic inspection targeting the disposal facilities, assessing, among other things, the disposal facilities and their use and the monitoring results regarding the properties and stability of the rock surrounding the facilities. The inspection summary is provided in Appendix 3.

STUK approved the commissioning of the solidified waste space of the final disposal facility for low and intermediate level waste at the end of 2019, which allows commencing the final disposal of concrete waste packages. In accordance with the licence issued by STUK in 2018, Fortum has been able to place concrete waste packages of solidified waste in interim storage in one maintenance waste space acting as the disposal repository for low level waste. The licence is valid until the end of 2021. By that time, Fortum will transfer the packages to the solidified waste space.

Fortum submitted to STUK an updated long-term safety case for the Loviisa disposal repository of low and intermediate level waste in late 2018. This material was supplemented in June. STUK approved the safety case for the Loviisa power plant's final disposal facility for low and intermediate level waste at the end of 2019. In the safety case, Fortum demonstrated that the long-term safety requirements for the existing part of the final disposal facility are met and the planned extension of the final disposal facility can be implemented in a way to meet the long-term safety requirements. However, Fortum has to further develop the long-term safety case by clarifying the safety arguments and the related methods and by decreasing the uncertainties related to the performance of the engineered barriers. In addition, Fortum submitted a report on the long-term safety impact of the quality non-conformances in concrete observed in 2018 with regard to the commissioning of the solidified waste space.

Fortum submitted to STUK for assessment an updated decommissioning plan for the Loviisa nuclear power plant at the end of 2018. This material was supplemented in February. STUK approved the decommissioning plan of the plant in autumn 2019.

The oversight and inspections by STUK indicate that power plant waste management at the Loviisa plant has been developed and as a whole meets the requirements.

Nuclear safeguards

STUK granted Fortum three licences concerning the use of nuclear commodities (Appendix 7).

STUK approved the updated version of Fortum's nuclear safeguards manual. In the manual, Fortum describes how the nuclear safeguards of the Loviisa nuclear power plant units have been organised. Fortum submitted the nuclear safeguards reports and notifications it was responsible for in time, and they were consistent with the observations made during inspections.

In 2019, a total of 9 nuclear safeguards inspections were conducted at the Loviisa power plant. STUK performed an inspection pertaining to the physical inventory verification of nuclear materials together with the IAEA and the European Commission both before and after the annual outages. Furthermore, STUK inspected the positioning of the fuel assemblies in the reactors of Loviisa 1 and Loviisa 2 prior to the closing of the reactor pressure vessel lids. The IAEA and the Commission carried out one inspection on short notice in the material balance area at the Loviisa power plant. No remarks were made in the inspections.

The oversight and inspections by STUK indicated that the Loviisa plant fulfilled its nuclear safeguard obligations in 2019.

Nuclear security

The oversight indicated that the level of security arrangements at the Loviisa plant has remained good and the arrangements have been purposefully developed.

In 2019, STUK performed one periodic inspection of security arrangements, which concerned physical protection of the use of nuclear energy and the safety of the radiation sources in view of the safety licence of the plant and the security arrangements for the use of radiation. In terms of the radiation sources, the most significant issue was the assessment of the new requirements of the new Radiation Act, for which STUK required further measures.

The security arrangements were also part of two other inspections, when STUK inspected the security arrangements at the plant during the annual outage in the periodic inspection of the annual outage and processed in the PRA inspection the use of analyses to develop the security arrangements. No requirements concerning the physical protection of the use of nuclear energy were presented in the inspections. The summary of the inspections is provided in Appendix 3.

Fire safety

Fire safety at the Loviisa power plant is at a good level. In 2019, STUK oversaw the fire safety of the power plant by means of site visits and by reviewing reports submitted by Fortum. The oversight focused on the implementation of fire protection arrangements during annual outages.

2.1.2 Technical condition of the plant and preparing for exceptional events

Development of the plant and its safety

Several reform projects that will improve plant safety are currently in progress at the Loviisa nuclear power plant. The most significant of these was the I&C reform of the Loviisa plant, which was implemented in 2016–2018. The last work tasks in the modernisation of secondary circuit safety functions, associated with the I&C reform, were completed at the same time, which means that the control of the most important safety functions of the plant has now been completely modernised.

Fortum started the pre-installation work for the new polar cranes of the reactor halls of the Loviisa power plant at the end of 2017 at Loviisa 2. The installation and commissioning at Loviisa 2 were completed in April 2018. At Loviisa 1, the pre-installation of the polar crane started in December, and the crane was installed and commissioned in late spring 2019. STUK monitored the smoothness of lifts during the annual outages as in the previous year.

The modifications started after the assessments done due to the Fukushima accident were finalised in 2019. These included, in particular, the installation of an additional system for ensuring the cooling of fuel pools and spent fuel storage pools under highly exceptional conditions, which was started in 2017. The system was completed with regard to mechanical parts in the 2018 annual outage. The 2019 annual outage covered the installation of the pump and I&C. The final commissioning will be completed at the beginning of 2020, when the pump bed, which caused excessive vibration in pre-operational testing during the 2019 annual outage, has been repaired. Changes to the procedures will be implemented after the system commissioning.

During the annual outage, modifications related to the water temperature of the spray system inside the containment were also made to increase the calculated cold crack margin of the reactor pressure vessel in the most restrictive situation (unexpected cold water spraying during power operation on the most critical weld area of the reactor pressure vessel). This is an improvement measure specified in connection with the periodic safety assessment of 2015 due to the small cold crack margin of the reactor pressure vessel of Loviisa 2.

Fortum also promoted many of its modernisation projects related to ageing management in 2019. These include the diesel I&C reform, reactor hall refuelling machine and low-frequency transformers of the control rod mechanisms. The start of the diesel I&C reform was postponed to the 2020 annual outage, during which it will be carried out at the same time as the reform of the diesel cooling pipes.

Ageing management as a programme and the related improvement projects, such as the above-mentioned management of the cold crack margin of the reactor pressure vessel, and the ageing management of the I&C systems and modernisation of the refuelling machine will continue to play an important role, from STUK's point of view, also in the future, as the new periodic safety assessment is being processed.

Reports and analyses

In order to further specify the earthquake risk of the Loviisa power plant, Fortum updated the seismic hazard reports and the earthquake response spectrum during 2017. These serve as the

basis for the seismic plant walk-around required in connection with the implementation of the YVL Guides. Fortum implemented the plant walk-around in 2018. Fortum compiled the results and submitted them to STUK for approval in spring 2019.

Fortum submitted to STUK also the reupdated seismic hazard reports in spring 2019, according to which the expected ground accelerations are higher than previously estimated. The ground response spectrum determined in the hazard report is needed as a starting point for seismic durability assessments of buildings and equipment. The processing of the reports regarding the seismic hazard will continue in 2020. Once the ground response spectrum has been definitively determined, Fortum can use it to calculate the fragility analyses for the seismic durability of buildings and equipment. Based on these, the plant's probabilistic risk assessment regarding seismic events will be updated and, where appropriate, corrective measures will be specified to ensure that the equipment critical to safety will withstand the plant's updated design basis earthquake. This involves long-term and extensive work, which has been systematically promoted by Fortum.

In 2019, Fortum has also updated other analyses related to the coming periodic safety assessment. These have included an update of the probability-based brittle fracture analysis of the reactor pressure vessel and updates of the analyses of power-state severe reactor accidents.

Emergency arrangements

STUK oversaw the ability of the Loviisa power plant emergency response organisation to act under exceptional conditions by making inspection visits and reviewing reports and emergency response plan updates submitted by Fortum. A periodic inspection was also prepared on emergency activities, the summary of which is presented in Appendix 3. No events requiring emergency response actions took place at the Loviisa power plant in 2019.

In November, an extensive co-operation exercise, which is organised every three years, was organised at the plant involving 48 organisations. The exercise was successful in terms of key objectives. When the exercise was assessed, possible development areas for the plant's emergency response organisation included further development of the contamination management procedures resulting from a possible release and establishing a joint view of the situation for the plant and authorities. Emergency preparedness arrangements at the Loviisa power plant have been systematically developed, and the plant's emergency response arrangements comply with all the key requirements.

2.1.3 Organisational operations and quality management

In 2019, STUK monitored Fortum's competence management, development of the process-based management system and especially the procurement process and the state of the assessment and development activities related to the safety culture. The summaries of periodic inspections regarding the management system, human resources, competence, management and safety culture are included in Appendix 3.

STUK also commissioned a survey from VTT in 2018 on the management of human factors at the Loviisa power plant. The results of the research project were obtained in early spring 2019. According to the survey, the overall view of the human factor and its management has improved at the Loviisa plant, but the final change will still take time. The recommendations of the survey report regarded a clearer implementation of the Human Performance tools, measurement of human factors, dissemination of good practices of different teams within the organisation and ways to manage workload. The report indicates improved people management as a strength of the Loviisa power plant. STUK will monitor the progress of Fortum's development measures.

Fortum has developed competence management over a long period of time, but it has progressed slower than expected. STUK will continue to monitor the development project in 2020. In the 2019 periodic inspection of competence management, the focus was on the refresher training and deputyship arrangements of persons operating in safety-related tasks in accordance with the administrative rules, which were found to be appropriate.

The development work of the process-like management system of the Loviisa plant has progressed, but it will require further efforts, for example, in view of the procurement process. STUK will monitor the development.

There have been no significant changes in Fortum's management and safety culture during the year. As a whole, the situation is acceptable, but there has been room for improvement in the assessment activities of safety culture, for example. Fortum has tackled the matter and strengthened resources in late 2019. Over the years, Fortum has also developed its decision-making procedures in the right direction. Fortum is implementing development measures in the area of supplier management of the Loviisa power plant, especially in terms of supplier safety culture. STUK will monitor these development measures as well as the development work on safety culture and the adequacy of resources as part of its oversight activities.

Fortum has been systematically developing project activities based on lessons learnt in the previous years. In terms of project activities and resources, the workload has clearly stabilised after the major modifications in 2018, and the work carried over to 2019 has progressed according to plans.

2.2 Olkiluoto 1 and 2

STUK oversaw the safety of the Olkiluoto nuclear power plant and assessed its organisation in different areas by reviewing materials provided by the licensee, carrying out inspections in line with the periodic inspection programme and the YVL Guides, and by overseeing operations at the plant. Summaries of inspections included in the periodic inspection programme for 2019 are included in Appendix 3.

On the basis of this regulatory oversight, STUK can state that as regards radiation exposure, the plant's activities were safe to the employees, the population and the environment.

2.2.1 Safe operation of the plant

Radiation safety of the plant, personnel and environment

The collective occupational radiation dose of the employees in 2019 was 0.19 manSv at Olkiluoto 1 and 0.46 manSv at Olkiluoto 2. Most of this accumulated from work completed during the annual outages (0.13 manSv at Olkiluoto 1 and 0.40 manSv at Olkiluoto 2).

According to the Government Decree on Ionising Radiation (1034/2018) that entered into force in December 2018, the effective radiation dose to persons engaged in radiation work must not exceed 20 mSv per year. The actual individual radiation doses remained clearly below this limit. The largest annual dose at the Olkiluoto nuclear power plant was 7,5 mSv.

Radioactive releases into the air and sea remained clearly below the set limits. The calculated radiation dose of the most exposed individual in the vicinity of the plant was less than 1% of the limit of 100 microsieverts set in the Nuclear Energy Decree (161/1988).

A total of approximately 390 samples were collected and analysed from the land and marine environment surrounding the Olkiluoto power plant in 2019. Small amounts of radioactive substances originating from the plant were observed in some of the analysed environmental samples. The measured concentrations were so low that they are insignificant in terms of radiation safety of the environment or people. The exposure to radioactivity of residents in the vicinity of the nuclear power plant was also measured. No radioactive substances originating from the Olkiluoto power plant were detected in them.

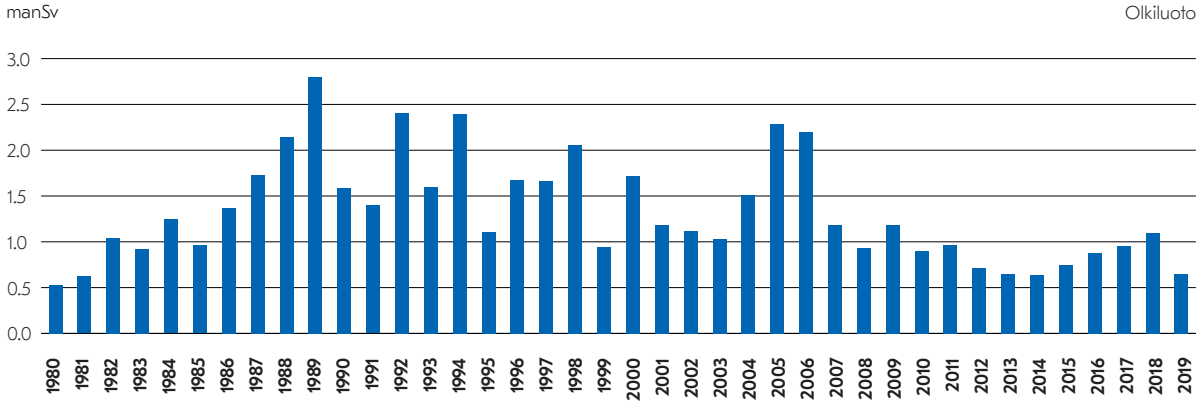

FIGURE 6. Collective occupational doses since the start of operation of the Olkiluoto nuclear power plant.

Operational events and operating experience feedback

TVO reported the results of 13 event analyses and investigations to STUK in 2019. As a conclusion, STUK can state that TVO identifies operational events at the plants and initiates event investigations to determine the causes and to improve the plant and the operation. Most of the events revealed areas for improvement in procedures and activities. The most important operational events are described in Appendix 2.

By reviewing the results of the event analyses and investigations, STUK verified that TVO had investigated the underlying causes of the events and initiated the necessary actions to correct technical faults and deficiencies in its operational methods and to prevent the reoccurrence of the events. STUK required further information on two events. In other respects, STUK deemed TVO's event analyses and investigations sufficient.

Event investigations and the implementation of the measures specified therein are part of learning from own operating experience. Learning from own operating experience also includes impact assessment and overall analysis. Based on a few events of 2019, it can be assessed that there is still room for improvement in learning from own operating experiences,

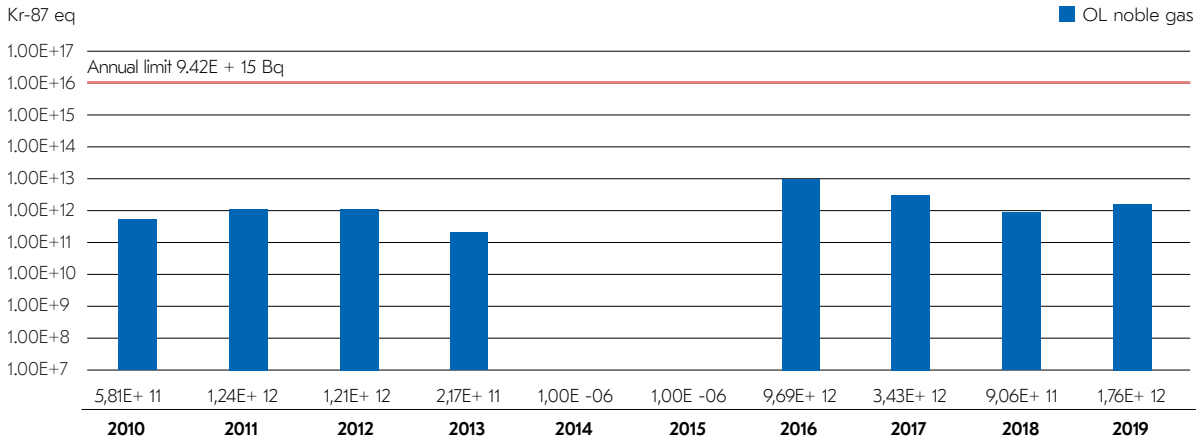

FIGURE 7. Noble gas releases to the atmosphere (Kr-87 eq), Olkiluoto.

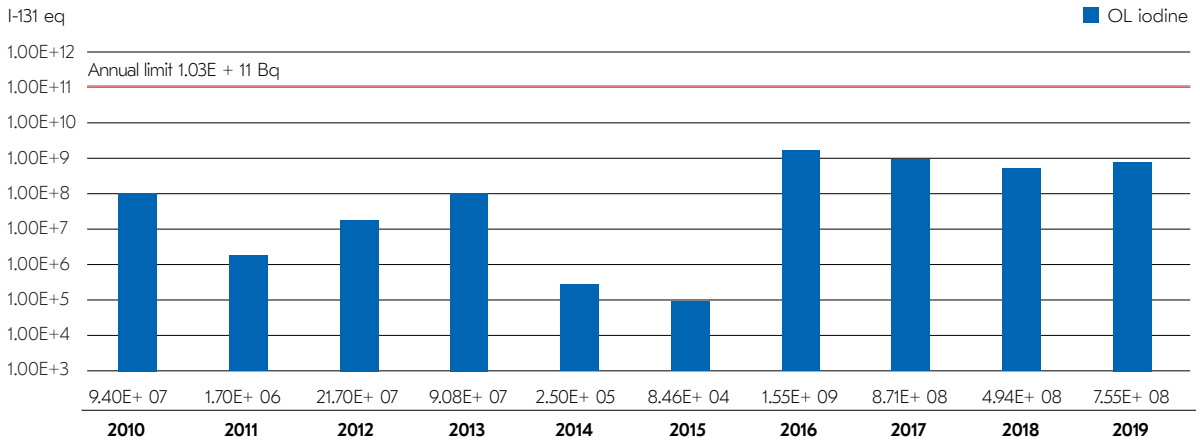

FIGURE 8. Iodine isotope releases to the atmosphere (I-131), Olkiluoto.

as the underlying factors are the same as in previous events. STUK required improved learning from own operating experience already in the 2017 inspection, after which TVO has specified and implemented corrective measures to develop its operations. Through its oversight activities, STUK monitors the progress of TVO.

Annual outages and maintenance operations

The annual outages of the plant units were implemented as planned in terms of nuclear and radiation safety. STUK oversaw the annual outages from their design to the start-up of the plant units. A large number of maintenance measures and inspections are also carried out during each annual outage to ensure the safe and reliable operation of the power plant. Non-destructive in-service inspections of pressure equipment were implemented in compliance with an in-service inspection programme approved by STUK. A pressure test of the reactor pressure vessel was also carried out at Olkiluoto 2. STUK required the completion of the test in accordance with pressure equipment legislation in the statement given on the operating

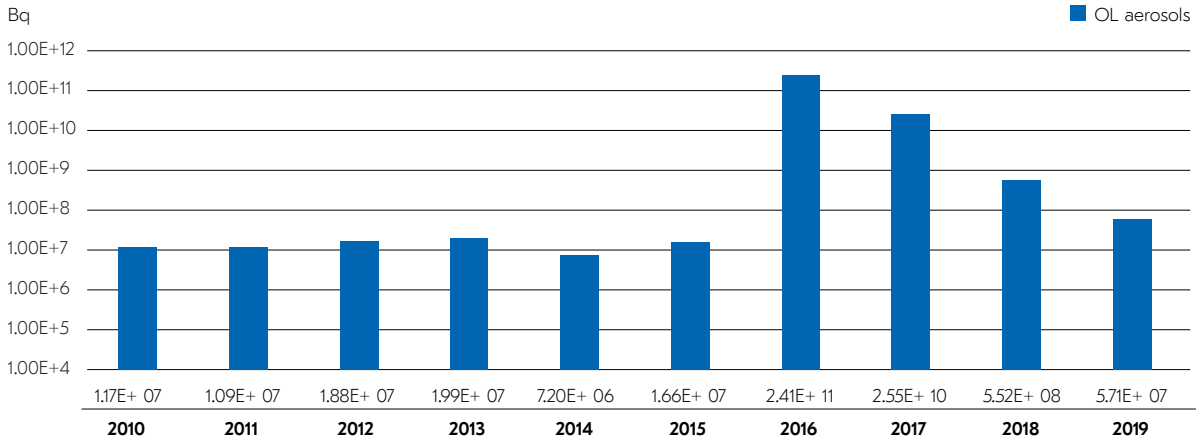

FIGURE 9. Aerosol releases to the atmosphere (Bq), Olkiluoto.

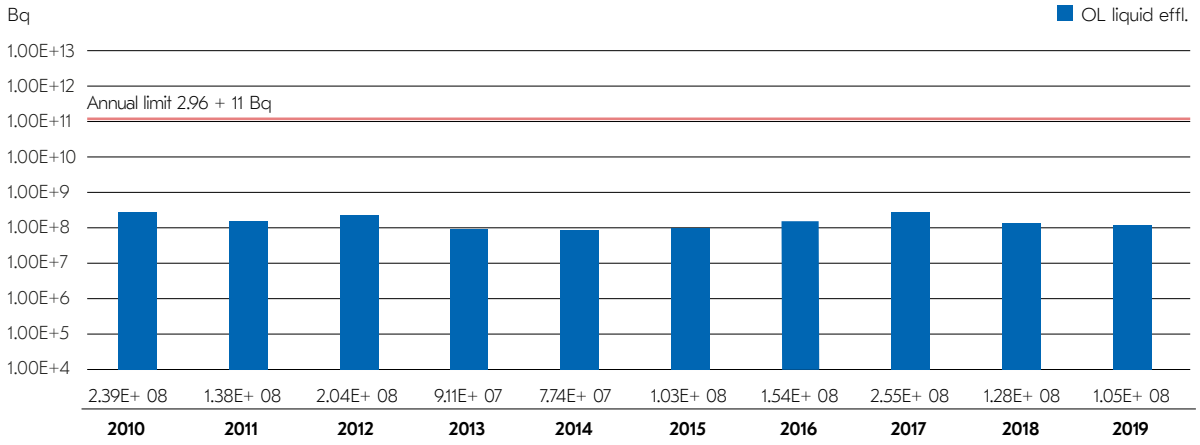

FIGURE 10. Gamma activity of the liquid effluents (Bq), Olkiluoto.

licence application of Olkiluoto 1 and 2. More information about annual outages of the plant units and STUK's regulatory oversight is available in Appendix 2. STUK carried out an inspection of the annual outages as part of the periodic inspection programme. The inspection summary is provided in Appendix 3.

Operational waste management

The processing, storage and disposal of low and intermediate level waste (operational waste) at the Olkiluoto power plant were carried out as planned. The volume and activity of operational waste in relation to reactor power remained low compared with most other countries. The power plant pays attention to keeping the amount of waste generated as low as possible by tightly packing the waste and releasing from control waste with so low a level of radioactivity that no special measures are needed.

In 2019, STUK carried out an inspection of power plant waste management in accordance with the operational inspection programme. The inspection included waste management processes, human resources planning and radiation doses to the personnel. The condition of facilities in which waste is processed, stored and disposed of, radiation levels in these facilities, their classification and their markings were inspected during the site visit. No major deficiencies or development needs were found in the inspection. In the holistic development of waste management, planning at TVO has concentrated on the harmonisation of the solidification process for waste resulting from all three plant units and on underground final disposal.

Nuclear safeguards

STUK granted TVO seven licences concerning the use of nuclear commodities for the Olkiluoto plant units in operation (Appendix 7).

TVO submitted the nuclear safeguards reports and notifications it was responsible for in time, and they were consistent with the observations made during inspections. STUK approved the updated version of TVO's nuclear safeguards manual. In the manual, TVO describes how the nuclear safeguards of Olkiluoto nuclear power plant units have been organised. In addition, STUK approved TVO's update of the accountancy and safeguards manual for international transfers of nuclear materials.

A total of 20 nuclear safeguards inspections were performed on the material balance areas of TVO's operating plant units and the spent fuel storage facility. STUK performed, together with the IAEA and the European Commission, inspections on the physical inventory of nuclear materials at both plant units and the spent nuclear fuel storage facility both before and after the annual outages. Furthermore, STUK inspected the positioning of the fuel assemblies in the reactors of Olkiluoto 1 and Olkiluoto 2 prior to the closing of the reactor pressure vessel lids. STUK also performed periodic inspections of nuclear safeguards at both plant units and at the spent fuel storage facility. STUK also participated in an inspection carried out at Olkiluoto 1 by the IAEA and the European Commission on short notice in August and November and in a complementary access type of inspection of the Olkiluoto site in accordance with the additional protocol in November. No remarks were made in the inspections.

The oversight and inspections by STUK indicated that the Olkiluoto plants in operation fulfilled their nuclear safeguard obligations.

Nuclear security

In 2019, STUK carried out one periodic inspection regarding nuclear security. The inspection also included an annual outage inspection in terms of security arrangements. During the annual outage, the activities at the site gate were monitored in particular, including monitoring of entry and exit traffic of persons and vehicles. The inspection summary is provided in Appendix 3.

As part of STUK's oversight activities, it has also monitored the development of TVO's exercise activities. TVO has developed security arrangement exercise activities more systematic in view of preparing for both physical and cyber threats. The exercise activities are a key method for demonstrating the effectiveness of security arrangements. Security arrangements are being developed in accordance with the principle of continuous improvement, and new security monitoring procedures have been introduced at Olkiluoto, for example, in the monitoring of transports and dangerous objects. Similarly, detection systems for information security deviations have been introduced and their implementation will be expanded. The information security skills of personnel are being developed and the situation assessment of information security is maintained. TVO is processing the action plan of the extensive and independent assessment of the security arrangements carried out in 2018. The procedures for demonstrating the effectiveness of the security arrangements as a whole must be further developed, as should the relevant regulatory requirements and oversight.

The security arrangements comprise an extensive package of administrative, technical and operational procedures. The whole formed by the security arrangements is at the required level.

Fire safety

In 2019, STUK oversaw the fire safety of the power plant by means of inspections and site visits and by reviewing reports submitted by TVO. Fire safety at the Olkiluoto power plant is at an acceptable level.

2.2.2 Technical condition of the plant and preparing for exceptional events

Development of the plant and its safety

Dependence of the auxiliary feedwater system from the seawater cooling was clearly reduced by implementing a modification at Olkiluoto 1 in 2014. Abnormal vibrations and sounds were nevertheless observed during the test run in one new recirculation line. TVO has continued its investigations to identify and eliminate the causes of the phenomenon since 2014. TVO has now solved the problems with piping vibration, for example, by improving piping supports. This established the basis for continuing the modification work at Olkiluoto 2 as well. TVO carried out the modification during the annual outage of Olkiluoto 2 by carrying out installations on two subsystems of the auxiliary feedwater system. According to the schedule reported by TVO, the installations of the last two subsystems will be carried out in spring 2020.

In the emergency diesel generator update project, the plant's eight emergency diesel generators will be replaced and a ninth generator will be built, enabling the replacement of diesel generators during power operation. The commissioning of the first new emergency diesel generator has been delayed. According to the schedule that was updated at the end of 2019, TVO estimated that commissioning will take place in spring 2020. Then, the remaining eight emergency diesel generators will be installed and commissioned one by one in such a manner that the last one will be commissioned in spring 2024. The new diesel generators can be cooled with seawater and air. The current ones can be cooled only with seawater. STUK is overseeing the upgrade and in 2019 inspected its related design documents and oversaw the manufacture.

An alternative float chamber-based trip that meets the diversity principle has been designed for the essential function of reactor water level measurement. In conjunction with the renewal of the operating licence, TVO proposed that the modification is intended to be implemented between 2019 and 2021. At the end of 2018, TVO submitted an application to STUK for approval, according to which the work will not yet be started in the 2019 annual outages. TVO has reassessed the risks related to the installation against the possible benefits of the modification and proposes that the preparation of the implementation in accordance with the current model be interrupted for further investigation. In 2019, STUK approved TVO's application for the reassessment of the modification. TVO must submit to STUK for approval the failure and common cause failure analyses related to the reactor tank level measurement. Based on the analyses, an assessment of the current safety situation must be provided, identifying the needs for possible safety improvements and drawing up a plan for the safety improvements to be made. STUK will continue the processing of the matter in 2020 on the basis of the received reports.

TVO has launched a project to renew the refuelling machines of the plant units. The modification involves the renewal of the mechanical devices and electrical and I&C system of the refuelling machines. The reason for this modification is the reduced availability of the existing refuelling machines, the difficult availability of spare parts and challenging maintenance. The new refuelling machines are more reliable, reducing interruptions during annual outages due to the refuelling machines. The update of the plan for principles of the new refuelling machines is planned to be submitted to STUK for approval in spring 2020. STUK will oversee the design, construction, installations and commissioning of the new refuelling machines.

Emergency arrangements

STUK oversaw the ability of the Olkiluoto power plant emergency response organisation to act under exceptional conditions by making inspection visits and reviewing reports and emergency response plan updates submitted by TVO. No events requiring emergency response actions took place at the Olkiluoto power plant in 2019. In December, a preparedness exercise was organised at the Olkiluoto power plant, focussing on the Olkiluoto 3 plant unit.

Emergency preparedness arrangements at the Olkiluoto nuclear power plant have been constantly developed, and the power plant's emergency preparedness arrangements comply with all the key requirements.

2.2.3 Organisational operations and quality management

In 2019, STUK continued intensified oversight of the implementation and efficacy of measures launched by TVO. Due to the challenges with work atmosphere experienced in the previous years, TVO has initiated extensive measures aiming towards a strong safety culture, good work atmosphere and improved management. In 2019, TVO continued to implement the above measures. TVO also made organisational changes during the year to improve the operational fluidity.

In conjunction with the renewal of the operating licence, STUK required regular reporting from TVO on the development of safety culture, work atmosphere and the organisation's resource situation. The annual report must be submitted to STUK for information regularly until STUK deems that the positive development of the work atmosphere and safety culture at TVO has been established as the norm and that the human resource situation has stabilised. TVO submitted the first report in January, and STUK has verified the situation by oversight and inspections.

Through its oversight, STUK has found that the preconditions for the high-quality and safety-informed operations of TVO' organisation have developed positively during 2019. A personnel survey carried out in autumn 2018 showed that the work atmosphere of TVO had improved significantly compared to the previous measurements. During 2019, personnel turnover has been normal and TVO has further strengthened its organisation by recruiting. The orientation of new employees is a challenge that TVO has addressed. TVO has responded to the development needs present, for example, in modifications, spare parts procurement and maintenance by changing organising and strengthening resources. TVO has also developed decision-making forums and the practices for assessing the situation to support decision-making regarding different plant units. In STUK's view, the interaction between management and personnel and the practical approach to developing safety culture have been strengthened at TVO. The implementation of development measures related to management and safety culture as well as staff resourcing and competence must be continued, and STUK will monitor their effectiveness as part of its oversight work.

2.3 Olkiluoto 3

STUK oversaw the construction of the Olkiluoto 3 plant unit and TVO's preparation for the coming operation stage by reviewing materials provided by the licensee, carrying out inspections in line with the inspection programme and the YVL Guides, and overseeing operations at the plant. Summaries of inspections included in the inspection programme for 2019 are presented in Appendix 6.

The Olkiluoto 3 project is in the commissioning phase, which includes the commissioning of components and systems, other preparations for plant operation, such as the production of instructions required for operation, personnel training and the completion of emergency preparedness and security arrangements. At the same time, the construction and installation work is being finalised.

In 2019, STUK completed its assessment related to the operating licence application. The operating licence is required before nuclear fuel is loaded into the reactor. STUK issued a statement on the matter to the Ministry of Economic Affairs and Employment on 25 February 2019, stating that the operation of the Olkiluoto 3 plant unit is safe. The statement was accompanied by a comprehensive safety assessment. There were still some outstanding issues in the statement, the completion of which STUK will check before nuclear fuel is loaded. Vibrations in the pressuriser surge line observed in pre-operational testing was one of these. The statement concluded that TVO has alternative technical solutions to solve the vibration problem.

The oversight of comissioning constituted a large part of the oversight work carried out by STUK in 2019. The oversight included the inspection of commissioning plans and results as well as the oversight of certain tests.

STUK carried out several inspections of functions related to preparations for plant operation and oversaw, for example, the testing and validation of the control room entity using a plant simulator and the training of future operators. STUK also oversaw the manufacturing of spare parts important to safety and the repair, maintenance and modification work performed at the plant. Based on these oversight measures, STUK observed that most of TVO's procedures and operations are at a good level.

2.3.1 Processing of the operating licence application

STUK's safety assessment of the operating licence application of Olkiluoto 3 was completed. The operating licence is required before starting the plant operation nuclear fuel loaded. TVO submitted an operating licence application to the Government in April 2016. After that, TVO submitted documentation updates to STUK, including modifications to the systems described in the operating licence documentation based on the commissioning tests.

STUK verified in connection with the processing of the operating licence application that the prerequisites for the safe operation of the plant are met. Detailed safety requirements are included in STUK's regulations and nuclear safety guides (the YVL Guides). STUK assesses compliance with these requirements during the operating licence review process. STUK's safety assessment was not based solely on a review of the operating licence documentation; instead, STUK utilised in its assessment all of its oversight operations, such as the general oversight on the plant site, its inspections and the results obtained during the commissioning tests of the plant.

On 25 February 2019, STUK issued a statement to the Ministry of Economic Affairs and Employment, stating that the operation of the Olkiluoto 3 plant unit is safe. The statement was accompanied by a safety assessment. There were still some outstanding issues in the statement, the completion of which STUK will check before nuclear fuel is loaded. Vibrations in the pressuriser surge line observed in pre-operational testing was one of these. The statement concluded that TVO has alternative technical solutions to solve the vibration problem. Another significant issue included in the statement was insufficient demonstration that appropriate operating procedures are available for the identification and control of abnormal and emergency situations.

2.3.2 Review of other licensing documents

I&C suitability analyses, stress analyses of piping and updates to plans for mechanical equipment and their updates, in particular, were submitted to STUK for processing in 2019.

STUK monitored the progress of the I&C component qualification and reviewed the suitability analyses of the I&C equipment and systems. Documentation work regarding the qualification tests and production of the suitability analyses continued throughout 2019, and the last documents will be completed in spring 2020 according to the schedule. However, the final suitability analyses must be submitted to STUK in good time before loading the fuel. The suitability analyses submitted in 2019 were of good quality, and STUK had little remarks to them.

Based on the observations made during commissioning and the operating experience of the two plant units of the Taishan sister plant in operation in China, some changes have been made to the plant's systems. For example, delays and logic relating to I&C functions have been optimised based on the results of commissioning. In addition, the facility documentation has been updated to reflect the results of the commissioning. STUK has reviewed and approved the major modifications related to safety.

During the year, STUK processed stress analyses of piping and constructions plans of mechanical equipment and their updates. Piping analyses were updated regarding the modifications made during the installation. Constructions plans of equipment had to be updated due process-technical and operational needs for change during the installation and commissioning phases. The stress analyses of the emergency cooling system indicated that the pipe supports are overloaded in a pipe break situation. The plant supplier reanalysed the situation with more realistic initial data and considering more carefully the forces in a pipe break situation. With a more realistic calculation, the loading of the pipe supports was lower and the load-bearing capacity of the supports could be demonstrated as sufficient for most supports. Where the strength could not be demonstrated by calculations, the supports were strengthened. STUK inspected the changes made during 2019.

2.3.3 Manufacture, installation and construction

STUK continued its oversight of manufacture and installation.

During commissioning in 2017, cracking was observed in the cobalt-free gasket face in certain valves of the reactor plant. Valve inspections were continued in 2019, and it was decided to replace the hard coating in the cracking valve gasket faces. The plant supplier and the valve manufacturer developed procedures relating to the welding of cobalt-free hard coating. STUK inspected new parts manufactured with an improved welding coating method during several inspection visits in 2019. The cracked valves will be repaired before nuclear fuel loading.

During 2018 and 2019, the plant supplier also presented several other observations relating to valves, as a result of which the suitability of the valves had to be reassessed. The investigations concerned the suitability of teflon, which is used as a sealing material for valves, in certain usage locations, usage of materials susceptible to cracking, the necessity of extension stems in hand valves and the corrosion resistance of valve materials. In addition, the

suitability of the valves had to be reassessed due to manufacture-related errors. STUK assessed the reports and plans submitted by TVO during 2019 and inspected the implementation of the modifications carried out. The work will continue in part during 2020.

The commissioning of the fuel handling equipment and reactor hall crane continued during 2019. STUK oversaw commissioning and reviewed their results reports. On the basis of the inspections, the equipment was granted a fixed-period operating licence.

STUK oversaw commissioning tests of the emergency diesel generators during 2019. STUK oversaw and inspected the repair and modification work of faults that were observed during commissioning tests. The cooling water pipes of the engines are connected to the engine with steel bellows. The redesign of the bellows started as a result of the leaks detected in the commissioning in 2019. Emergency stop of the engine in an overspeed situation required the redesign of the overspeed protection valve.

2.3.4 Oversight of commissioning

The purpose of commissioning is to verify that the plant's systems, structures and components operate as planned and have been successfully installed. Large-scale commissioning at the Olkiluoto 3 plant unit began already in 2016 when mainly individual components and systems were tested. In 2018, the so-called hot functional tests were performed at the plant in which main coolant pumps were used to heat the reactor plant and turbine plant systems to the normal operating temperature and pressure. During hot functional tests, STUK inspected matters relating to the performance of the tests, such as the administration of commissioning activities in the control room, the meeting of prerequisites for starting the tests to be performed, the orientation of the personnel and the work permit practices relating to the tests. As part of the inspection, STUK oversaw the performance of the most significant tests.

STUK sent a request for clarification based on the result report of the hot functional tests. On the basis of the review of the updated report, the results are acceptable. Some tests have been postponed or they will be repeated during nuclear test operation.

The biggest open issue in the hot functional tests was related to the higher than expected vibration of the pressuriser surge line belonging to the reactor cooling circuit. The cause of the vibration is still unknown. A possible cause is a hydraulic initiator of the primary circuit causing the pipe to vibrate at the natural frequency of the surge line. To suppress vibrations, the plant supplier will install two dampers in the line. STUK has approved the plan for principles for the dampers and inspected a part of the more detailed plans and analyses regarding the design of the dampers. These must be processed by STUK before starting the operation of the plant. Bitumen is used as damping fluid in the dampers. In a pipe break of the surge line, bitumen could leak from the damper. Before the final approval of the damper solution, the plant supplier had to demonstrate that bitumen cannot block the filters along the flow routes of the reactor's emergency cooling water and that bitumen cannot enter emergency cooling pumps or the reactor core with the coolant flow. The plant supplier commissioned tests on the behaviour of bitumen in pipe break situations at the Lappeenranta University of Technology and conducted tests with its own test equipment in Erlangen in Germany. STUK has monitored some of the tests. Based on the test results, STUK approved the use of bitumen

in the dampers. The plant supplier tested the operation of the dampers in the surge line in summer 2019. STUK oversaw the tests and assessed their preliminary results. The design of the installation and support structures of the dampers will continue during 2020.

Although the joint operation tests of the plant's systems had been carried out in 2018, a significant number of testings of individual systems were still carried out in 2019. All of the plant's systems were not needed in the hot functional tests, and some of the tests of these systems had been postponed to take place after the hot functional tests. Examples of these systems are standalone systems relating to waste management, some of the ventilation systems and the emergency diesel generators. Changes made to previously tested systems were also retested.

In 2019, the commissioning inspections of systems and equipment were started for the verification of the readiness for operation of the systems and equipment. STUK evaluates the readiness for operation of the systems and equipment in connection with the commissioning inspections. During commissioning, the equipment are maintained to ensure their operational condition and to evaluate the implementation of necessary maintenance measures. STUK verified the implementation of maintenance of the equipment most important to safety during 2019.

During the year, STUK reviewed several changes made to the commissioning programmes. Some of the changes had been made on the basis of experience from other EPR units, but most of the changes were updates that corrected the test programme to reflect the actual test. In its reviews, STUK pays particular attention to having all safety-significant functions tested and to having appropriate acceptance criteria for the tests. The test programmes have been of good quality, and STUK has approved almost all of them without any requirements. Reports of the commissioning results were submitted to STUK throughout the year. The result reports have been comprehensive, and STUK has not had any objections regarding them. STUK has paid attention to the long time it takes to produce the reports. Some of the long completion times are due to the fact that the individual tests of the test programmes have not been completed due to known future changes, which have prevented the completion of a comprehensive results report for the trial programme.

2.3.5 Oversight of preparation for operation

In addition to the technical readiness of the plant, a prerequisite for safe operation of the plant is the organisation's ability to use the plant in a safe manner. This includes ensuring that the organisation has sufficient resources and the necessary skills and competence, activities are instructed and there are arrangements and procedures for managing different types of matters (such as emergency response arrangements, security arrangements, nuclear safeguards and maintenance operations). STUK made several inspections relating to the preparation for the operation of the plant unit. STUK inspected, for example, security arrangements, chemical operations, mechanical quality assurance operations, spare parts management, emergency preparedness arrangements, resource planning, the adequacy and competence of personnel, radiation protection and operating experience feedback. When the operations to be inspected concerned the entire TVO instead of just the Olkiluoto 3 plant unit, the inspection was

included in the periodic inspection programme of the plant units in operation. Summaries of the inspections included in the inspection programme for 2019 are presented in Appendix 4. In its inspections and other oversight activities, STUK paid attention to the clarity of the procedures of control room activities, the compliance with instructions, the functioning of work permit practices and the clarity of the division of responsibilities between the organisations.

During 2019, TVO managed to complete the suitability qualification of the plant's procedures for abnormal conditions and emergency procedures for their intended application using a replica training simulator. Based on the observations made in the qualifications, the plant supplier and TVO assessed the change and training needs necessary for the procedures and the need to have the procedures requalified. On the basis of the assessment, TVO and the plant supplier decided to perform requalification for several procedures. During 2019, STUK reviewed qualifications and requalifications of procedures made with the training simulator and processed the assessment report on the requalification of the procedures. STUK presented a request for clarification regarding the procedures and instructions for partial failure of digital I&C. According to STUK's observations, the facility did not have appropriate procedures for detecting possible failures and how to act in such situations.

In addition to the procedures for abnormal conditions and emergency procedures, TVO and the plant supplier carried out the qualification of the control room entity during 2019, evaluating the suitability of the control room user interface, operators and procedures. The qualification evaluated with the help of the training simulator the functionality of the shifts and the control room entity via different operational situations in normal operation of the plant and in abnormal conditions and in emergency situations. All operational situations were successfully completed in 2019. However, according to STUK's observations, there were still development needs in some areas, such as in the monitoring of the plant's operating parameters and taking into account the restrictions applying to them. Based on its observations, STUK presented a requirement in late 2019 requiring TVO to perform a supplementary functional demonstration of the control room entity before starting the operation of the facility.

According to the Nuclear Energy Act, only a person approved by the Radiation and Nuclear Safety Authority (STUK) for the position in question may act as a nuclear facility operator in the control room of the facility. STUK approved the operators of Olkiluoto 3 in accordance with TVO's applications already at the end of 2018.

TVO has suffered from work atmosphere issues and staff turnover in the previous years. Therefore, TVO has developed its organisation in several areas over the past couple of years. Among other things, a large number of people have been recruited over the past few years and also exit turnover has decreased. According to personnel surveys, the problems have previously involved matters related to management and managerial work and the smooth running of work. During 2019, TVO has made many smaller organisational changes aimed at improving the smooth running of the organisation's operations. Staff management training and changes to operating methods have been introduced to supervisors and managers. According to the most recent surveys, the situation has developed in a favourable direction. STUK will continue to monitor the development of the situation alongside its other oversight work.

At the beginning of 2019, TVO submitted to the European Commission the updated Basic Technical Characteristics (BTC) of the Olkiluoto 3 plant unit. STUK performed on Olkiluoto 3 the first safeguards inspection concerning the physical inventory verification of nuclear materials on 19 November 2019 together with the IAEA and the European Commission. TVO submitted the nuclear safeguards reports and notifications regarding Olkiluoto 3 it was responsible for in time, and they were consistent with the observations made during the inspections. The oversight and inspections by STUK indicated that TVO fulfilled its nuclear safeguards obligations at Olkiluoto 3 in 2019.

2.4 Hanhikivi 1

In 2019, STUK did not yet have at its disposal comprehensive information on the plant and system design of Fennovoima's Hanhikivi nuclear power plant for the detailed assessment of the plant design and the analyses made and for the preparation of the safety assessment.

A key document for the processing of the safety case in the construction licence phase is the Preliminary Safety Analysis Report (PSAR) of the facility. The plant supplier and Principle Designer set up a separate project (PSAR Localisation Project, PLP) to produce a safety analysis report that would meet the Finnish requirements. The project has acquired extensive nuclear and radiation safety expertise from Finland, Russia and other European countries. Fennovoima submitted the first batch of the Preliminary Safety Analysis Report produced by the PLP project to STUK at the beginning of December 2019. The batch consists of a document description of the safety analysis report, a general description of the facility, a comparison with other similar facilities and a safety concept. The submitted sections of the report are based on the first phase of the basic design of the facility.

For the decision in principle, STUK made a preliminary safety assessment in 2014. In the suitability assessment of the AES-2006 plant alternative of the Preliminary Safety Analysis Report STUK presented that the AES-2006 plant alternative can meet the Finnish nuclear and radiation safety requirements via design changes, additional analyses and qualification. During the construction licence process, the plant supplier has continued to change the basic design of the facility in order to meet the Finnish safety requirements. To implement the changes in basic design, the plant designers need advanced design systems to manage the requirements set for the facility and organisation and to maintain design integrity, among other things, through the procedures and tools of configuration management, i.e. technical configuration management. The review at the end of 2019 verified the progress made by the lead designer and concluded that the procedures have been developed in many respects.

In 2019, STUK continued to assess the management systems and operations of Fennovoima and other organisations involved in the implementation of the project through reviews to ensure that their practical operations are in line with what is presented in the management systems and meet the requirements. STUK launched the inspections included in the regulatory inspection programme (RKT) in September 2015. The inspections are planned every six months, and STUK carried out six inspections according to its inspection programme in 2019. The results of the inspections will be used by STUK when preparing a safety assessment and statement on the construction licence application. Out of the four inspections planned for the

first half of 2019, two were postponed. At the request of Fennovoima, the inspection regarding the lead designer was transferred to the autumn because the corrective actions related to the observations of the previous inspections were incomplete. The inspection of I&C technology was transferred to the beginning of 2020 due to the delay in the selection of the main I&C supplier.

Summaries of the inspection programme's inspections related to the processing of the construction licence carried out in 2019 are presented in Appendix 5.

2.4.1 Management systems, quality management and safety culture

Fennovoima was reorganised in the spring of 2019 and is currently developing procedures in line with its new management principles. STUK monitored the development of operations in the inspections of the RKT inspection programme related to the processing of the construction licence. The description of the core processes of Fennovoima's new organisation for the management system was started in 2019 in connection with the reorganisation and the work will continue in 2020. STUK monitored the progress of the work in the management reviews.

Supply chain monitoring by Fennovoima was discussed, for example, in a dedicated review in autumn 2019. Fennovoima stated that its aim is to ensure the conformity and quality of the entire plant delivery as a comprehensive feature covering in a broad sense the operations of Fennovoima. For this purpose, Fennovoima is developing its core processes extensively.

STUK commissioned from VTT an investigation on the safety culture of the Principle Designer of the project, Atomproekt. VTT estimated that the safety culture as a whole is at an acceptable level – no safety culture subarea is at an unacceptable level and there are some fairly good subareas in the organisation. According to VTT's assessment, the appreciation of safety is at a very good level at Atomproekt. STUK sent the investigation report to Fennovoima for possible actions. STUK sets the results of VTT's investigation in proportion to the requirements of legislation and regulations concerning the safety culture and management. STUK assessed the safety culture of the project in its safety assessment related to the construction licence processing of the Hanhikivi project. VTT's investigation is one of the source materials used in STUK's safety assessment.

2.4.2 Plant site and technology

During 2019, Fennovoima continued to evaluate the results of the geological surveys and compiled summary reports of them. In the autumn, Fennovoima presented to STUK in a meeting in a preliminary manner the geological survey reports aiming at justifying the design bases of the foundations and placing of the facility at the plant site. STUK has commented on the reports in a preliminary manner and is waiting for their official submittal. STUK makes use of the expertise of the geologists at the University of Turku to evaluate the results.

Open issues in the safety assessment of the geological surveys by STUK include the observation of the plant site's brittle deformation zones in the placing of the buildings and structures significant to safety and in the establishment of the design bases for the foundations.

STUK approved out of the construction plan for the reactor pressure vessel's forgings the section prepared by the lead designer of the nuclear island. The construction plan of the manufacturer of the reactor pressure vessel can now be submitted to STUK for processing. In the same connection, the possibility to inspect the pipe connections of the reactor pressure vessel by means of non-destructive testing must also be determined.

STUK has processed a plan to serve as the research programme for radiation embrittlement of the reactor pressure vessel. Laboratory tests will further define the ageing forecast of the vessel. The design service life is 60 years. STUK required the research programme in October 2017 so that the results are available in good time before the operating licence application for the facility is submitted.

STUK and Fennovoima's experts on mechanics and manufacturing have discussed the updated requirements of the YVL Guides relating to the welding and NDT methods, personnel qualifications, reporting requirements for the destructive testing laboratories, new certification of the main coolant pump forgings and surface welding and the connection of steel structures to concrete structures.

Framatome has been chosen by the plant supplier as the supplier of safety-classified main I&C systems. No information has yet been provided to STUK on the design and delivery scope of Framatome.

Fennovoima has progressed in the commissioning of weather monitoring systems for the plant site. It has been possible to start collecting weather data at the site. In the next phase, Fennovoima will set up a connection from the weather monitoring system to the Finnish Meteorological Institute. The procurement of fixed environmental dose rate measurement stations has also progressed.

STUK has emphasised in discussions with Fennovoima and the lead designer that the radiation doses during the operation of the nuclear power plant can be significantly influenced by both material choices and layout design of the plant, so the early phase solutions of system design play a major role.

As regards the management of safety-related human factors, Fennovoima has determined the practices of the supply chain by auditing the supplier in charge of the matter. According to the audit, the management of safety-related human factors is not yet as such at the level of STUK's requirements.

2.4.3 Security arrangements

As regards the security arrangements of the Hanhikivi 1 plant project, actual plans have not yet been presented to STUK in relation to the power plant itself and its operating environment. The IT environment of Fennovoima's Salmisaari facilities was found to be adequate in terms of safety-classified official material up to security level IV at the end of 2019. STUK continued to oversee the storage and processing of safety-classified official material held by Fennovoima in view of a previous request for clarifications.

2.4.4 Nuclear waste management

STUK assesses the safety of the interim storage for spent fuel in two stages: In the first phase, Fennovoima submitted to STUK the draft plans of the interim storage for spent fuel as part of the construction licence documentation for the nuclear power plant. STUK processed the material and provided Fennovoima with information on the supplements needed in the construction licence phase at the turn of the year 2018–2019. In the second phase, following the granting of the construction licence, Fennovoima will submit to STUK detailed design documentation describing the systems. Fennovoima cannot start building the storage until STUK has approved the design documentation.

In addition to this, Fennovoima will submit to STUK in the construction licence phase reports on the nuclear waste management strategy, construction feasibility of the interim storage and site surveys.

2.4.5 Nuclear safeguards

Fennovoima submitted the nuclear safeguards reports and notifications it was responsible for in time. The oversight by STUK indicated that Fennovoima fulfilled its nuclear safeguards obligations in the Hanhikivi 1 project in 2019.

At this stage of the project, the nuclear safeguards obligations relate to the import, receipt, handing over for processing and export of licensed nuclear information. The subcontractors of Fennovoima and plant supplier Rosatom must also obtain the necessary licences for information processing.

Fennovoima applied in 2018 for approval of a nuclear safeguards manual and a plan under Section 35 of the Nuclear Energy Decree for arranging the necessary safeguards to prevent the proliferation of nuclear weapons. The documents submitted were approved in 2018 with certain conditions to be fulfilled before the construction licence can be issued. STUK will continue its oversight activities by assessing whether Fennovoima's operations comply with the approved plan and manual and whether the manual or related Fennovoima processes require updating.

2.5 Research reactor

VTT submitted the operating licence application regarding decommissioning to the Government in June 2017. STUK finalised the review of the operating licence documentation in the first half of 2019 and prepared a safety assessment on the periodic licence application. STUK issued a statement concerning the operating licence application to the Ministry of Employment and the Economy (MEAE) on 2 April 2019. In STUK's view, VTT meets the requirements of the Nuclear Energy Act with regard to the permanent shutdown state of the research reactor. The safety of the decommissioning phase has also been adequately demonstrated for the purpose of granting the licence, but detailed plans for the decommissioning phase of the research reactor need to be further specified before the dismantling of the reactor is started. VTT must, among other things, submit the Final Safety

Analysis Report regarding the decommissioning phase to STUK for approval before the start of the dismantling phase. In STUK's view, VTT's plans decommissioning waste management are not sufficiently complete and detailed to ensure the safe and smooth treatment, storage and final disposal of the generated nuclear waste. In addition, the security arrangements of the research reactor need to be developed to meet changing needs, conditions and threat assessments. According to current knowledge, the Government will continue the handling of VTT's operating licence application in 2020.

Inspections in accordance with the operating inspection programme have been continued at the research reactor. The inspection activities will continue in the current scope until the dismantling of the research reactor begins. For the dismantling phase, STUK will prepare a separate inspection programme. VTT submitted a waste management scheme for the research reactor to the MEAE in June 2019. The waste management scheme includes the details of VTT's provisions for nuclear waste management costs during decommissioning of the research reactor. STUK submitted a statement to the Ministry regarding the waste management scheme, stating that the uncertainties related to VTT's cost estimate for the decommissioning of the research reactor have not been reduced. As in previous years, the decommissioning cost estimate is still subject to considerable uncertainties due to the ongoing negotiations, for example, regarding the treatment of nuclear waste, interim storage, final disposal and return of nuclear fuel.

VTT has not been required to submit a nuclear waste management plan to MEAE in 2019 due to pending operating licence application processing and the ongoing negotiations regarding VTT's nuclear waste management. MEAE has required VTT to update the nuclear waste management plan by the end of September 2020.

Concerning nuclear safeguards, the material balance area of VTT's research reactor includes nuclear materials in the Otakaari 3 building and their related activities. VTT's site, which is compliant with the Additional Protocol of the Safeguards Agreement, includes the buildings in the material balance areas of both the research reactor and the Centre for Nuclear Safety. In June 2019, STUK inspected the nuclear material accountancy of the research reactor together with the European Commission. Prior to this, STUK carried out a site inspection in February 2019, during which STUK took environmental samples (swipe sample) from the laboratory facilities in Otakaari 3. The oversight and inspections by STUK indicated that VTT fulfilled its nuclear safeguards obligations in 2019.

2.6 Spent nuclear fuel encapsulation and disposal facility

In 2019, Posiva continued the construction of the disposal facility. At the disposal facility, the excavation of the central tunnel was started and the excavation of the technical rooms was completed. The central tunnel is the first safety-classified room to be excavated. In summer 2019, Posiva also started to build the encapsulation plant. STUK carried out a readiness inspection before the construction of these phases started, as the start of construction of the central tunnels and encapsulation plant were subject to requirements set in the construction licence phase.

The regulatory oversight during the construction stage of the nuclear fuel encapsulation and disposal facility covers the design, manufacture, construction and installation of the nuclear waste facility and its safety-classified systems, structures and components, as well as demonstrating long-term safety. At a later stage, the oversight will also target commissioning, at which time STUK will oversee Posiva's operations during commissioning, review test plans and test results, and perform commissioning inspections of components, structures and systems.

2.6.1 Construction of the disposal facility

In the excavation of the final disposal facility, Posiva moved on to excavating the central tunnels. In 2019, Posiva also completed the excavation of the technical rooms, with the exception of the facilities intended for the compatibility test. During 2019, Posiva submitted rock engineering plans concerning the central tunnel of the disposal area to STUK for review. The central tunnels of the disposal facility belong to the safety-classified areas. In these areas, the approval of the rock engineering plans by STUK was a prerequisite in addition to the readiness inspection for starting the excavation of the rooms. In the readiness inspection, STUK verified that the requirements of the construction licence phase related to this phase had been closed. In addition, the readiness inspection verified that the plans for the area had been approved and that the open requirements had been closed.

During 2019, Posiva had challenges in producing rock engineering planning documentation of sufficient quality. Related requirements have been presented in STUK's decisions regarding the documentation, and Posiva is carrying out development measures to correct the shortcomings.

2.6.2 Construction of the encapsulation plant

Posiva began the construction of the encapsulation plant in summer 2019. The start of the construction of the encapsulation plant was preceded by a readiness inspection carried out by STUK, which verified that the requirements regarding this phase had been closed. In the construction licence phase, requirements related to this phase were raised in relation to fire safety and accident analyses. In addition, the readiness inspection verified Posiva's organisational readiness to start the construction of the encapsulation plant.

2.6.3 Oversight of requirements set at the construction licence phase and Posiva's development work

During the construction licence application review, STUK set requirements on Posiva that must be taken into account during the construction or before submitting the operating licence application. STUK has systematically monitored compliance with the requirements set based on the construction licence application review and Posiva's plans to ensure compliance with the requirements.

Posiva has taken into account the requirements set by STUK during the construction licence review in the system design. According to the schedule it has produced, Posiva has submitted system design documents to STUK for review. During 2019, STUK has extensively processed system materials of various fields: rock caverns, encapsulation plant and handling cell, radiation measurements, hoisting and transfer equipment, fire protection systems, electrical systems and sewage treatment systems in the control area as well as design documentation.

Posiva has ongoing projects for demonstrating long-term safety and for the designing and development of engineered barriers. STUK has monitored the progress of the projects, and they have been discussed at meetings with Posiva. With its oversight, STUK ensures that the project plans and programmes have sufficiently taken into account the requirements set by STUK in connection with the construction licence review.

STUK has developed its own analytical capabilities for supporting its oversight and commissioned expert assessments from external experts. The purpose of STUK's own analyses is to produce comparisons with the analyses of the safety case produced by Posiva. In 2019, the near- and remote-area modelling capabilities have been developed and the development of the biosphere model has been pursued and tools have been further developed for the formation of scenarios.

2.6.4 Organisational operations and quality management

STUK has overseen the activities of Posiva's organisation in inspections included in the construction inspection programme. The inspections have assessed the design of the rock construction of the final disposal facility, the construction of the nuclear waste facility, the impact of changes to the final disposal concept on the preparation and management of the safety case, the security arrangements of the encapsulation plant as well as management and safety culture.

The inspection of management and safety culture investigated the target-orientation and consistency of the development of Posiva's safety culture, and STUK identified development needs in the area of safety culture. As observed during the inspection, Posiva's action programme on safety culture includes many different types of measures, some of which are continuous basic activities and some content change needs. The management level monitors the implementation of the measures regularly. According to Posiva, the most important areas of development of safety culture in the current year have been learning from operating experience, efficiency and clarity of decision-making and increasing pride in one's own work (job satisfaction).

In the review of the documentation related to Posiva's construction activities, STUK has observed a significant number of shortcomings in the documentation submitted for approval and information. Posiva was requested to submit a report on the matter and to describe the improvement measures to reduce errors and shortcomings in the documentation. Posiva submitted the report in 2018. Due to the continuing shortcomings in the documentation submitted to STUK, STUK required Posiva to plan and perform quality improvement measures again and to update the submitted report. In the report, Posiva stated, among other things, that it had acquired more expertise. As a result of the improvement measures taken in 2019, the

quality of the design documentation has improved. However, the quality of the construction documentation will continue to be monitored more closely by STUK.

STUK carried out an inspection on Posiva's design of the rock construction of the final disposal facility in spring 2019. The inspections covered, among other things, the phases of the design process and the interfaces involved in the design process. On the basis of the inspection, STUK required that Posiva improve the initial data review of design, improve the acceptability of design documents and develop its own competence requirements and those of its suppliers in terms of design.

STUK also carried out an inspection on Posiva's construction operations of the final disposal facility in spring 2019. The inspection focused on the construction operations of Posiva's nuclear facilities, focusing on the construction operations of the encapsulation plant. Later in the summer of 2019, Posiva started to build the encapsulation plant. The inspection included, among other things, quality management of the construction of the encapsulation plant, management of human resources as well as control and management of the encapsulation plant project. The inspection established that the development of resource management is moving in the right direction and that Posiva has adequate procedures in place for competence management, qualifications and orientation needed to build the encapsulation plant.

The inspection and their results, as well as the requirements set by STUK, are described in more detail in Appendix 6.

According to STUK's oversight findings in 2019, the most important areas, in which Posiva and its subcontractors must develop themselves, include following instructions and procedures, competence and resource management and project management.

In 2019, STUK continued oversight and assessment of Posiva's auditing activities by participating in two audits of Posiva's suppliers. Based on these events, Posiva's supplier audits were found to comply with STUK's requirements.

2.6.5 Preparations for the operating licence phase

Posiva has an ongoing operating licence project, and a project plan has been submitted to STUK. STUK has commented on the project plan, and regular discussions are taking place with Posiva regarding the operating licence phase.

Posiva submits operating licence application documents to STUK in advance for comments. This is done to streamline the processing of the actual operating licence application documents. During 2019, Posiva submitted to STUK chapters of the final safety analysis report, topical reports and reports on the safety case of long-term safety for pre-processing. STUK compiles comments on the documentation for Posiva to be taken into account when preparing the actual operating licence application documentation.

Nuclear safeguards

STUK implemented nuclear safeguards for the final disposal in compliance with the national regulatory plan. STUK inspected the site which was reported by Posiva to be compliant with

the Additional Protocol of the Safeguards Agreement and the construction activities in two periodic inspections.

STUK granted Posiva and Posiva Solutions Oy a licence to hold nuclear information. In the same connection, Posiva updated the joint nuclear safeguards manual of the companies. In the course of the periodic inspection, STUK closed the requirements it set in the Construction Inspection Programme inspection in 2018 regarding the successor planning of nuclear safeguards and the inclusion of nuclear safeguard requirements into Posiva's requirement management system.

Posiva submitted the nuclear safeguards reports and notifications it was responsible for in good time. The oversight and inspections by STUK indicated that Posiva fulfilled its nuclear safeguards obligations in 2019.

STUK continued its close cooperation with the IAEA and the European Commission aimed at ensuring that the plans on arranging the international nuclear safeguards for the encapsulation plant and disposal facility will proceed in line with the design of the facility and also meet national requirements. Technical meetings concerning the oversight arrangements of the encapsulation plant were held with Posiva, the European Commission and the IAEA three times in 2019. The IAEA and the Commission's surveillance and monitoring equipment plan for the encapsulation plant was completed so that Posiva will take into account the equipment accordant with the plan in the plant design.

The safeguards projects of final disposal in Finland and Sweden are coordinated on the EPGR forum of the IAEA, the European Commission, the Swedish and Finnish authorities (SSM and STUK) and the operators (SKB and Posiva). The EPGR forum convened once during the year.

Nuclear fuel placed in final disposal can no longer be inspected or verified by any known means. Therefore, it is important for nuclear safeguards that fuel be verified before encapsulation and final disposal and that the verification be documented using such methods that leave no doubt as to the accuracy and completeness of the data reported.

STUK's project to develop the verification methods and equipment for spent nuclear fuel to be disposed of progressed well during the year. The project is currently investigating the integration of two complementary methods PGET (Passive Gamma Emission Tomography) and PNAR (Passive Neutron Albedo Reactivity) into one modular equipment. The prototype of the equipment was successfully tested at Olkiluoto in July 2019. The test was successful in view of both methods and the equipment integration proved to work.

In the case of the PGET method, development continued also on the software side. The algorithm developed in collaboration by HIP (Helsinki Institute of Physics) and STUK achieved the second place in an international competition organised by the IAEA, searching for new PGET data analysis methods.

2.7 Terrafame

STUK oversaw the commissioning of Terrafame in accordance with the licence granted in 2017. As regards nuclear safeguards, Terrafame started regular reporting to STUK and the European

Commission in summer 2019. The oversight and inspections by STUK indicated that Terrafame fulfilled its nuclear safeguards obligations in 2019.

On 31 October 2017, Terrafame submitted an application to the Finnish Government for starting the extraction of uranium in the uranium extraction plant built earlier in the mining and milling area. In May 2018, Terrafame submitted safety documents relating to the licence application to STUK. STUK inspected the documents and submitted a request for further clarification in October 2018. Terrafame submitted the supplementary application documents in November, and STUK's inspection and the preparation of the safety assessment and statement continued in 2019.

STUK issued a statement about the licence application regarding Terrafame Oy's mining and milling operations on 10 June 2019. STUK found that the conditions for the granting of a licence under Articles 5 to 7 and Article 21 of the Nuclear Energy Act were fulfilled in view of its line of business. However, based on the operating experience from the recovery plant, Terrafame must update the reports on the decommissioning of the plant and on the nuclear waste management. If the Government grants the licence for the production of uranium, operations cannot be started until STUK has conducted an inspection on the safety of the whole uranium production activity of the production plant. According to the application, the annual production of Terrafame would not exceed 250 tonnes of uranium.

2.8 Other operators

Producers of uranium, parties in possession of small amounts of nuclear use items or nuclear information subject to a licence, and research facilities participating in research of the nuclear fuel cycle are also included in the scope of regulatory nuclear energy oversight. STUK oversees that the users of nuclear energy (operators in the field) meet the set requirements, the most essential of which are competent organisation and up-to-date internal instructions. In 2019, STUK approved two new nuclear safeguard manuals prepared by operators and updates to six manuals. In line with the respective applications, STUK approves the responsible managers or deputies. In 2019, one new responsible manager and their deputy were presented for approval.

With regard to uranium producers, STUK reviewed the reports and notifications submitted by the Kokkola and Harjavalta facilities. In Kokkola, the ownership of Freeport Cobalt Oy was transferred to Umicore Oy and, in Harjavalta, the licence of the NNH to produce and possess uranium was renewed for 10 years. At both plants, the responsible persons remained unchanged and there were no significant changes in the operations.

In 2017, STUK received a notification concerning the concentration of uranium in the copper deposit created in the zinc metal production process and transported to the Harjavalta copper factory. In December 2018, STUK granted a permission to Boliden Kokkola Oy to produce and possess nuclear material and deliver it to Boliden Harjavalta Oy and a permission to Boliden Harjavalta Oy to possess and process nuclear material. The responsible managers and their deputies were approved in 2019. In 2019, a licence accordant with the Nuclear Energy Act was granted to Dragon Mining for the production and processing of uranium-bearing gold concentrate and, in the same connection, the responsible manager and their deputy were

approved. A nuclear safeguards annual report indicating the amount of processed nuclear material must be prepared for the new type of activity.

Other operators submitted the nuclear safeguards reports and notifications required from them. Of these operators, STUK inspected the nuclear material inventories of VTT and the University of Helsinki together with the Commission in 2019. In addition, STUK's nuclear safeguards section verified the compliance of the nuclear safeguards system related to STUK's own activities. The inspections produced observations that led the University of Helsinki and STUK to update their nuclear safeguards system.

In 2019, NDT Kotka Oy submitted as a new operator a description of its operations related to nuclear materials, i.e. the Basic Technical Characteristics, to STUK and to the European Commission, which confirmed the reporting requirements for small-scale operations. The new operator was subjected to a joint inspection of the different departments of STUK to verify the operator's practices in terms of radiation protection and nuclear safeguards.

STUK inspected the annual reports on nuclear fuel cycle related research and development activities and produced a report on their basis for the IAEA.

On the basis of the inspections, as well as the reports and notifications submitted, STUK has satisfied itself that operation classified as the use of nuclear energy in Finland has been implemented in compliance with the nuclear safeguards obligations.

3 Safety research

Publicly funded safety research on the use of nuclear energy has a key role in the development and maintenance of nuclear technology expertise in Finland. The four-year research programmes on nuclear power plant safety (SAFIR2018) and nuclear waste management (KYT2018) were concluded and the new research programmes SAFIR2022 and KYT2022 started research activities. Final seminars were organised for the concluded programmes with the participation of international experts and researchers in the first quarter of 2019.

The objective of the SAFIR research programmes is to ensure that the authorities have sufficient competence and expertise in matters relating to the operation of nuclear power plants. During the four-year SAFIR2018 research programme, which began in 2015, 209 man-years have been spent on nuclear safety research and more than a thousand publications have been produced. At the same time, research work has trained new Finnish experts with in-depth competence on the field and helped those already in the field to maintain and develop their expertise.

In 2015–2018, a total of approximately EUR 30 million was spent on the SAFIR2018 research projects. During the programme, funding was also allocated for the construction of the infrastructure needed for research. The majority of this, EUR 18 million, was used to build the hot shells of the new VTT Centre for Nuclear Safety.

Without safety research programmes like SAFIR and KYT, developing the expertise needed in the nuclear sector to support the authorities in ensuring safety would not be possible in Finland. According to the Nuclear Energy Act, research funded by the Finnish State Nuclear Waste Management Fund (VYR) aims at ensuring that the authorities have available adequate and comprehensive nuclear expertise. Both STUK and the licensees have hired several people who have obtained their training for expert positions in the field of nuclear energy use and oversight in publicly funded research programmes. The safety research programmes also have an important role in the training of organisations that provide STUK with technical support services, such as the VTT Technical Research Centre of Finland, the University of Helsinki, the Aalto University, the Geological Survey of Finland and Lappeenranta University of Technology.

The SAFIR2022 safety research programme consists of 32 projects that were selected in the autumn of 2018 based on a competitive bidding. The available VYR funding for the research was around EUR 4 million. The total funding of the research programme remained at the 2018 level. In 2019, the programme volume was EUR 6.8 million and 46 research years. As shown in Figure 11, the programme is divided into four research areas of the programme: 1) overall safety and systemic approach to safety, 2) reactor safety, 3) structural integrity and materials, and 4) research infrastructure. The VTT Technical Research Centre of Finland and Lappeenranta University of Technology (LUT) will use around 19% of the entire public funding for safety research when renewing the national infrastructure. This mainly covers the work related to the acquisition and commissioning of infrastructure-related equipment investments. VYR finances

equipment investments from a separate research-related funding portion aimed at the renewal of hot shells at the VTT Centre for Nuclear Safety and the thermohydraulic test equipment of LUT. In 2019, the funding was channelled to VTT in the manner required by the Nuclear Energy Act, and it amounted to EUR 2.74 million. The research programme covers all issues integral to nuclear safety, and it will develop and maintain the expertise, analysis methods and experimental capability to resolve any unforeseen safety issues as they may occur.

The SAFIR2022 research projects are supervised by eight reference groups in addition to the four research areas. The reference groups take care of the scientific supervision of research. Members of the reference groups were appointed from organisations relating to the research of the use of nuclear energy. The reference groups are: 1) overall safety and organisation, 2) plant level analyses, 3) reactor and fuel, 4) thermal hydraulics, 5) mechanical integrity, 6) structures and materials, 7) severe accidents, and 8) research infrastructure. The projects for the reference groups were assigned based on the research areas. All of the projects included in one reference group are typically belong to a single research area.

The projects included in the SAFIR2022 programme for 2019 meet the requirements set for VYR-funded research. The research programme has a special focus on the development of high-quality infrastructure. The project launched in 2018, making use of new infrastructure, continued in cooperation with Swedish power companies and research organisations. The project deals with investigating the radiation embrittlement of the Barsebäck pressure vessel using samples taken during the decommissioning of the nuclear power plant. This is an excellent opportunity, first, to gain authentic operating experience data on the properties of the materials of the pressure vessel and, second, to utilise the new research opportunities provided by the VTT Centre for Nuclear Safety.

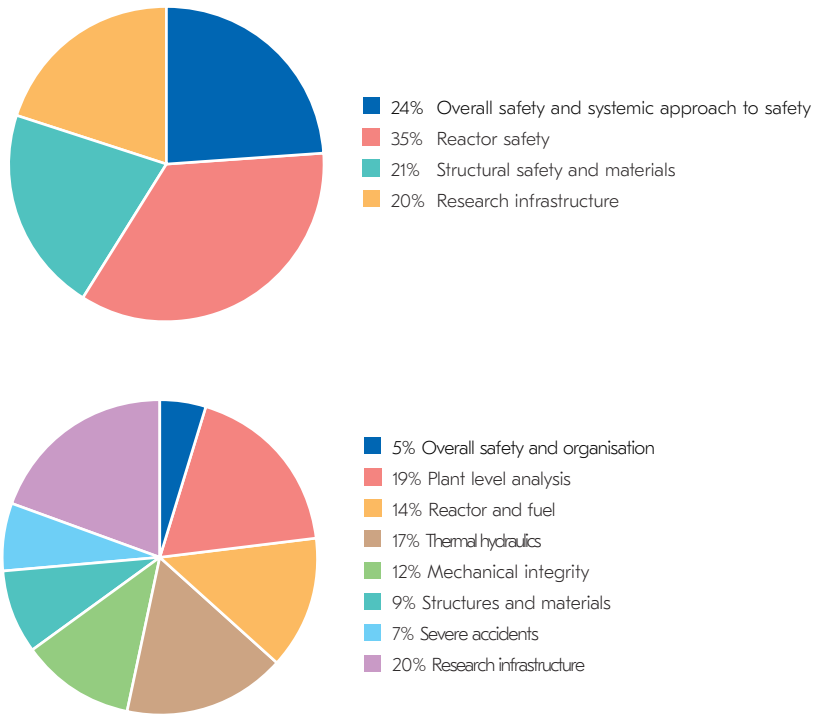

FIGURE 11. Research areas of SAFIR2022 programme and their shares of the total funding in 2019.

The SAFIR2022 projects include several projects for developing capabilities, e.g. for avoiding accidents of the type that occurred at the Tepco Fukushima Dai-ichi nuclear power plant or for understanding the sequence of events in such accidents. The projects' subject matters range from design bases of nuclear facilities and the analysis of accidents to the operation of organisations during accidents and as systems comprising several organisations. An international research project that started in 2015 has offered as reliable information as possible about the course of the Tepco Fukushima Dai-ichi accident in order to create Finnish accident analyses, validate and benchmark results globally.

In addition to the above, the SAFIR2022 management group may fund small projects aimed at helping the renewal of the programme and including new topical issues to the programme. This procedure has been in use from the beginning of the previous SAFIR2018 research programme, and it has proven to be an efficient way to promote the creation of high standard topical research projects. The 2019 small project was aimed at planning of safety management and safety culture research, the metallurgical characterisation of materials with high nickel concentrations and with a nickel base, the potential of machine learning to improve NDT measurements and familiarisation with the Japanese CLAD test equipment.

A new feature in the SAFIR2022 programme is the inclusion of the eight overarching topical areas indicating the focus of the programme. The topics highlight, among other things, the development of the assessment methods of overall safety, the modernisation of safety assessment methods, the long-term use of plants and the requirements set by the changing environment for the safe use of nuclear power plants. The topics relating to overall safety and the life cycle of fuel are shared with the KYT2022 programme, and the aim is to make the cooperation between the programmes even closer.

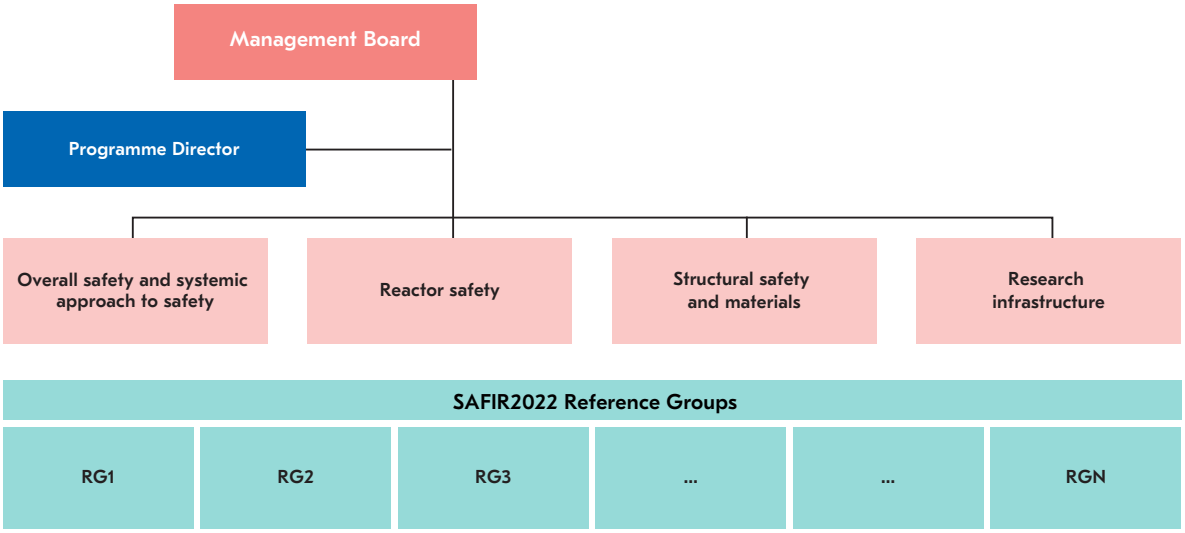

FIGURE 12. The administrative structure of SAFIR2022 research programme.

The four-year KYT2022 research programme was launched in 2018. The structure of the framework programme was renewed with the aim of increasing the applicability and usability of the research. In the renewed structure, research topics were arranged so that they are wider, acknowledge larger entities better and emphasise the integration between projects better. The research areas consist of the assessment of overall safety, the management of spent nuclear fuel, maintenance waste, decommissioning waste and other radioactive waste, the feasibility of nuclear waste management and social research. The areas relating to overall safety and the life cycle of nuclear fuel are shared with the SAFIR2022 programme, and the aim is to make the cooperation between the programmes even closer. The programme consisted of research areas which are important for national expertise. It is aimed at extensive coordinated multidisciplinary research projects, which were formed particularly regarding the research areas related to the bedrock, the performance of buffer and backfilling materials and the long-term durability of final disposal canisters as well as microbiology. When the Nuclear Energy Act was amended (in 2016), funding of the research infrastructure was added to the KYT2018 programme, and it has continued also in the KYT2022 programme.

The KYT2022 steering group provided funding recommendations to MEAE using assessments by the support groups based on the applicability and content of the subject matter. In 2019, the funding of the KYT2022 programme from the National Nuclear Waste Management Fund (VYR) was approximately EUR 1.9 million. In 2019, the research programme provided funding for 27 research projects representing new and alternative technologies for nuclear waste management (1 project), safety research concerning nuclear waste management (25 projects), social nuclear waste management research (1 project) and research infrastructure (1 project). The Ministry undertakes to present funding for several years for the best-rated projects, the so-called Excellence projects. There were 6 such projects. The projects concern systematic scenario methods in assessing overall safety (2 projects), bentonite-rock interaction (3 projects) and long-term behaviour of the copper capsule (1 project). For 2019, EUR 50,000 had been reserved for small project funding, to be decided on by the management team, and EUR 28,000 of this was used to fund a small project related to the assessment of overall safety.

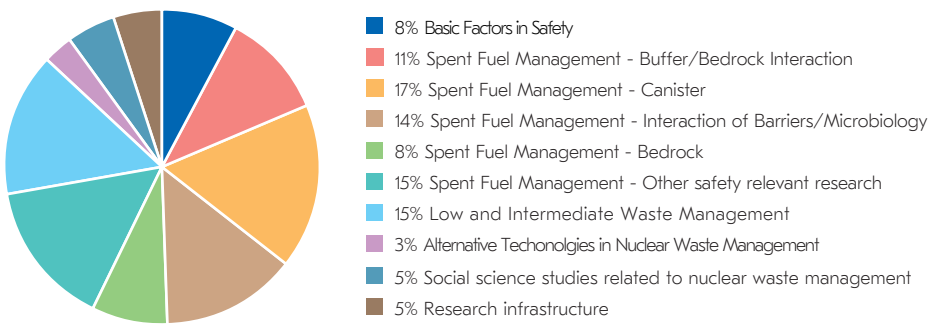

FIGURE 13. Distribution of VYR funding by research area in 2019.

4 Oversight of nuclear facilities in figures

4.1 Processing of matters

A total of 3,064 matters were submitted to STUK for processing in 2019. Of these, 907 concerned the nuclear power plant under construction and 165 concerned the disposal facility for spent nuclear fuel. The review process of a total of 3,112 matters was completed, including matters submitted in 2019, those submitted earlier and licences granted by STUK by virtue of the Nuclear Energy Act, which are listed in Appendix 7. The average matter review time was 72 days. The number of matters and their average review times in 2015–2019 are illustrated in Figure 14. Figures 15–18 illustrate the review time distribution among matters from the various plant units and matters about Posiva.

4.2 Inspections at nuclear facility sites and suppliers' premises

Inspection programmes

A total of 15 inspections at the Loviisa plant and 15 inspections at the Olkiluoto plant were carried out under the 2019 periodic inspection programme (Appendix 3). STUK carried 10 readiness inspections at Olkiluoto 3 and 5 inspections under the periodic inspection programme of Olkiluoto 1 and Olkiluoto 2 that also included Olkiluoto 3 (Appendix 3). There were 6 inspections pertaining to the processing of Fennovoima's construction licence application (Appendix 5). 5 inspections of the encapsulation plant and disposal facility construction inspection programme were carried out in 2019 (Appendix 6). The key findings of the inspections are presented in the appendices and the chapters on regulatory oversight.

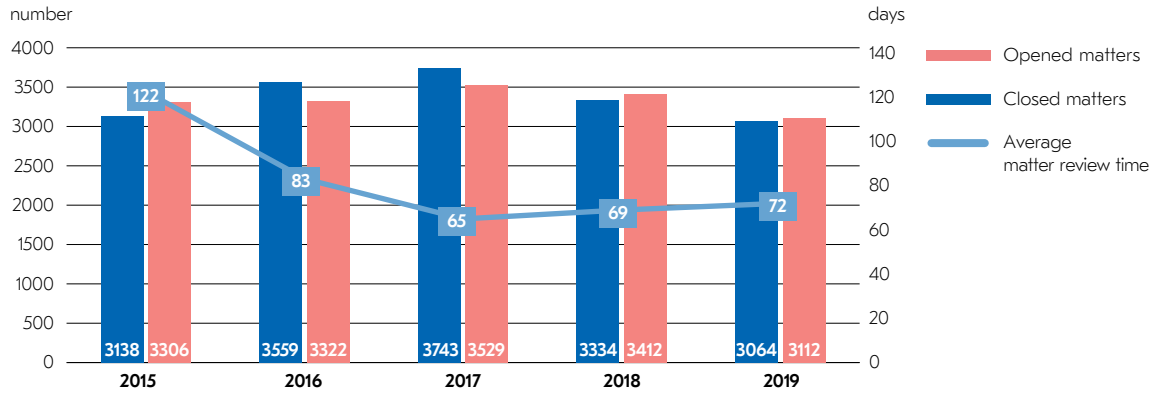

FIGURE 14. Number of opened and closed matters and as well as average matter review time.

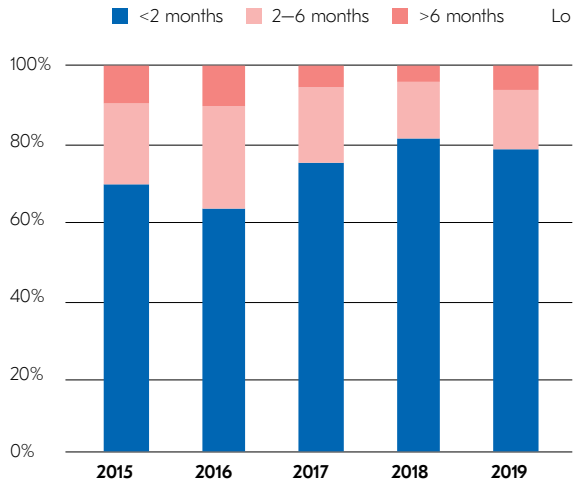

FIGURE 15. Distribution of time spent on preparing decisions on the Loviisa plant.

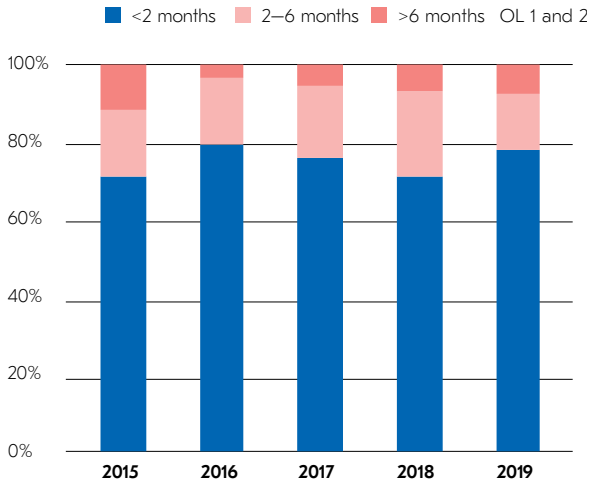

FIGURE 16. Distribution of time spent on preparing decisions on the operating plant units of Olkiluoto.

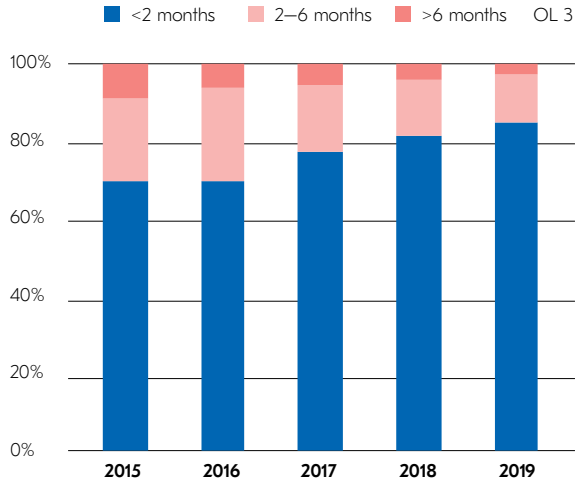

FIGURE 17. Distribution of time spent on preparing decisions on Olkiluoto plant unit 3.

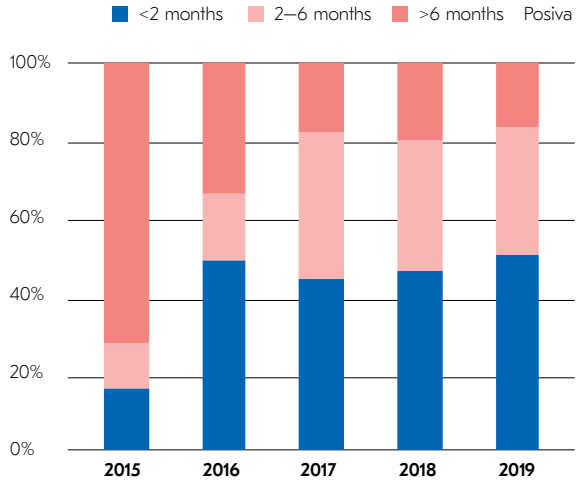

FIGURE 18. Distribution of time spent on preparing decisions on Posiva.

Other inspections at plant sites

A total of 2,149 inspections were carried out on site or on the suppliers' premises in 2019 (other than the above-mentioned inspection programme inspections and the nuclear safeguards inspections, which are separately described). An inspection comprises one or more sub-inspections, such as a review of results, an inspection of a component or structure, a pressure or leak test, a functional test or a commissioning inspection. Of these inspections, 1,137 were part of the oversight of Olkiluoto 3 and 1,010 of the units in operation. The oversight of the construction of Posiva's final disposal facility included two readiness inspections and

completion of 8 construction inspections. In addition, the construction readiness inspection of Posiva's encapsulation plant was carried out.

The number of inspection days on site and on the component manufacturers' premises totalled 3,386. This number includes not only inspections pertaining to the safety of nuclear power plants but also those associated with nuclear waste management and nuclear materials as well as oversigh visits and inspections of the underground research facility at Olkiluoto. Five resident inspectors worked at the Olkiluoto power plant and two resident inspectors at the Loviisa power plant. The numbers of onsite inspection days in 2015–2019 are illustrated in Figure 19.

4.3 Finances and resources

The duty area of nuclear safety regulation included basic operations subject to a charge as well as those not subject to a charge. Basic operations subject to a charge mostly consisted of the regulatory oversight of nuclear facilities, the costs of which were charged to those subject to the oversight. Basic operations not subject to a charge included international and domestic cooperation as well as emergency response operations and communications. Basic operations not subject to a charge are publicly funded. Overheads from the preparation of regulations and support functions (administration, development projects in support of regulatory activities, training, maintenance and development of expertise, reporting, and participation in nuclear safety research) were carried forward into the costs of both types of basic operation and of contracted services in relation to the number of working hours spent on each function.

Consequently, the cost correlation of the regulatory oversight was 100%. Attainment of the cost price for the regulatory oversight of nuclear safety is ensured by adjusting the invoicing with a balancing bill to correspond to actual costs after annual cost accounting. The income and costs of regulatory oversight of nuclear safety subject to a charge were EUR 18.4 million. The figure includes the radiation monitoring in the immediate vicinity of nuclear facilities that was changed from a service operation to regulatory oversight in 2015. The total costs of regulatory oversight of nuclear safety were EUR 21.4 million. Thus, the share of activities

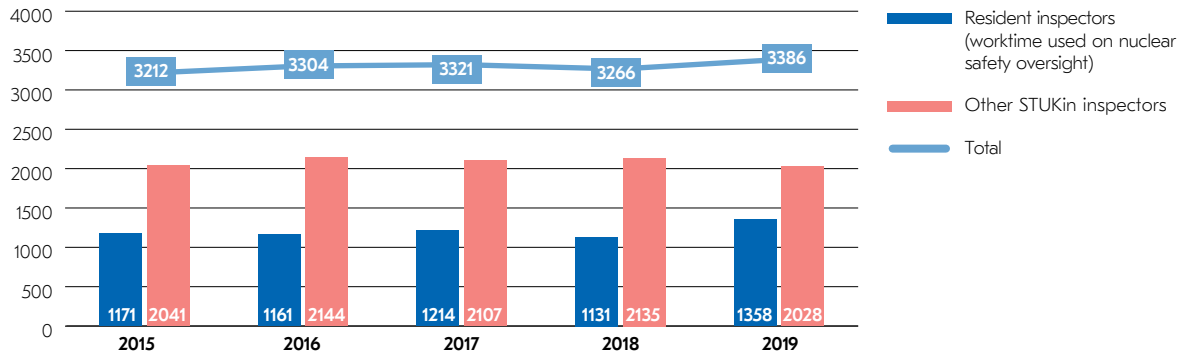

FIGURE 19. Number of inspection days onsite and at component manufacturers' premises.

subject to a charge was 86.0%. Figure 20 shows the annual costs of regulatory oversight of nuclear safety in 2015–2019.

The time spent on the inspection and review of the Loviisa nuclear power plant was 18.4 man-years or 12.5% of the total working time of the nuclear safety regulatory personnel. The time spent on the inspection and review of the Olkiluoto nuclear power plant's operating units was 15.5 man-years or 10.5% of the total working time. In addition to the monitoring of the operation of the nuclear power plants, these figures include nuclear safeguards. The time spent on the inspection and review of Olkiluoto 3 was 19.6 man-years or 13.3% of the total working time. Work related to the Fennovoima plant project amounted to 8 man-years or 5.4% of the total working time. A total of 6.6 man-years or 4.5% of the total working time was spent on the inspection and review of Posiva's operations, and the time spent on the inspection and review of the FiR 1 research reactor was 0.6 man-years. Figure 21 shows the division of working hours of the personnel engaged in nuclear safety oversight (in man-years) by subject of oversight during 2012–2019.

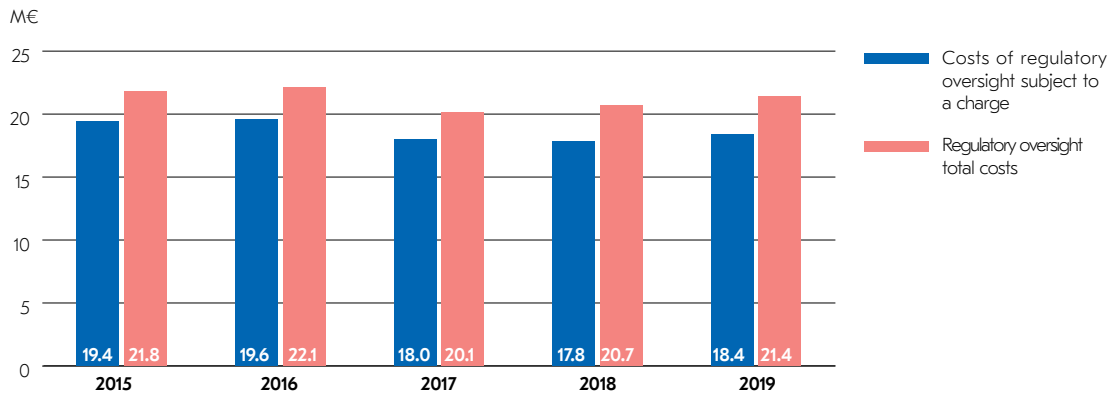

FIGURE 20. Income and costs of nuclear safety regulation.

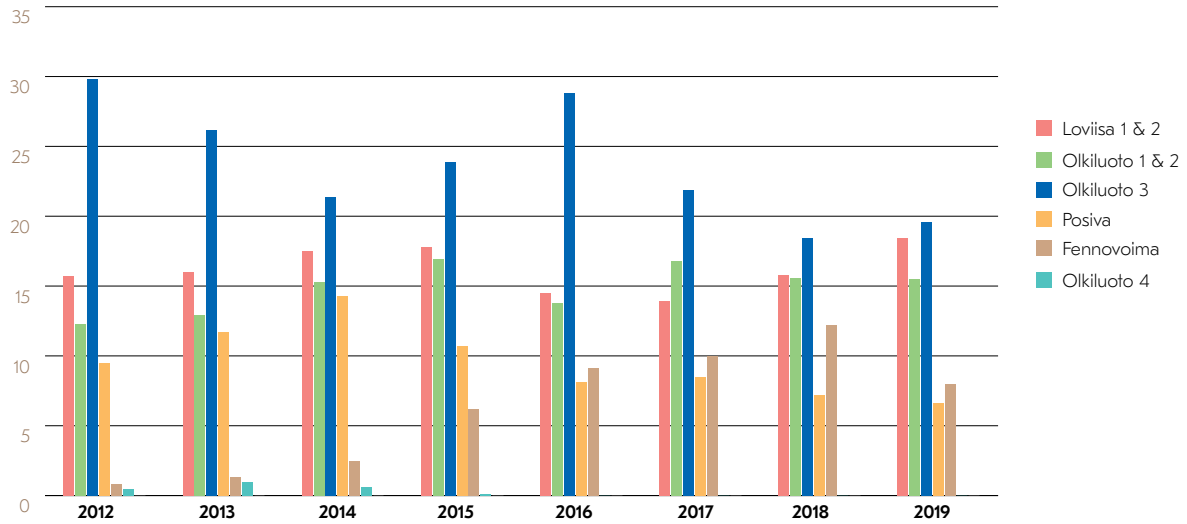

FIGURE 21. Distribution of working hours (person-years) of the regulatory personnel by subject of oversight in 2012–2019.

Where necessary, STUK commissions independent assessments and analyses in support of its oversight. Figure 22 illustrates the costs of such assignments in 2015–2019. The expenses in 2019 were mainly associated with the sensitivity analyses of the sites' seismic design bases, comparison analyses of Hanhikivi 1, assessment of the Loviisa nuclear power plant's safety case for low and intermediate level waste, design reviews of the hoisting and transfer equipment at Posiva's spent nuclear fuel encapsulation and final disposal facility and, in general, with the assessment of the safety of the final disposal project.

Distribution of the annual working time of the nuclear safety regulatory personnel to the various duty areas is shown in Table 1. The figures do not include the work for radiation monitoring in the surrounding environment.

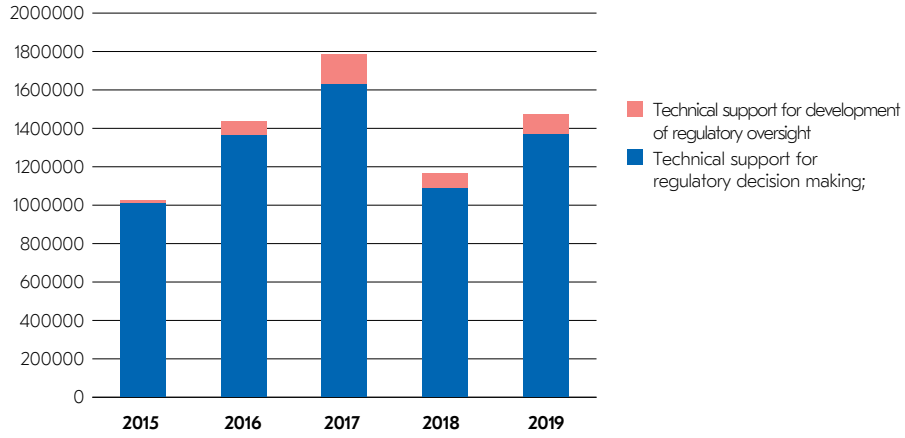

FIGURE 22. The costs of research and commissioned work.

Duty area	2015	2016	2017	2018	2019
Basic operations subject to a charge	76.6	74.9	72.0	71.0	68.7
Basic operations not subject to a charge	2.6	4.0	4.0	4.8	6.3
Service activities	2.8	2.1	4.3	3.7	1.1
Regulation work and support functions	42.2	44.5	42.9	44.1	45.2
Holidays and absences	26.4	26.6	26.9	26.3	26.0
Total	150.5	152.1	150.1	149.9	147.4

TABLE 1. Distribution of working hours (person-years) of the regulatory personnel in each duty area.

5 International cooperation

International conventions

The Convention on Nuclear Safety requires the presentation of a report to be prepared every three years on the fulfilment of its obligations. STUK was responsible for the preparation of the Finnish country report, which was submitted to the IAEA, serving as the secretariat of the convention, in August 2019. In the past, similar reports have been produced every three years since 1999, most recently in 2016. The fulfilment and reporting of the obligations of the convention will be assessed at the international review meeting of the contracting parties in Vienna in spring 2020. The convention procedure also includes the possibility of asking questions about the activities of other countries. STUK evaluates, among other things, reports of our neighbouring countries and reports of countries that have engaged in international cooperation with STUK. Based on the reports, STUK posed approximately 130 specifying questions to other countries. On the other hand, 226 specifying questions were posed to Finland. This was the highest number of questions ever posed to Finland.

The previous review meeting for the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management was held in May 2018. During 2019, meetings on the amendment of the Joint Convention rules were organised, in which STUK participated. The next report will be prepared during 2020 and the review meeting will be held in 2021.

International cooperation groups

The **IAEA** continued to develop its safety standards on nuclear safety and security. STUK had a representative on the Commission on Safety Standards (CSS) managing the preparation of the standards as well as in the committees dealing with the content of the standards, i.e. the Nuclear Safety Standards Committee (NUSSC), the Waste Safety Standards Committee (WASSC), the Radiation Safety Standards Committee (RASSC), the Transport Safety Standards Committee (TRANSSC) and the Nuclear Security Guidance Committee (NSGC). STUK issued statements on the IAEA safety standards under preparation.

The **Nuclear Energy Agency of the OECD (NEA)** coordinates international cooperation in the field of safety research in particular. The organisation also provides an opportunity for cooperation between regulatory authorities. STUK was represented in all main committees of the organisation dealing with radiation and nuclear safety issues. The main committees' fields of activity are the following:

- nuclear safety regulation (CNRA, Committee on Nuclear Regulatory Activities),
- safety research (CSNI, Committee on the Safety of Nuclear Installations),
- radiation safety (CRPPH, Committee on Radiation Protection and Public Health) and
- nuclear waste management (RWMC, Radioactive Waste Management Committee).

The **Multinational Design Evaluation Programme (MDEP)** involves 16 countries with the objective of improving cooperation in the field of the assessment of new nuclear power plants and developing convergent regulatory practices. Participants in the programme include only those countries with new nuclear power plants at some stage of assessment by the regulatory authorities. The OECD Nuclear Energy Agency (NEA) functions as the secretariat for the programme. The MDEP's work is organised in design-specific working groups. In addition, the MDEP has an issue-specific working group, Steering Technical Committee and Policy Group. There are five design-specific working groups for the EPR, AP1000, APR1400, VVER and HPR1000 plant types. Of these, STUK has participated in the EPR Working Group and the VVER Working Group, because an EPR plant is under construction in Olkiluoto (the Olkiluoto 3 project) and Fennovoima has submitted a construction licence application for the construction of a VVER plant in Pyhäjoki (the Hanhikivi 1 project). Finland acts as the chair of the VVER Working Group. The only MDEP working group which is independent of plant design deals with plant and equipment supplier inspections.

WENRA's (Western European Nuclear Regulator's Association) Reactor Harmonisation Working Group (RHWG) convened as usual three times in 2019. During the year, the main tasks of the working group were updates of the reference levels for internal and external threats, management system and ageing management. STUK actively participated in the work, including the RHWG's subgroups, which processed the need to update the safety objectives set by WENRA for new nuclear power plants, the suitability of the safety objectives for small modular reactors (SMR) and the measures to improve safety at the operating plants required by the EU Nuclear Safety Directive.

STUK actively participated in the work of **WENRA's Working Group on Waste and Decommissioning (WGWD)** in 2019. The working group convened twice. Self-assessments and peer reviews of reference levels associated with disposal were finalised during the year, and self-assessments and peer reviews of the reference level report on nuclear waste processing facilities were continued.

STUK participated in the activities of the **European Nuclear Safety Regulators Group (ENSREG)** and three of its subgroups (nuclear safety, nuclear waste management and communication). The first Topical Peer Review according to the Nuclear Safety Directive updated in 2014 was carried out on ageing management of nuclear power plants in 2017–2018. As regards Finland, the most significant development needs relate to ageing management in prolonged construction projects and maintenance outages. At the component level, the inspectability of inaccessible piping was discussed, but their integrity monitoring was, however, considered sufficient. Good practices that came up included Finland's active participation in international peer reviews, for example, SALTO and OSART coordinated by the International Atomic Energy Agency (IAEA). As regards identified development targets, STUK prepared a national action plan in collaboration with the power companies and submitted it to ENSREG in September 2019. In line with the Nuclear Safety Directive, the peer review will be organised every six years in the future, and planning the next review has started by collecting experiences from the first peer review.

Nuclear waste management cooperation at ENSREG focused on a few requirements of the directive on waste management, the purpose of which the Member States have wanted

to specify. The issues to be specified regarded the progress indicators of the national waste management programme and reporting of the national waste inventory. In Finland, these specifications will be taken into account in the update of the national programme and in the three-year report to be submitted to the Commission.

The **Deep geological repository regulators forum (DGRRF)** is a cooperation forum for six nuclear and radiation safety authorities (USA, Canada, Sweden, France, Switzerland and Finland) where disposal projects for spent nuclear fuel and high-level nuclear waste are discussed from the perspective of public authorities. In January 2019, the third workshop of the DGRRF was organised by the Swiss authority ENSI. The main topics included the oversight practices of disposal projects and the evaluation of R&D programmes in terms of disposal projects. Interaction between the authorities and a future licence applicant before the licence application sparked discussion. The practices of Finland, Sweden and Switzerland were considered to be good, but the importance of keeping roles and responsibilities clear from the outset was also emphasised. The evaluation of R&D programmes is quite similar in all countries, both in terms of substance content and implementation methods. It was established that sharing the evaluation plans and evaluation result summaries among the group members could be useful. On the last day of the workshop, Mont Terri Rock Laboratory (argillaceous rock) was visited, where also Posiva has participated in some research projects. Switzerland's special feature is that the national authority ENSI commissions also its own research projects from Mont Terri Rock Laboratory.

The **VVER Forum** is a cooperation group for authorities operating Russian VVER pressurized water-type nuclear facilities, mainly concentrating on developing oversight activities of plants operating in its member countries. During 2019, STUK participated in the working group activities of the VVER forum and in the forum's annual meeting in Bulgaria.

Bilateral cooperation between authorities

STUK continued its regular meetings with the **Swedish nuclear safety authority SSM**, focusing on topical issues concerning nuclear power plants. The issues included topical oversight matters concerning plants and the related tools, the management system of regulatory oversight of nuclear safety, competence and resource issues of the authorities, STUK's new strategy and the related development projects and comparison of regulatory practices, changes of safety regulations and inspector exchange between authorities.

The French nuclear safety authority, **Autorité de sûreté nucléaire (ASN)** asked STUK to provide training on the licensing and oversight of a nuclear waste final disposal facility. STUK organised a week-long training, the content of which was agreed together with ASN. The training covered monitoring of a final disposal facility, long-term safety, evaluation of facility design during the construction licence phase, the inspection programme during construction. In addition, the training included a visit to Posiva's final disposal facility, where the participants were able to familiarise themselves with the final disposal facility and related monitoring.

STUK started regular cooperation with the *French nuclear safety authority Autorité de sûreté nucléaire (ASN)* and its support organisation **Institut de radioprotection et de sûreté nucléaire (IRSN)** when the Olkiluoto 3 project was launched in the early 2000s. During the cooperation, regulatory practices and requirements of the countries involved have been compared and challenges and problems pertaining to the EPR plants under construction (Olkiluoto 3 and Flamanville 3) have been discussed. In 2019, STUK met with ASN and IRSN in Paris in September. Topical issues regarding trial operation, the preparation for operation and mechanical components were discussed in the meeting. The Flamanville 3 site was visited after the meeting. STUK also met with the management of ASN in a meeting held at STUK in December. The meeting covered the ongoing plant projects, issues related to the service life extension of nuclear power plants, waste management, emergency response arrangements and the utilisation of digital monitoring. The Olkiluoto 3 site was visited after the meeting.

Together with the **Russian nuclear safety authority Rostechnadzor (RTN)**, the commissioning inspections carried out by STUK at Olkiluoto 3 in 2019 and the comprehensive inspection of the Kola Nuclear Power Plant were explored. The purpose of these activities is to compare the inspection practices between the authorities. The meetings between RTN and STUK covered issues such as risk-informed oversight, final disposal of nuclear waste, security arrangements of nuclear material transports and requirements pertaining to the physical protection of nuclear facilities. Inspectors of Russian nuclear power plants located in the nearby areas came to Finland twice to report events.

The first unit of the Leningrad 2 power plant in Sosnovyi Bor, which is the reference plant for Fennovoima's Hanhikivi 1 project, has been commissioned and the next unit is about to be completed. The situation of the plant projects was discussed in the annual meeting, which agreed on future cooperation relating to, for example, experiences from the commissioning of the first and second unit of the Leningrad 2 power plant.

The **Hungarian radiation and nuclear safety authority HAEA** is preparing for the safety assessment of the construction licence for the AES-2006 nuclear power plant (PAKS-2 project). In 2019, STUK and HAEA held one collaboration meeting concerning plant design issues. The second meeting scheduled for 2019 was transferred to January 2020 at the request of HAEA. The meetings have compared the assessment and inspection findings of the authorities concerning, among other things, site surveys, plant design and the submittal of official licence documents. During the meetings, STUK and HAEA have shared their assessment and inspection experiences and practices.

Cooperation for the prevention of the proliferation of nuclear weapons

The **Non-Proliferation Treaty (NPT)** entered into force in 1970. Over 190 countries around the world are members to the treaty. The **NPT Review Conference** is held every five years. The previous conference was held in 2015, and the next will be held in 2020. The NPT Preparatory Committee holds sessions prior to the Review Conference. An expert from STUK, together

with the Ministry for Foreign Affairs, the Ministry of Economic Affairs and Employment, the Ministry of Defence and other organisations, attended the session held in May in New York.

A group of nuclear supplier countries, the **Nuclear Suppliers Group (NSG)** is a multilateral export control regime and a group of nuclear supplier countries that seek to prevent nuclear proliferation by controlling the export of materials, equipment and technology that can be used in the manufacture nuclear weapons. The group consists of 48 countries. In the Nuclear Suppliers Group Finland is represented by the Ministry for Foreign Affairs. STUK's experts participated in the the NSG Technical Expert Group meetings in April and November 2019.

The **Finnish Support Programme to the IAEA Safeguards (FINSP)** is funded by the Ministry for Foreign Affairs and coordinated by STUK. The objective of the support programme is to provide support to the IAEA in tasks related to the development of safeguards verification methods, safeguards concepts and training of the IAEA inspectors. The Finnish support programme had two review meetings with the IAEA, one in April and one in October 2019. Both meetings were held at the IAEA in Vienna. In 2019, the support programme had 15 active active tasks.

STUK is a member of the **European Safeguards Research and Development Association (ESARDA)** and it has appointed experts to the committees and several working groups of the association. STUK is also a member of the Executive Board and Steering Committee of the ESARDA. STUK's expert acts as the vice chair of the Implementation of Safeguards working group. Two STUK's experts participated in the preparation of ESARDA's 10-year strategy. The new strategy was presented at ESARDA's 50th anniversary symposium at the World Café event in May 2019. The objective is to continuously follow the needs of ESARDA's members.

Low Level Liaison Committee (LLLC) meeting held in Vienna on 26 September 2012 recommended the establishment of a working group to coordinate the activities of the **Encapsulation Plant and Geological Repository (EPGR)** project and to be attended by representatives of the IAEA, European Commission, Sweden and Finland. The LLLC EPGR would be a Liaison Group and would ensure good communication and cooperation between all parties and report regularly to the LLLC. The development of safeguards approaches and techniques had started simultaneously with the development of the final disposal concepts and technologies. The application of safeguards-by-design in plant design is possible through close cooperation of the plant designers, plant operating personnel and authorities. In 2019, the EC hosted the 7th EPGR meeting in Luxembourg in February and the IAEA organised the 8th meeting in November in Vienna. The main topics of last year's meetings were the plans for the safeguards concepts for Posiva's encapsulation plant and and geological repository.

APPENDIX 1
Objects of regulation

Loviisa nuclear power plant

Plant unit	Start-up	National grid	Nominal electric power (gross/net, MW)	Type, supplier
Loviisa 1	8 Feb 1977	9 May 1977	531/507	Pressurised water reactor (PWR), Atomenergoexport
Loviisa 2	4 Nov 1980	5 Jan 1981	531/507	Pressurised water reactor (PWR), Atomenergoexport

Fortum Power and Heat Oy owns the Loviisa 1 and 2 plant units located in Loviisa.

Olkiluoto nuclear power plant

Plant unit	Start-up	National grid	Nominal electric power (gross/net, MW)	Type, supplier
Olkiluoto 1	2 Sep 1978	10 Oct 1979	920/890	Boiling water reactor (BWR), Asea Atom
Olkiluoto 2	18 Feb 1980	1 Jul 1982	920/890	Boiling water reactor (BWR), Asea Atom
Olkiluoto 3	Operating licence granted on 7 Mar 2019		Approx. 1,600 (net)	Boiling water reactor (BWR), Areva NP

Teollisuuden Voima Oyj owns the Olkiluoto 1 and 2 plant units located in Olkiluoto, Eurajoki and the Olkiluoto 3 plant unit under commissioning.

Hanhikivi nuclar power plant project

Plant unit	Supplemented decision-in-principle approved	Nominal electric power, net (MW)	Type, supplier
Hanhikivi 1	5 Dec 2014	Approx. 1,200	Pressurised Water Reactor (PWR), ROSATOM

Hanhikivi nuclear power plant FH1 is a power plant project of Fennovoima.

Olkiluoto encapsulation plant and disposal facility

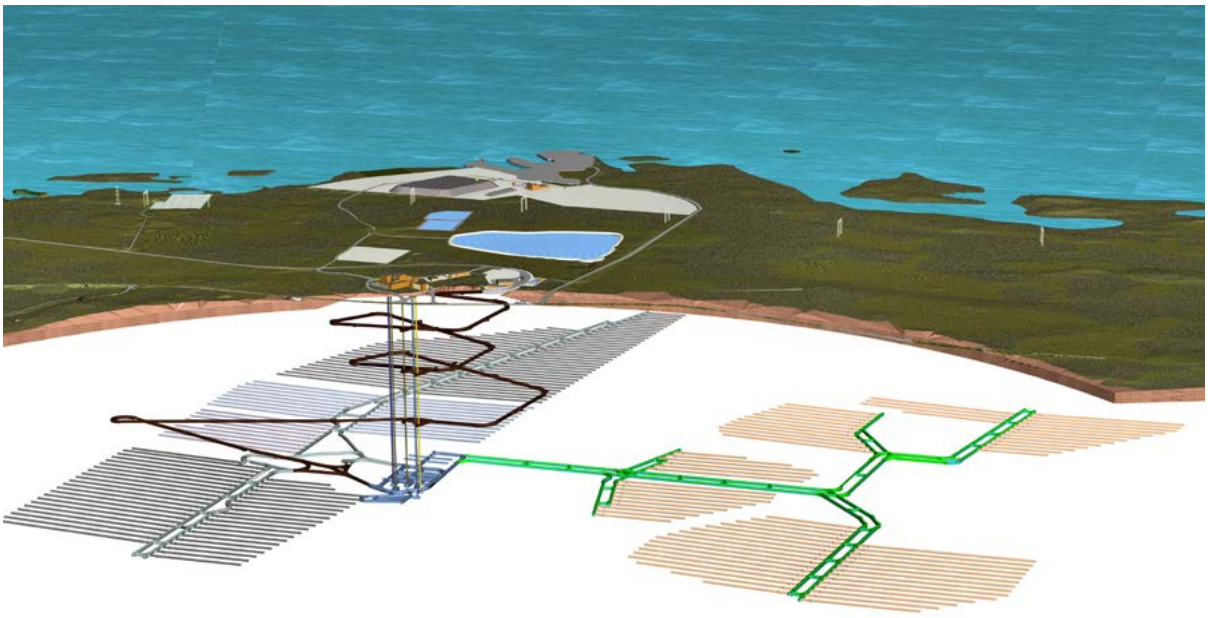

Diagram of the Olkiluoto encapsulation and disposal facility (Posiva Oy).

In November 2015, the Government granted Posiva a construction licence for the Olkiluoto encapsulation plant and disposal facility. The planned facility consists of a surface facility for the encapsulation of spent nuclear fuel, an underground disposal facility, and supporting buildings. Posiva has already built an access tunnel, three shafts and a technical facility and research area at a depth of 420–437 metres as parts of the underground research facility Onkalo. For the actual disposal facility, the underground facility will be expanded by two additional shafts and the disposal tunnels that will be excavated in stages. The construction of an underground research facility was a prerequisite for granting a construction licence. Onkalo provides an opportunity for a more detailed study of the rock volumes best suited for the disposal of spent nuclear fuel and allows for the testing of disposal facility construction methods and installation of the disposal system components.

FiR 1 research reactor

Plant	Thermal power	In operation	Fuel	TRIGA reactor's fuel type
TRIGA Mark II research reactor	250 kW	03/1962 – 06/2015	reactor core contains 80 fuel rods with 15 kg of uranium	uranium–zirconium hydrid combination: 8% of uranium 91% of zirconium and 1% of hydrogen

The use of VTT's FiR 1 research reactor in Otaniemi, Espoo, started in March 1962. VTT ended the use of the reactor in June 2015, and the reactor was placed into a permanent shutdown state. VTT submitted the operating licence application regarding decommissioning to the Government in June 2017.

Other objects of regulatory oversight

In accordance with Section 2 of the Nuclear Energy Act, the regulatory oversight of the use of nuclear energy covers the nuclear material in research laboratories and in industry. The control also covers nuclear equipment, systems and information as well as nuclear fuel cycle-related research and development activities and the transport of nuclear materials and nuclear waste.

In addition, the regulatory oversight of the use of nuclear energy covers mining and milling operations aimed at producing uranium or thorium. The planned Terrafame uranium extraction plant is part of this group. As nuclear materials, the intermediate products of metal industry containing uranium have also been included in the regulatory oversight of the use of nuclear energy when the concentration, as defined by the nuclear material specification, is exceeded in an industrial process or product

APPENDIX 2
Significant events at nuclear power plants

Loviisa nuclear power plant

Annual outages at Loviisa, 18 August–27 September 2019

Both units of the Loviisa nuclear power plant had short so-called refuelling outages. Despite the short outages, a large number of modifications were carried out at both plant units.

The annual outages of the Loviisa nuclear power plant started with the stopping of the Loviisa 2 unit on 18 August 2019. One month before the annual outage, a leak was observed in the cooling piping of one emergency diesel generator at Loviisa 2, which is why it was necessary to establish and correct any problems caused by piping vibrations on all four cooling pipelines installed in the emergency diesel generators of Loviisa 2 in 2018. The work included pipeline vibration mapping by Fortum with tests and analyses, planning and implementing the necessary repairs and long trial operations to demonstrate the viability of the solution before starting up the plant unit. STUK processed Fortum's reports and approved the corrections made. The plant did not receive STUK's authorisation for start-up until there was absolute certainty that all diesels at Loviisa 2 were fully operational in case of a long-term need. The annual outage of Loviisa 2 was completed on 13 September 2019.

Loviisa 1 was stopped for its annual outage on 7 September 2019. Originally, the intent was to make the same modification of the emergency diesel generator cooling pipes at Loviisa 1 that was made at Loviisa 2 in 2018. Due to the findings made at Loviisa 2 and the modifications made during the annual outage in 2019, STUK approved Fortum's proposal to transfer the diesel cooling piping modification to the annual outage of 2020. The annual outages of Loviisa ended on 27 September 2019 when the Loviisa 1 unit was reconnected to the national grid.

During the annual outages, Fortum installed to both plant units an additional circuit into the cleaning system of the primary circuit water to remove impurities and radioactivity during the annual outages. During the shut-down and start-up of the reactors, high levels of impurities circulate in the primary circuit, and when they are reduced radiation doses to annual outage workers are also reduced. The additional circuits were already in use in the start-up of both plant units.

In addition, Fortum carried out finalising and final work on the safety I&C reform implemented in 2018, which included dismantling a part of the original reactor protection system and other decommissioned systems and functions, and minor updates and modifications to the new system installed in 2018. These included a modification of the start-up of the sprinkler system inside the containment controlled by the plant protection system,

which increased the analysed cold crack risk margin of the reactor vessel at both plant units. After the modification, the spray water temperature stays higher, so that in the event of possible incorrect spraying during power operation the outside surface of the reactor pressure vessel will be subjected to a less of a thermal shock than with cold water.

The radiation doses of the personnel who participated in the annual outage of the Loviisa power plant were significantly below the dose limits laid down in radiation legislation. The collective (total) radiation dose received by the personnel was approximately 268 manmSv at Loviisa 2 and 234 manmSv at Loviisa 1. The radiation doses at both plant units were below Fortum's estimate by just under a fifth.

STUK also monitors the radioactivity of the environment near the Loviisa power plant by analysing samples collected from the air, soil and marine environment. Laboratory measurements revealed very small quantities of radioactive substances, some of which originate from the power plant. The observed levels were so small that they do not pose a risk to people or the environment.

In 2019, the regulatory oversight of outage was performed by approximately 30 STUK experts. They ensured that Fortum took care of radiation and nuclear safety during the annual outage work. During the annual outages, STUK also carried out an inspection of the annual outages in accordance with the operational inspection programme (see Appendix 3). This year's annual outage inspection focussed in particular on the evaluation of control room operations with the aim of establishing the operating procedures and practices in the main control rooms of the plants during the annual outage of Loviisa. Other inspection targets included heavy lifting, implementation of the additional circuit of the primary circuit cleaning system, refuelling and radiation protection. STUK's general monitoring theme was procedures related to the management of foreign material that STUK's inspectors verified at the work sites. According to STUK's findings, the annual outages were performed safely. No safety deficiencies that would have required immediate intervention by STUK emerged during the inspection. The inspection summary is provided in Appendix 3.

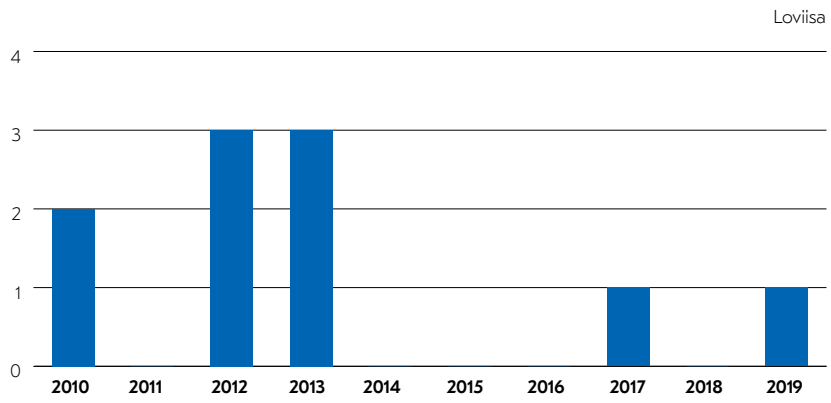

FIGURE A2.1 INES classified events at the Loviisa plant (INES Level 1).

Damage to one emergency diesel cooling piping of Loviisa 2 in the piping replaced in 2018

On 22 July 2019, Fortum detected a leak in the cooling piping of one emergency diesel generator of Loviisa 2 during the monthly test. Fortum repaired the leaking pipe, but the retest on 24 July 2019 revealed a new leak in another point of the piping. After the second leak, a larger section of the piping was replaced and supported, because there was a strong suspicion that vibrations had caused the leaks. In addition, Fortum inspected the other emergency diesels of Loviisa 2 to map whether there could be a more wide-ranging problem, because all cooling piping of the emergency diesel generators (4) of Loviisa 2 were replaced in 2018. Fortum sent the leaking pipe parts to VTT for analysis.

On the basis of the incident, STUK required a report on the operational condition of all emergency diesel generators at Loviisa 2 and the necessary repairs before the start-up of the plant unit. The repair made immediately after the manifestation of the failure and the subsequent trial operation confirmed that the plant was able to safely continue power operation until the annual outages.

VTT's analyses confirmed that the cause of the event was a fatigue fracture resulting from vibration of the piping. Fortum prepared strength calculations for the cooling water piping aimed at identifying the causes of the failure and possible corrective measures. Just before the annual outage, Fortum carried out a 72-hour long-term test on one of the emergency diesel generators to confirm the significance of the supporting replaced on 24 July. No leaks were detected during the test.

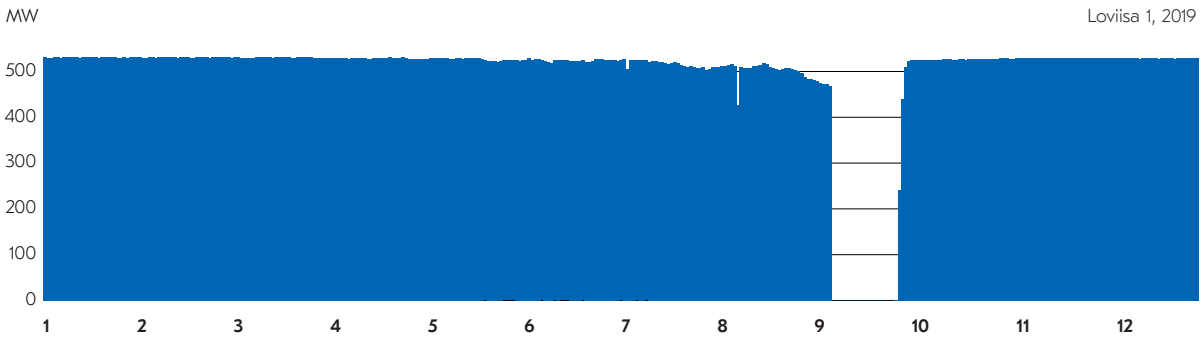

FIGURE A2.2 Daily average gross electrical power of the Loviisa 1 plant unit in 2019.

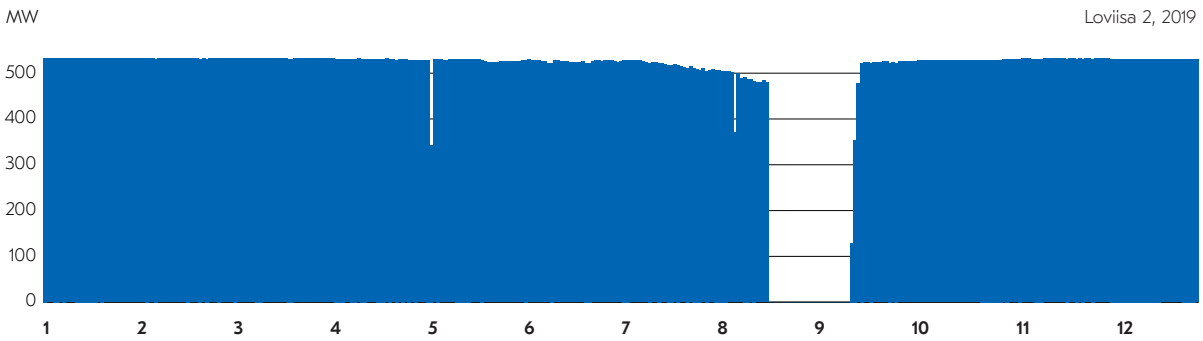

FIGURE A2.3 Daily average gross electrical power of the Loviisa 2 plant unit in 2019.

However, on 15 August 2019, Fortum estimated, based on the results of the strength calculations, that the piping installed in 2018 will not withstand long-term vibrations and forced displacement at different points of the pipe ends. As a result, Fortum decided to add to the other two diesel generators flexible metal bellows to resolve the forced displacements and supports to resolve the vibrations causing service life issues. As there were uncertainties in the calculations and modelling, Fortum decided to repair the piping of two generators instead of four to avoid a possible common cause failure of all emergency diesel generators of the plant unit. STUK approved the approach and designs for piping modifications.

First, the modification was implemented on one machine. In order to confirm the functionality of the solution, a 72-hour trial operation was carried out to ensure long-term reliability. On 29 August 2019, however, this reliability test had to be discontinued because a leak was detected in one of the installed metal bellows. As a corrective measure, the metal bellows were installed under compression and the reliability test was started from the beginning. On 31 August 2019, the 72-hour reliability test had to be discontinued again because one of the arched metal bellows was leaking. During the previous leak, it was thought that the arched installation would protect the flexible metal bellows and, therefore, no precompression had been applied to it as in the case of the other bellows.

As a corrective measure, Fortum decided to qualify and install rubber bellows in the place of the metal bellows. This solution is used in similar type diesel engines in other countries. STUK approved the installation of the rubber bellows, but only for one year, because there was insufficient documentation on the long-term behaviour of these rubber bellows. This solution enabled Fortum to successfully perform the new 72-hour trial operations. STUK reviewed Fortum's reports on the operability of all diesel generators before the plant was started. The plant did not receive STUK's authorisation for start-up until there was absolute certainty that all emergency diesel generators at Loviisa 2 were fully operational in case of a long-term need. There have been no leaks in the installed rubber bellows during the operating period following the annual outage.

As a further measure, Fortum submitted a separate operational event report to STUK for approval in October 2019, which described the course of events starting with the leak observed on 22 July 2019 and analysing the lessons learnt from the event and the corrective actions taken. Fortum will also prepare a separate root cause analysis of the event, which will examine the different design phases of the 2018 replacement of the diesels' cooling water piping and decision-making during the 2018 annual outage. Fortum will submit the root cause analysis to STUK for information in the early spring of 2020.

Insufficient compensation of temperatures measured in the primary circuit pipe and the reactor core of Loviisa 2 during start-up.

During the start-up of Loviisa 2 on 6 September 2019, the compensation of the temperatures measured in the primary circuit pipe and the reactor core was carried out, in deviation from the test procedure, with five main coolant pumps in operation, as the test requirement is to have all six main coolant pumps in operation. The reason for stopping one pump was the need to separate the pump due to high vibrations just when the compensation was about to be performed. This is a test according to the Operational Limits and Conditions (OLC), which is

intended to minimise the uncertainties of reactor calculation in order to better know, among other things, the power distribution between the fuel rods in the reactor core.

The persons in charge of the compensation estimated that performing the compensation with five pumps in operation would be sufficient, so the compensation was performed. No separate written plan was prepared for the deviation. The reactor engineer responsible for the facility's reactor state and reactor calculation was also not informed of the matter and no clear approval for the gained results was sought from them.

Since the separated main coolant pump continued to vibrate after commissioning despite the corrective measures taken, the plant was brought back into a shutdown state for the replacement of the main coolant pump on 10 September. But the compensation was not repeated in the following start-up.

The matter was not observed until the reactor's power distribution inspections carried out on 23 September 2019, in this connection Fortum decided to report the matter on 25 September 2019 and verified the situation with calculations. At this point, also STUK was informed and required Fortum to submit a report and OLC deviation application on the matter and to process the matter as an OLC violation, because it was unclear what the safety significance of the deviation is.

During the heating of Loviisa 1, on 26 September 2019, Fortum tested the effect of the compensation on the temperature measurements of the primary circuit cold and hot legs, at which time the temperature calibration was first carried out with five and then six pumps. The results obtained did not differ significantly from those calculated at Loviisa 2. On this basis, the temperature in the stopped circuit was only 0.3 °C higher than in the others, with a tolerance of 0.5 °C. On 27 September 2019, Fortum submitted to STUK the OLC deviation application including these more comprehensive safety cases, and STUK approved the application. On 28 November 2019, Fortum submitted to STUK the final operational event report covering the causes of the event and corrective actions in a comprehensive manner.

The event did not have direct significance in view of plant safety. The compensation has no effect on protection signals, such as the scram, because they use uncompensated values.

A failed compensation can lead to an inaccurate calculation of the reactor power distribution used to ensure the necessary fuel assembly power limits. There is a separate, dedicated alarm in the control room for excessive assembly power, which issues a warning before the allowed assembly power is reached. If it is suspected that the assembly power could be exceeded, the total power of the reactor is restricted.

However, during the event, there was no clear image of the overall situation and the procedures did not provide sufficient support for the operations. The reason for the deviations was the differences and inaccuracies in the various procedures and practices, for example, the approval procedure was not sufficiently instructed. The decision to perform the test with 5 pumps and its justifications were not documented and it was not assessed how the deviation from the procedures affects the fulfilment of the OLC requirement. In addition, no time limit or criteria were specified for the approval or review of the compensation. There was also a lack of certainty as to whether the compensation can be made in some other state.

As corrective measures, Fortum will improve its procedures and set clearer performance and acceptability criteria for the compensation.

Olkiluoto nuclear power plant

Olkiluoto annual outages on 1 May–11 June 2019

The Olkiluoto annual outages started on 1 May 2019, when TVO shut down Olkiluoto 2 for a maintenance outage. During the maintenance of unit 2, which ended on 26 May, TVO carried out the work associated with a normal annual outage, such as replacing approximately one-fifth of its nuclear fuel with fresh fuel. TVO also continued the modification of the startup and shutdown piping system at Olkiluoto 2 by installing new recirculating lines in two subsystems. The modification allowed to significantly reduce the dependency of the startup and shutdown piping system on seawater cooling. TVO also performed a pressure test of the primary circuit at unit 2. STUK required the completion of the test in accordance with pressure equipment legislation in the statement given on the operating licence application of Olkiluoto 1 and 2. The leaktightness of the primary circuit was at a good level and the acceptability criteria set for the test were met with a fair margin. According to STUK's observations, the personnel involved in carrying out the pressure test acted in an exemplary manner. A corresponding pressure test will be performed at Olkiluoto 1 in 2020.

The fuel replacement outage of Olkiluoto 1 started on 2 June 2019. During the fuel replacement outage, TVO replaced approximately a fifth of the nuclear fuel to fresh fuel and performed maintenance work included in a normal annual outage. The annual outages ended when, after STUK had issued the start-up permit, unit 1 of the Olkiluoto power plant was reconnected to the national grid on Tuesday, 11 June.

The radiation doses of the personnel who participated in the annual outage of the Olkiluoto power plant were significantly below the dose limits laid down in the Radiation Decree as well as the dose restrictions set for itself by the power company.

STUK monitors the radioactivity of the environment near the Olkiluoto power plant and regularly takes samples of the air, soil and marine environment. During the annual outage, extremely small amounts of radioactive iodine were observed in the air at sampling stations near the power plant. This was to be expected because fuel rods that had broken during the operating cycle were removed from the reactor during the annual outage. The observed amounts of iodine were so small that they could barely be detected by the highly accurate measuring instruments. They did not affect the safety of the environment or people.

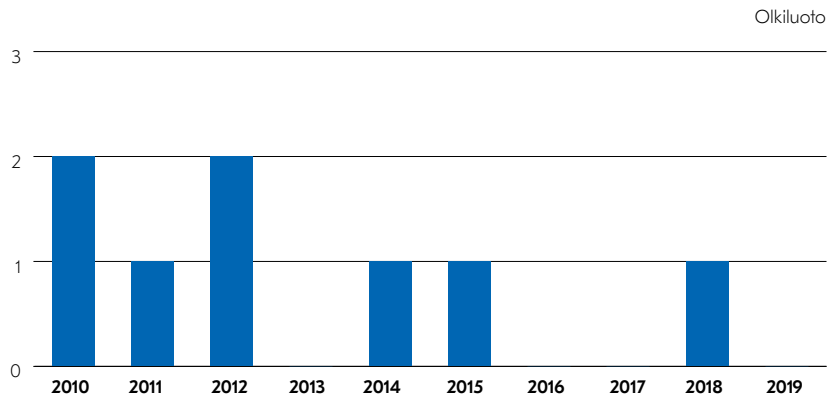

FIGURE A2.4 INES classified events at the Olkiluoto plant (INES Level 1).

This year, the regulatory oversight of outage was reformed by approximately 30 STUK experts. They ensured that TVO took care of radiation and nuclear safety during the annual outage work. During the annual outages, STUK also carried out an inspection of the annual outages in accordance with the operational inspection programme. During this year's outages, STUK monitored, in particular, the performance of the primary circuit pressure test at Olkiluoto 2. Other areas of the inspection included operating procedures and practices during the annual outage, radiation protection of workers, electrical and I&C technology, criticality and scram tests of the plant, construction engineering and fire protection. STUK's general oversight theme was procedures related to the management of foreign material that STUK's inspectors verified at the work sites. Based on the inspection, the annual outages went safely and almost all the work planned for them was completed. No safety deficiencies that would have required immediate intervention by STUK emerged during the inspection. The inspection summary is provided in Appendix 3.

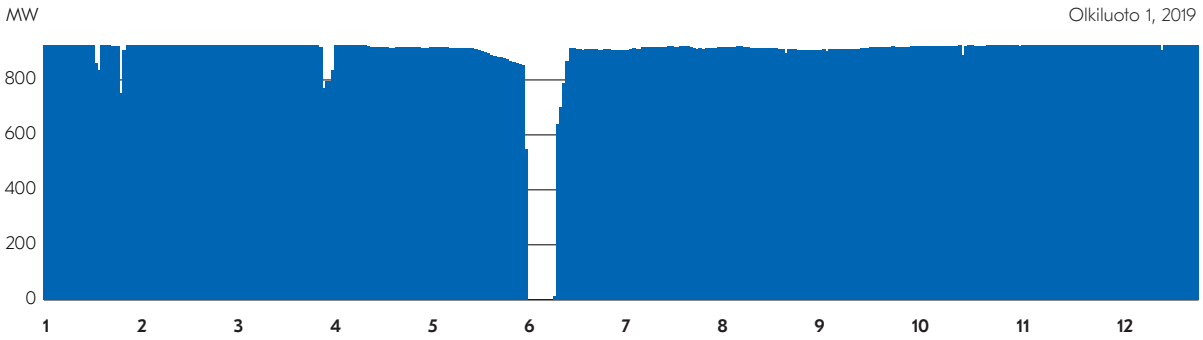

FIGURE A2.5 Daily average gross electrical power of the Loviisa 1 plant unit in 2019.

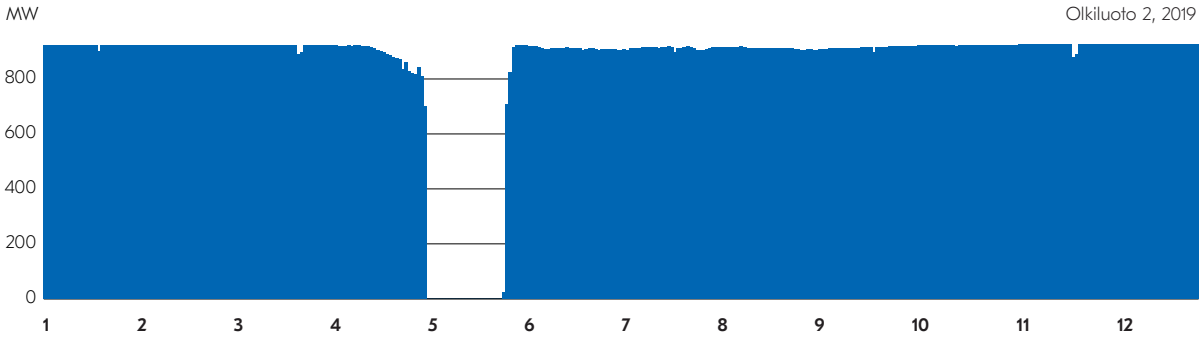

FIGURE A2.6 Daily average gross electrical power of the Loviisa 2 plant unit in 2019.

There were rarer radioactive substances in the sea area in front of Olkiluoto

In the samples collected by STUK from the marine environment of the Olkiluoto nuclear power plant, more radioactive substances than usual originating from the nuclear power plant were detected in September and October. The amounts were very small, of no importance in view of people and the environment.

The reason for the findings was a failure of the liquid waste processing system at unit 1 of the Olkiluoto power plant. Due to the failure, the evaporator intended for the treatment of waste water cannot be used and water released into the environment is purified by means of filtration. The method is less effective than evaporation. Radioactivity limits have been set for the water releases of the nuclear power plant that cannot be exceeded. The releases from Olkiluoto are still clearly below the limits.

Samples collected from the marine environment of the nuclear power plants occasionally reveal small quantities of radioactive substances originating from the power plant. The samples in October and November were exceptional, as they contained, for example, caesium-134 and iodine-131, which are very rarely observed. Among the other observed radioactive substances were cobalt-60, chromium-51, manganese-54 and cerium-141. The levels of caesium-137 and tritium were also higher than normal. The observed radioactive substances are only detectable from the samples via highly sensitive laboratory measurements, and in practice the observed quantities have no effect on the radioactivity of sea water or sea plants and animals.

APPENDIX 3
Periodic inspection programme of nuclear power plants 2019

Inspections included in the periodic inspection programme focus on safety management, operational main processes and procedures as well as the technical acceptability of systems. The compliance of safety assessments, operation, maintenance and protection activities with the requirements of nuclear safety regulations are verified with the inspections. No material deficiencies with an effect on the safety of the plant, the personnel or the environment were observed in the 2019 inspections.

	Inspections in 2019	
Basic programme	**Loviisa 1 and 2**	**Olkiluoto 1 and 2**
Human resources and competence	x	x
Management and safety culture	x	x
Management system	x	
Disposal facilities	x	
Chemistry	x	x
Operating experience feedback		x
Operation		x
Plant maintenance	x	x
Fire protection		x
Utilisation of the PRA	x	
Structures and buildings	x	
Radiation Protection	x	x
Nuclear security	x	x
Safety design	x	x
Safety functions	x	x
Emergency arrangements	x	x
Power plant waste		x
Annual outage	x	x
Nuclear safeguards	x	
Special subjects		
Management of human factors		x
Control of manufacture and delivery chain in the EDG project (additional)		x

Matters concerning Olkiluoto 3 are also reviewed in the periodic inspection programme of Olkiluoto if the matters to be reviewed are common for the whole of TVO, not merely plant unit-specific. Plant unit-specific (OL1/2 and OL3) inspections are Conduct of operations, Plant maintenance, Safety Functions and Annual outage.

Inspections in accordance with the periodic inspection programme at the Loviisa plant

Human resources and competence, 16–17 May 2019

The inspection concerned, among other things, the refresher training and deputyship arrangements of persons operating in safety-related tasks in accordance with the administrative rules at the Loviisa power plant. STUK interviewed persons working in safety-related tasks and their deputies and, according to interviews, the deputyship arrangements seem to work well. The rate of participation in refresher training organised annually has typically been slightly lower than the target. The inspection also covered the planning of the power plant's training, training offering and the evaluation procedures for the effectiveness of the training. Fortum has a systematic procedure for planning training events and it has invested in the training of those providing training to others. Methods for assessing the immediate learning effects of the training include tests and demonstrations of skills. During the inspection, the new mock-up and VR training facilities of the power plant were explored. The facilities have been introduced for the refresher training of the whole personnel. No requirements were issued in the inspection.

Management and safety culture, 1–3 October 2019

The inspection covered the procedures of the Loviisa Power plant to ensure that good safety culture is observed by the suppliers and subcontractors. In addition, the decision-making procedures related to the safety of the Loviisa plant were reviewed. The third inspection target was the current state of the assessment and development activities of safety culture at the Loviisa facility.

The inspection found that ensuring good safety culture of the suppliers and reacting to shortcomings have been incorporated in many respects in the practices of Fortum's/Loviisa's facility over time. In practice, supplier management is dispersed across different organisational units, depending on the function and supplier, and the procedures have been developed under the management of different organisational units.

Currently, some of the procedures related to assessing the delivery capacity of suppliers, as presented during the inspection, have not been implemented to a satisfactory degree. Therefore, there is variation in the application of practices related to supplier management, in the assessment, recording and addressing of shortcomings of "non-technical issues" in particular. Fortum itself has identified development targets in the area of supplier selection, monitoring and evaluation. Through its oversight activities, STUK monitors what development measures Fortum implements in the supplier management area of the Loviisa power plant, in particular in terms of safety culture of the suppliers.

Based on the inspection, the decision-making forums of the Loviisa facility and their key relationships are clear to Fortum's representatives, although it is challenging for outsiders to conceive the mutual relationship of the procedures and differences in the processed matters. The application of the operative decision-making procedures was established and flexible based on the inspection. The safety aspects of the decisions are reflected in the minutes of the operative decision-making meetings, and the advantages and risks of the chosen approach

are addressed. Project-related decision-making takes place in many forums and their ways of recording decisions vary. The key decision-making bodies involved in the progress of projects do not systematically record the safety aspects of the decisions.

The inspection found that the assessment and development of safety culture is not sufficiently consistent and traceable in terms of content. STUK set one requirement regarding this.

Management system, 5–7 November 2019

The inspection covered the procurement process of the Loviisa power plant. The current process description is based on procedures. STUK concluded, based on the inspection, that Fortum must prepare a description of the procurement process, taking into account the process progress and stages as well as the interfaces and interactions with other processes.

Delivery monitoring, manufacturing controls and reception of goods were inspected in more detail as procedures of the procurement process. In STUK's view, Fortum must assess the need to further specify and develop the procedures for the tasks of a delivery controller and for preparing a delivery control plan and for manufacturing control, as the procedures related to these is currently in part open to interpretation and the procedures are not fully compatible.

The inspection also covered updating and the up-to-dateness of the organisation and quality assurance manuals. STUK verified that the procedures included in the above manuals have been updated on time.

Disposal facilities, 1–2 October 2019

The aim of the inspection is to assess the disposal facilities of power plant waste and the use of the facilities. The Loviisa power plant waste facility (VLJ repository) currently includes the solidified waste space and 3 maintenance waste spaces. The inspection also focused on monitoring the properties of the rock surrounding the disposal facilities of power plant waste and their stability. The state of the construction engineering structures of the disposal facilities was examined during a facility walkdown.

The solidified waste space is a significant part of Loviisa's VLJ repository. After the completion of the renovation project of the concrete trough of the solidified waste space, the commissioning licensing of the space is progressing as planned. Due to the fact that the space is being licensed, the solidified waste has been temporarily placed in one of the maintenance waste spaces with STUK's authorisation.

Process diagrams related to the VLJ repository had been developed after a corresponding inspection in 2017 and STUK noted that the development work was systematic. Fortum has also developed a waste management index to monitor the quantitative fulfilment of the objectives of the VLJ repository. In STUK's view, the maintenance of the VLJ repository is systematic. STUK stated, however, that the number of personnel needed at the Loviisa plant to monitor the use of the Loviisa VLJ repository, including substitution arrangements, is not sufficient. The most important tasks related to the use of the VLJ repository have been completed, but others have been moved forward within the schedule. It has not been possible to advance development tasks related to the use of the repository or to start new ones. In the long-term, the situation would be bad. STUK set a requirement to increase resources within 2 years.

A significant observation by Fortum has involved the drums placed in the two first maintenance waste spaces in 2011, white crystals (minor leak) were observed on the outer surfaces of the drums in summer 2019. The drum damage has been caused by low-level solidified resin waste inside the drums. Fortum has already launched an investigation to allow repacking of the said waste so that similar problems will not occur in the future. STUK will monitor the progress of Fortum's work.

No significant observations were made in the monitoring of the bedrock and groundwater environment of the VLJ repository in 2018, which indicates that the bedrock and groundwater conditions of the VLJ repository are stable.

Chemistry, 22–23 October 2019

The inspection focused on hydrochemistry and radiochemistry, laboratory activities and decontamination of the primary and secondary circuits. In addition to these, the inspection covered the competence management of the operating chemistry group. There have been many staff changes in the group in the recent years, which has led to the postponement of some chemistry development tasks due to the increased need for orientation. During the plant visit, the chemistry laboratory was visited, verifying, among other things, the operation of the analysis machine and that the method employed by it corresponds to the applied methods.

The new primary circuit filtration to be used during annual outages was implemented in the 2019 annual outage and it cleans corrosion products from the coolant, which reduces the primary circuit radiation level and the resulting doses. It was possible to establish that the modification had impacted the results of 2019. In 2019, the secondary circuit was also raised to a higher pH level to reduce corrosion in the iron-containing piping in the long term. The impacts of this modification were also verifiable in the inspection.

On the basis of the inspection, STUK required Fortum to update the laboratory procedures with the values used as the statistical calculation basis of the control limits in a traceable manner. Secondly, STUK required the submittal of a report on the update method of the design documentation regarding the primary circuit filtering modification. In addition, STUK required a report on the adequacy of human resources in Fortum's operating chemistry.

Plant maintenance, 12–13 November 2019

The objective of the inspection was to verify that Fortum takes care of the operability of the structures and equipment in the short and long term. The selected inspection targets (e.g. the state of development of the ageing management programme, the determination of the condition category in monitoring reports, internal maintenance audits, accruals of pressure and temperature transients, qualifications of in-service inspections, piping support condition monitoring) were used to assess the sufficiency of the resources, functions and tasks relating to the condition monitoring and maintenance of the Loviisa power plant to ensure safe operation of the plant units in the design-basis operational and environmental conditions.

The inspection did not reveal any significant deficiencies in the maintenance of the Loviisa plant units. In the view of the inspection team, the service life management is well organised and comprehensive. Fortum has resolutely continued the development of its ageing management procedures, focussing on the ageing management programme and its

comprehensive integration into Loviisa's LOMAX plant database, which manages, for example, maintenance, inspection and testing activities and storage. According to STUK, the condition category of ageing monitoring reports developed by Fortum is appropriate and includes the necessary factors for assessing the operational condition.

The accruals of pressure and temperature transients and strength analyses form a significant part of the periodic safety review, which is currently being prepared by Fortum. With regard to these, STUK required Fortum to submit to STUK for information an up-to-date register on the strength and load analyses performed on the Loviisa plant units and to update the procedure prepared for load monitoring in terms of the transient data accrual and reporting.

The inspection covered the current state of the method qualification of the periodic inspection targets of pressure equipment and the resources reserved for Fortum's qualifications. Some of the qualifications have been unfinished or undone for a long time and it seems that the time extension sought by Fortum for them is not going to be sufficient. Based on the inspection, STUK required Fortum to submit for approval an updated overall qualification plan, including a schedule for the completion of the remaining qualifications (both new qualifications and those to be updated). The piping support condition monitoring was considered as sufficient in the inspection.

Utilisation of the PRA, 26 November 2019

The inspection concerned the preparation of the probabilistic risk assessment (PRA) of the nuclear power plant and the procedures relating to its application and the utilisation of PRA in the management of safety at the nuclear power plant. In the inspection, the situation regarding the PRA models and applications of the Loviisa 1 and 2 plant units and the spent fuel storage facility, the updates under preparation and their schedules were reviewed. In addition, the procedures, the operation of the organisation relating to the preparation and application of the PRA and the utilisation of the PRA in the development of the security arrangements were assessed in the inspection.

No requirements were presented based on the inspection. Based on the inspection it can be stated that the procedures concerning the PRA are up to date, the development of the PRA has been continued and the PRA is used in accordance with the plans and in a versatile manner as a support for safety management. As a result of staff changes, the PRA resources have decreased slightly.

Structures and buildings, 16–17 October 2019

The inspection concerned the use, condition monitoring, maintenance and ageing control of structures, buildings and sea water ducts and tunnels. In addition, the structures of the VLJ repository were discussed. The inspection included an assessment of the licensee's procedures and operations and a review of the results of the power company's inspections and the completed modifications, some of which were selected to the scope of the facility walkdown.

There have been no significant changes in the organisational hierarchy of Fortum's organisation. In practice, the number of permanent staff has not changed, and new recruitments have been made to replace, for example, those retiring.

In terms of the in-service inspections of the structures, STUK reviewed the different phases of the operation and the reporting procedures. The inspection programme and the related reporting are an important part of Fortum's constructional ageing management. Fortum has identified the alkaline-aggregate reaction of concrete structures as a potential ageing mechanism.

The ageing and condition monitoring of the anchor bolts of the steel-constructed containment was one of the issues discussed in detail. The anchor bolts of the steel-constructed containment are not currently in stock as spare parts and, thus, it has not been possible to replace these bolts as planned in recent years. Fortum has identified this essential shortcoming and has launched the procurement of new spare parts. STUK considers that the condition monitoring methods of the anchor bolts are sufficient. STUK considered that there are development areas in clarifying the procedures for anchoring design, in particular in view of the anchoring of structures with a seismic classification, and in the manifestation of the special implementation and monitoring requirements of the said target in the procedure.

In addition, recent constructional modifications and complementary construction projects of the plant units were reviewed, including the Loviisa 1 unit's reactor building's roof repair in 2019, the repair of the coarse screens of the seawater structures in 2017 and the ongoing new store for strong chemicals, the commissioning of which is planned in a preliminary manner for the first half of 2020. This roof repair was a temporary fix to prevent leaks found in the roof – a comprehensive renovation is provisionally planned for 2021. STUK will monitor the progress of the matter. As regards the repair of the coarse screens of the seawater structures, STUK's observation was that Fortum has taken into account the corrosion protection of the structures as part of the repair and modification design. No specific comments were made in view of the chemical station.

In addition, the inspection found that Fortum has not submitted to STUK, in terms of the new fire seal products, the documentation demonstrating the fulfilment of the fire resistance requirement and the documentation demonstrating the quality control of manufacture, so STUK required Fortum to submit these to STUK.

Radiation protection, 26–27 November 2019

The inspection concerning radiation protection focused on radiation protection, radiation measurements and release and environmental monitoring at the nuclear power plant. This year's inspection targeted dosimetry. In addition, one topic of the inspection was the operating condition of continuous radiation measurements.

For the purpose of the inspection, the thermoluminescent dosimeters were subjected to a blind test, the results of which were reviewed in connection with the inspection. The blind test did not reveal any evidence that would indicate any defects in the analysis of the results of the dosimetric service.

One condition for the fixed-term approval of the dosimetric service in force is that Fortum must notify STUK of all major changes to the dosimetric service. To this end, it was required in the inspection that Fortum must submit to STUK a description of the current organisation of the dosimetric service and the related responsibilities.

Fortum has investigated the need and procedure for measuring the equivalent dose for the lens of the eye through measurement campaigns and it has identified case-specific special work tasks where the eye dosimeter can be used. In the inspection, STUK presented two requirements related to eye dosimetry, namely the plan to get approval for the selected eye dosimeter and submitting the already measured eye doses to STUK's dose register.

In terms of the continuous radiation measurements, their calibration, failure history, spare parts situation and further measures were covered. During the facility walkdown, the folders containing the inspection and calibration log sheets of the radiation monitors were examined, some of which did not fully comply with the procedures in place. With regard to this, STUK set a requirement that Fortum must ensure that the performance of the in-service inspections of the radiation monitors comply fully with its own procedures.

Security arrangements, 4–5 March 2019

The inspection was implemented in two parts on different days: the conventional (physical) security arrangements of the use of nuclear energy on the first day, and the safety and security arrangements of the radiation sources, related to the safety licence of the plant, regarding the use of radiation on the second day. In both parts, the inspection was carried out extensively, covering structural, technical, operative and organisational security arrangements in the nuclear power plant. The inspection assessed the procedures of the Loviisa nuclear power plant and the security arrangements-related operating procedures, human resources and expertise.

As regards the radiation sources, the most significant issue was the assessment of the matters required by the new Radiation Act, in terms of the new requirements regarding both security arrangements and the use of radiation. The four requirements presented during the inspection concern the management system of radiation practices, the quality assurance programme, the plan for radiation safety deviations and the accountancy of radiation protection training, which were amended by the new Radiation Act. In addition, two requirements were presented for the security arrangements of the radiation sources.

The inspection did not result in any requirements regarding the use of nuclear energy. The measures taken in response to the findings of previous inspections have been satisfactorily implemented.

Safety design, 31 October – 1 November 2019

The inspection focused on the analyses used by Fortum to justify the design solutions of the plant modifications, namely the deterministic safety analyses, probabilistic risk assessment (PRA) and the failure tolerance and common cause failure analyses. The inspection examined the procedures currently in place and their development needs and focused both on analyses carried out by Fortum itself and those commissioned from third parties.

A number of examples from each of the above analysis groups were examined during the inspection. On the basis of the inspection, Fortum carries out the majority of the analyses related to the design of the plant modifications of the Loviisa power plant. The analyses describing the plant's behaviour in disturbance and accident situations were updated to a large extent in connection with Loviisa's projects on I&C modernisation and secondary circuit safety functions completed in 2018. In the same connection, the procedures for carrying out the

analyses developed considerably. The current document structure used by Fortum for accident management and analyses is systematic and forms a logical whole.

On the basis of the inspection, STUK presented one requirement regarding the development of the modification design procedures: Fortum must develop its procedures to ensure that the effects of potential common cause failures of an individual component type are fully taken into account in the design.

Safety functions, 6–7 November 2019

The inspection assessed the licensee's procedures used to ensure that the systems implementing safety functions are in a state required for safety and that their basis is correct. The inspection was carried out at system level, by means of a cross-technological inspection. The 2019 inspection focused on the primary circuit boron supply, neutron flux measurement, reactor core temperature measurement and the reactor scram system's response time in different situations.

With regard to the boron supply system, the equipment failures, completed replacements, maintenance measures and tests as well as a summary of the spare parts were covered.

In terms of the neutron flux measurement, the measurement calibration, sensor modifications and service life management were covered. Also the maintenance, spare part status and ageing management of thermocouples used to measure the reactor core temperature were examined.

As regards the response time of the reactor scram system, the scram function taking place via the neutron flux measurement, which is the longest of the measuring sequences, was selected for inspection. In addition to the realisation of the response time, this inspection focused on the coverage of periodic testing. The inspection did not establish whether the fulfilment of the response time requirement for the whole chain of functions becomes regularly demonstrated, and full certainty on comprehensive periodic testing covering the whole chain of protection functions was not reached, i.e. do the individual tests carried out in batches overlap sufficiently to demonstrate the correct functioning of the interfaces. On the basis of the inspection, STUK presented no requirements. As the response time requirements of the safety functions and their periodic testing are a relevant topic also in a wider sense than in view of the functions selected for this inspection, STUK decided to issue a separate request for clarification on the topic, which can better take these other aspects into account.

Emergency response arrangements, 19–20 November 2019

The inspection regarding the emergency response arrangements covers the emergency response arrangements, procedures, facilities and training of the nuclear power plant. It covers the lessons learnt over the past year on emergency response operations, experiences and feedback on emergency response exercises and the development projects of emergency response operations. The inspection area also includes the automatic radiation monitoring of the environment, meteorological measurements and forecasting of dispersion. The 2019 inspection also covered the process-like operations of the emergency response organisation, the assessment of the design bases and receiving external assistance in accordance with

Section 3 and the training and orientation of the emergency workers and helpers in an emergency situation in accordance with Section 4 of STUK Regulation Y/2/2018.

Based on the inspection, STUK required, in relation to orientation during an emergency situation, that Fortum must develop its orientation for emergency workers and helpers arriving at the power plant site, prepare the necessary material, specify the training arrangements and train a sufficient number of personnel for providing orientation.

Fortum's emergency response arrangements are at a good level and its organisation develops the emergency response arrangements in accordance with the regulations and procedures.

Annual outage 18 August–25 September 2019

The annual outage inspection covered and verified the power plant's annual outage actions used to maintain safety as well as the actions used to manage and control operations during an annual outage. Inspectors from several fields of technology from STUK's nuclear reactor regulation department participated in the inspection. They had their own predetermined inspection areas. STUK also performed general oversight of the plant site by means of regular site walk-arounds and overseeing the progress of planned work, for example. Furthermore, STUK oversaw the way in which safety is prioritised in the licensee's decision-making process.

The annual outage inspection focussed in particular on the evaluation of control room operations with the aim of establishing the operating procedures and practices in the main control rooms of the plants during the annual outage of Loviisa. On the basis of the inspection, STUK required that the operating groups of the Loviisa power plant must develop the assessment of their own operations and make it more systematic and process the separate findings of the inspection in a traceable manner. STUK will inspect the development of the situation alongside its other oversight work. Other inspection targets included heavy lifting, implementation of the additional circuit of the primary circuit cleaning system, refuelling and radiation protection.

In the regulatory oversight targeting the management of foreign material, STUK verified the procedures implemented by Fortum during the annual outage both in the controlled areas of the plant units and in the turbine halls. STUK made several observations about foreign material risks and about the good or inadequate use of protections. There were clear improvements in the operations during the annual outage in comparison to the previous year, in terms of both using foreign material protections and in the storage of goods kept at the work sites. Fortum had made the separations and markings of work sites one of the safety themes of the annual outage and, this year, the Loviisa power plant had also invested in the training of its own personnel with the completion of the training facility in the spring. The improvement in operations was verifiable at the plant – the goods were mainly marked and the work sites had made a better use of separations than before. According to STUK's observations, the management of foreign material at work sites had improved.

STUK carried out its regulatory oversight targeting the radiation protection activities by carrying out several facility walkdowns and by discussing with the representatives of Fortum's Radiation Protection Unit. Based on STUK's observations, most of the work areas established to prevent the spread of contamination were separated and marked clearly, and there were

sufficient protective equipment available at the work areas. During the annual outages, the cleanliness level of the controlled area was good, and no significant spread of contamination was observed. The objects emitting intensive radiation were clearly marked, and the modifications went smoothly in view of radiation protection. There were a few abnormal events related to radiation protection during the annual outages. Contaminated reactor tools were removed from the reactor hall of Loviisa 2 without appropriate contamination measurements, and measuring objects inside pockets on the tool monitor was not routine according to STUK's observations.

STUK oversaw the procedures for heavy lifting by monitoring the lifting of the protective tube units at the plant units and by comparing the lifting plans with the lifts carried out. The inspection did not reveal any deficiencies in relation to heavy lifting. STUK also monitored fuel transfers that were carried out safely and according to pre-established plans. The fuel transfer work was well organised and the operation seemed appropriate.

The regulatory oversight targeting the modification of the primary circuit cleaning system, STUK verified Fortum's procedures in the commissioning of the new cleaning cycle. The aim of the modification is to allow the cleaning of the primary circuit coolant during power operation and also during the annual outage. No deficiencies were found in the inspection.

No deviations that would have required immediate intervention by STUK were observed in the operations of Fortum during the annual outage. According to STUK's findings, the annual outages were performed safely.

Nuclear safeguards, 30–31 October 2019

The inspection targeted the nuclear safeguards system of Fortum's Loviisa nuclear power plant. The purpose of the inspection was to establish how the Loviisa plant is managing its nuclear safeguards obligations.

The inspection covered, among other things, how Fortum's division of responsibilities and observation of nuclear safeguards are taken into account in different situations, such as procurement projects and fuel handling, and how sufficient resources and provision of information are ensured for the person in charge of nuclear safeguards. To date, the overall success of interaction and nuclear safeguards has been assessed at Fortum largely on the basis of the inspection findings. Fortum is developing its own meter to assess and report success more systematically within the company. The competence of the organisation has been developed through nuclear safeguards training. There are no actual successor plans for the persons in charge of nuclear safeguards, so STUK required their establishment.

The nuclear safeguards documents are kept well up-to-date, ensuring inspection readiness. The development of the safeguards manual is currently focused on covering the amendments to Guide YVL D.1. In the course of the inspection, it was discovered that in the most recent update of the safeguards manual, it had been submitted to STUK for information together with the plant procedure package, and not for approval as required by Guide YVL D.1. STUK required that the update of the safeguards manual be submitted to STUK for approval without delay.

STUK also required Fortum to present a procedure to ensure that the information provided in the site description is correct and up-to-date.

Inspections in accordance with the periodic inspection programme at the Olkiluoto plant

Human resources and competence, 2–4 December 2019

The inspection assessed the effectiveness evaluation of the training activities of the licensee, the risk assessment of organisational changes and the competence of maintenance activities and procurement, as well as the adequacy of resources. The inspection was carried out by interviewing staff from different units and different organisational levels and by verifying materials from the licensee's systems and documentation.

During the summer and autumn of 2019, TVO has made organisational changes to improve the smoothness of its operations. The assessments of risks involved in organisational changes reveal caution in identifying risks and proposing preparations for them. As these changes were recent, the inspection did not yet reveal any experiences resulting from these changes. During the inspection, STUK stated that the procedure for the assessment of organisational changes does not support risk assessment. It is too general, which is why STUK required TVO to update the procedure for the assessment of organisational changes to match the practice.

In recent years, a large number of maintenance personnel have been recruited by TVO. In early December 2019, STUK examined the experiences related to the orientation and development of professional skill of maintenance personnel through interviews and document reviews. According to the examination, the maintenance personnel of the OL1/2 plant units had clearly better experiences of job management than those of the OL3 plant unit. According to STUK's estimate, this may be due to the fact that the maintenance of OL3 has not had as much previous experience as the operating facilities. In addition, the job description is still changing because the actual maintenance operations are not yet the responsibility of TVO. The inspection also covered the resources and operational possibilities of procurement activities. Based on the inspection, it appears that TVO has invested in the procurement of spare parts, among other things, by acquiring additional resources and developing operating methods. On the basis of the inspection, STUK required TVO to submit to STUK for information a maintenance strategy plan and a competence assessment summary of the equipment owners and the related development measures before fuel loading of OL3.

Management and safety culture, 15–16 January 2020

The inspection was postponed from the planned date with a few months, so it was carried out in 2020. The inspection assessed TVO's development measures to improve the conditions for high-quality work in the control room of the OL3 plant unit. In addition, the inspection addressed how TVO's management is forming an understanding of the issues of the three units requiring attention and how it prioritises them. The third inspection target was the procedures of the Olkiluoto power plant to ensure that good safety culture is observed by the suppliers and subcontractors.

TVO has taken a number of measures to clarify the responsibilities of the OL3 control room operations and to manage the workload of the operators. Among other things, the procedure updates, which required long-term collaboration with the plant supplier and in which the roles of the joint organisations and, for example, that of TVO's shift supervisor have been described,

have been published. In addition, the plant status management organisation schedules work and, thus, supports the manageability of control room work. The implementation of measures targeting the control room operations is still ongoing, and STUK expects TVO to assess their effectiveness during the spring.

TVO developed its management forums during 2019. In order to process the safety matters of OL3, the OL3 plant meeting and the OL3 safety group have been launched, similarly to the operating plant units. The OL3 project's emergency readiness development is monitored by the OL3 Emergency Coordination Team, which is supported by the so-called situation room. The establishment of the overall picture is promoted by the fact that same management representatives participate in specific meetings of both the operating facilities and OL3. On the basis of the inspection, TVO's management has planned three-unit management forums and appropriate processing of safety matters.

Ensuring good safety culture of suppliers is considered important at TVO, and the expectations of the nuclear industry are emphasised to the suppliers and the shortcomings in operations are addressed. However, the related instructions in TVO's management system are limited, and observations-related information about the suppliers' safety culture is currently dispersed and, in part, tacit knowledge. TVO has initiated development measures to manage information and develop supplier evaluations, among other things. STUK set a requirement regarding this topic.

Chemistry, 29-30 January 2019

The inspection assessed the procedures used to maintain and control the chemical conditions of systems important to safety and to control the radionuclide concentrations of the primary coolant. The inspection did not result in requirements, but eight observations were made, four of which were positive.

The inspection involved going over the monitoring of the chemical and radiochemical conditions of the OL1 and OL2 units in terms of years 2016, 2017 and 2018. There have been no OLC deviations during these years. In addition, the monitoring of hydrochemistry and radiochemistry of the OL3 loading pool was reviewed. There have been no deviations in this area either.

TVO has strengthened the substance competence of chemistry, among other things, by adding a chemist, laboratory engineer and laboratory analyst to the chemistry team. In addition, staff, who have previously worked in the chemistry team, have transferred to other work duties within TVO. The operations of the OL3 laboratory have been integrated into operations of the OL1 and OL2 laboratory, i.e. it was established that the facility has one joint chemistry team. It was established that the operative monitoring of the OL3 chemical conditions and routine laboratory activities had started. STUK monitors the training of laboratory personnel as part of its regulatory oversight. A cause for concern in the OL3 laboratory is noise nuisance, which also TVO itself has taken into account in the risk survey.

The inspection also verified the results of the chemical and radiochemical comparison analyses of 2016, 2017 and 2018, as well as the control of the equipment-specific QC quality cards and the keeping of the equipment logs. Based on the inspection, TVO has improved

the quality management of laboratory work. In addition, TVO has developed HU procedures (human performance management) in the chemistry subarea.

The inspection covered the activities of the chemistry working group, in particular in view of the safety-classified materials. It is important to communicate information about the safety-classified materials to the personnel and to be able to trace history data of safety-classified materials in view of operational events. On the basis of the inspection, TVO has developed its procedures for safety-classified materials.

Operating experience feedback, 1–2 October 2019

The inspection targeted the processes and organising of the power plant's operating experience feedback and the related procedures and practices. The inspection assessed in particular the utilisation of external operating experience feedback. The inspection verified the procedures and their functioning through example cases.

The inspection reviewed the organising of TVO's external operating experience feedback. TVO's operating experience feedback covers also the OL3 plant unit and the operations of Posiva. The triannually meeting operating experience feedback steering group controls and directs operations. TVO has revised the procedure for operating experience feedback to better reflect the operations, and all the instructions have been compiled to form a manual-like entity. For the selection, screening and evaluation of external operating experience, TVO cooperates extensively with various external operators (e.g. NordERF), in which respect TVO presented the procedures in place for monitoring, screening and analysing of operational experience.

Based on the inspection, the organisation of and instructions for TVO's external operating experience feedback have been developed and the operations improved in line with the changes in the operating environment. On the basis of the inspection, STUK did not set any requirements for TVO's external operating experience feedback.

Conduct of operations (OL1/2), 1–2 October 2019

The inspection focused on the conduct of operations of the OL1/2 plant units. The inspection targets included the development work of the procedures for abnormal conditions and emergency procedures as well as the validation of the procedures and the implementation of the operator examinations.

It was established in the inspection that the plan prepared by TVO for 2017–2019 for the development of the procedures for abnormal conditions and emergency procedures has not been implemented as planned. Out of the tasks included in the plan, many had had just the preliminary background reports done to allow starting the development of the procedures. A small part of the tasks had been completed in their entirety. Some of the tasks included in the plan were still to be started. In addition, TVO does not systematically monitor the implementation of the development plan. On the basis of the inspection, STUK required TVO to prepare a follow-up plan to continue the development work and to develop systematic procedures for monitoring the progress of the plan.

The procedures for verifying and validating the procedures for abnormal conditions and emergency procedures of TVO were verified from the related procedure and completed

protocols. Prior to the inspection, STUK also participated in the simulator validation of the new procedures for abnormal conditions. Development needs were identified both in the procedures, in the preparation of protocols and in the general validation practices. STUK required TVO to develop the verification and validation methods of the procedures for abnormal conditions and emergency procedures and to update the related procedures.

The inspection also covered, in view of the oral operator examinations, the preparation and selection of questions. In addition, the participants and practices of the oral examinations were discussed. STUK established that TVO's practices for conducting the operator examinations are well established and functional.

Plant maintenance (OL1/2), 27–28 March 2019

The inspection assessed the adequacy of the resources, functions and tasks associated with the condition monitoring and maintenance of the OL1 and OL2 plant units to ensure the safe operation of the plant units in the design-basis operational and environmental conditions. The selected inspection items were

- means for identifying counterfeit products in the factory and acceptance inspections of equipment, spare parts and materials
- condition monitoring of the fuel transfer piping of the emergency diesel generators
- inspection procedures of small-diameter piping and their supports in inaccessible rooms during operation
- ensuring the operability of spare parts past their recommended life in case it is absolutely necessary to use these parts
- reserve of critical (long-term operational occurrences and accidents) spare parts
- specifying the licensee's structural competence
- readiness of the licensee to carry out such inspections that can be carried out when the opportunity for the inspection presents itself alongside other tasks (measure from the WENRA/ENSREG peer review)
- periodic testing of pumps
- qualifications of in-service inspections (NDT)
- programme for periodic pressure test of the OL2 reactor pressure vessel
- the licensee's maintenance human resources
- budgets, realisations and forecasts of pressure and temperature transients (ageing management)

No significant deficiencies were identified in the inspection. STUK requested specifications or additional clarification on some issues, for example, in the test results of safety-classified pumps, some inaccuracies were found when examined against the design bases specified in the safety analysis. In addition, the qualification of the surface inspection methods of the in-service inspections has not yet been completed, and the acceptability criteria for the periodic pressure test of the reactor pressure vessel were found to be inadequate. [The acceptability criteria were updated after the inspection and well before the pressure test of the 2019 annual outage of OL2.]

Fire protection, 30–31 October 2019

The inspection concerned the fire protection arrangements at the nuclear power plant. The focus of the inspection was on fire protection of the OL1/2 plant units. Matters of the OL3 plant unit STUK has processed in more detail in the commissioning inspections of the fire protection arrangements. The inspection targets included, among other things, the management procedures of penetrations, training and exercises of the fire brigade, inspections by TVO and other organisations, alarms, in-service inspections of the fire protection systems and modifications. The inspection also included a facility walkdown.

The inspection focused in particular on the management of opened penetrations. The previous fire protection inspection revealed an observation about the management procedures of open penetrations. The inspection verified TVO's procedures and a new tool for managing opened penetrations. According to STUK's estimate, the situation for managing opened penetrations was now considerably improved.

No significant deficiencies were identified in view of the other inspection targets and, based on the inspection, it can be established that the fire protection arrangements at the OL1/2 plant units are at an acceptable level.

Radiation protection, 20–21 March 2019

The inspection focused on dosimetry. For the purpose of the inspection, the dosimeters were subjected to a blind test, the results of which were reviewed in connection with the inspection. The test did not reveal any evidence that would indicate any defects in the analysis of the results of the dosimetric service. The approaching commissioning of the OL3 plant unit has increased the number of dosimeters in use and working in the facilities reserved for dosimetry.

Work on the determination of the equivalent dose for the lens of the eye has progressed. With the help of the measurement campaigns, TVO has been able to establish that the dose targeted to the eye does not significantly differ from the effective dose. In future, the doses of the eye will be determined in the case of work tasks where the dose for the lens of the eye may be higher than the dose for the rest of the body. These doses will be reported to the dose register as separate doses.

The amendments to the radiation legislation that came into force at the end of 2018 have not yet been fully updated to TVO's radiation protection procedures. In the inspection, it was required that amendments to the legislation be included in the facility's procedures as soon as possible, although in practice, the facility is already operating in accordance with the new Radiation Act.

Furthermore, it was required in the inspection that the equipment approved in connection with the approval of the dosimetric service be documented in the safety analysis report of the facility.

Security arrangements, 21–24 May 2019

The inspection targeted the security arrangements of the OL1/OL2 power plant units. The inspection also included an annual outage inspection in terms of security arrangements. During the annual outage, the activities at the site gate were monitored in particular, including monitoring of entry and exit traffic of persons and vehicles. On the basis of the inspection,

STUK presented 2 requirements relating to the monitoring of passenger traffic in and out of the facility. Also several observations were recorded in the inspection, including good practices related to the operations of the security organisation and follow-up of the exercise measures. All STUK's requirements as set out in the previous inspection have been properly implemented and closed.

Safety design, 4–5 September 2019

The inspection focused on the analyses used by TVO to justify the design solutions of the plant modifications, namely the deterministic safety analyses, probabilistic risk assessment (PRA) and the failure tolerance and common cause failure analyses. The inspection covered the measures currently in place and their development needs. The inspection targeted analyses performed by TVO itself and those commissioned from a third party.

A number of examples from each of the above analysis groups were examined during the inspection. As a positive observation, STUK stated that TVO carries out a number of analyses to support its own operations, which are not submitted to STUK for inspection. The inspection also found that the new investigations carried out in connection with the renewal of the operating licence improved significantly the overall picture of the current failure tolerance and operational entity of the OL1/2 plant units.

On the basis of the inspection, STUK presented one requirement regarding the development of the modification design procedures. TVO must develop its procedures to ensure that the effects of potential common cause failures of an individual component type are fully taken into account in the design.

Safety functions (OL1/2), 8–9 October 2019

The inspection assessed the licensee's procedures used to ensure that the systems implementing safety functions are in a state required for safety and that their basis is correct. The 2019 inspection entity was "Fuel and reactor". The system responsibility analyses of the systems relating to the aforementioned subject were reviewed in the inspection, and the status of the systems was discussed with TVO based on the analyses. In the case of the systems, documentation was used to verify, among other things, performed and planned maintenance work tasks, results of periodic tests and the spare parts situation.

The inspection was mainly aimed at determining whether TVO is testing in the periodic tests the critical operating times in view of the implementation of the safety functions. Based on the findings of the inspection, a requirement for reassessing the general procedures related to periodic testing was presented. TVO must establish whether the response time criteria for the implementation of the safety functions are fully taken into account in the tests. In addition, STUK required TVO to develop the test arrangements for the periodic testing of the extra borating system in such a way that the tests establish whether the necessary measures for starting the extra borating are being implemented quickly enough in view of the assumptions used in the safety analyses.

On the basis of the inspection, STUK concluded that, in view of the inspected systems, the procedures to ensure the operating condition are sufficient, but some observations, resulting

from ageing, have been made and system modernisation projects are being planned. STUK considers the measures taken to be necessary.

Emergency response arrangements, 3–4 April 2019

The emergency preparedness arrangements inspection comprehensively covers the nuclear power plant's emergency preparedness arrangements. Issues that are regularly inspected include emergency preparedness guidelines, facilities and equipment, the emergency response organisation and related training. In 2019, also the fulfilment of the new requirements of STUK Regulation Y/2/2018 and the readiness level of the emergency response arrangements in view of starting the OL3 plant unit were verified.

The development and training of TVO's emergency response organisation has been targeted in view of starting the OL3 plant unit, in addition to which TVO has invested in the management of contamination in an emergency situation. TVO's external radiation monitoring network stations are in a good condition, except for two stations, but no new spare parts are available after the equipment supplier stopped manufacturing the stations. A replacement project of the external radiation monitoring network has been launched. On the basis of the inspection, the operation of the radiation monitoring network can be estimated to remain sufficient until its replacement begins (autumn 2021). TVO has fixed almost all the shortcomings identified in the 2017 emergency response exercise. However, TVO has not been able to start equipping the emergency response premises, because the OL3 plant supplier has not yet handed over the emergency response premises for TVO's use. STUK will verify the readiness of the emergency response premises before fuel loading to the OL3 reactor.

On the basis of the inspection, STUK presented six requirements. TVO must appoint the emergency workers and complete the arrangements of the "just in time" emergency training for the emergency helpers. TVO must appoint more persons to a few emergency positions, complete its emergency preparedness plan in terms of receiving external assistance and describe the regular assessment of the design bases of the emergency response arrangements in its operating system. In addition, TVO must supplement the emergency readiness plan in view of the evacuation arrangements to be used at OL3. The evacuation arrangements must take into account the annual outages, when there are exceptionally many workers at the facility.

Power plant waste, 30 September – 4 October 2019

STUK oversees and inspects the treatment and final disposal of radioactive power plant waste at the Olkiluoto nuclear power plant. Low and medium level waste is generated in maintenance and repair work and in the cleaning of process water. The waste inspection covered the observations from the previous inspection and the development and notable events after the previous inspection. The inspection included waste management processes, human resources planning and radiation doses to the personnel. The condition of facilities in which waste is processed, stored and disposed of, radiation levels in these facilities, their classification and their markings were inspected during the site visit.

The inspection resulted in three requirements regarding the procedures for the transport of nuclear waste, the revision of the task groups of radiation workers to be reported to the

radiation dose register and the update of the correlation ratios of the alpha nuclides to the power plant waste treatment manual. No major deficiencies or development needs were found in the inspection. In the holistic development of waste management, planning at TVO has concentrated on the harmonisation of the solidification process for waste resulting from all three plant units and on underground final disposal.

Annual outage (OL1/2), 1 May – 11 June 2019

The inspection concerning annual outages covered and verified Teollisuuden Voima Oyj's (TVO) OL1 and OL2 plant units' annual outage actions used to maintain safety as well as the actions used to manage and control operations during an annual outage. Inspectors from several fields of technology participated in the inspection. They monitored the activities, conducted site walk-arounds, interviewed employees and oversaw the progress of planned work.

The particular subjects of this year's inspection were the implementation of the primary circuit pressure test at the OL2 plant unit. Other areas of the inspection included operating procedures and practices during the annual outage, radiation protection of workers, electrical and I&C technology, criticality and scram tests of the plant, construction engineering and fire protection. STUK's general oversight theme was procedures related to the management of foreign material that STUK's inspectors verified at the work sites.

The primary circuit pressure test carried out by TVO at the OL2 plant unit was successful. STUK carried out the inspection by participating with TVO's QC inspectors in the inspection rounds of the controlled area, by interviewing TVO's staff responsible for carrying out the test and by monitoring the test in the main control room of OL2. The leaktightness of the primary circuit was at a good level and the acceptability criteria set for the test were met with a fair margin. According to STUK's observations, the personnel involved in carrying out the pressure test acted in an exemplary manner.

The inspection targeting the management of foreign material (FME) concluded that TVO's investment in developing the management of foreign material shows at the work sites and in the operations of the facility. The observations made by STUK in the field were mostly positive. The cleanliness of the work sites has clearly improved from the previous years, but also shortcomings were observed. In STUK's view, the recruitment of a full-time FME coordinator has introduced to the FME activities much needed holistic vision and a systematic approach to the further development of the activities.

In the inspection targeting the procedures of the conduct of operations during the annual outage, STUK made observations concerning, among other things, working hours, workload, additional human resources of the shift, managerial work and reacting to alarms. The operations of the shifts during annual outages differ in some respects from the operations during power operation. A lot of work is being done at the facility in a short time (weeks). Additional human resources (e.g. work permit office staff, persons in charge of line-up, extra operators) are assigned to assist the operating shift and some of the normal tasks of the operating shift are transferred to them. The work permit office in connection with the main control room is responsible for the work permits and the scheduling of annual outage work. Based on the inspection, it was concluded that the conduct of operations during the

annual outages of OL1/OL2 is well-established, it has reached its current form on the basis of experiences gained over decades. The main control room operations were controlled.

Three requirements were presented based on the inspection. TVO must process the findings and conclusions made by STUK on the conduct of operations as part of its normal annual outage development work. In addition, TVO must instruct the necessary procedures for opening the turbine smoke hatches in cases when there is no fire. The third requirement concerned the renewal of the electrical penetration modules of the containment. It was not possible to start the replacement of the penetrations as planned at OL2 due to delays in the qualification of the penetrations. STUK required TVO to submit for information an updated project and quality plan, taking into account the penetration replacements that were not carried out during the annual outage.

Management of human factors, 9–10 September 2019

The inspection examined TVO's procedures in the following subareas of human factor management: management of human factors in the design and implementation of plant modifications, processing of human and organisational factors in resolving and investigating operational events and in learning from experiences, and TVO's HU programme (Human Performance). In addition, TVO's human resources in the management of human factors and the connections between the PRA and management of human factors were examined.

STUK stated that TVO's procedures for managing human factors in the design of plant modifications are in part fairly technical in nature and do not necessarily allow systematic processing of human performance and phenomena related to factors limiting it. As regards resolving and investigating operational events, STUK stated that TVO is committed to investigating human and organisational factors of operational events and that competence related to human factors in the investigation of events has improved at TVO in recent years.

Three requirements were presented based on the inspection in order to develop the procedures. Among other things, TVO must develop the procedures to systematically observe human factors in the design of plant modifications. STUK also required TVO to develop the use of the HU methods in the maintenance operations to allow comprehensive use of the methods and to improve the monitoring of the implementation of the HU programme.

Control of manufacture and delivery chain in the EDG project, 27–28 August 2019

The inspection focused on monitoring the delivery chain and manufacture of the replacement project of the emergency diesel generators (EDG) of the Olkiluoto power plant and the related processes and procedures. In addition, the processing of deviations and how the lessons learnt from the challenges in the delivery of the OL3 emergency diesel generators have been utilised in the project were examined. In the emergency diesel generator update project, the plant's eight emergency diesel generators will be replaced and a ninth generator will be built, enabling the replacement of diesel generators during power operation. The commissioning of the first new emergency diesel generator will take place, according to TVO's estimate, in late 2019. Then, the remaining eight emergency diesel generators will be installed and commissioned one by one in such a manner that the last one will be commissioned in spring 2023.

According to STUK, TVO has learned from the OL3 project and actively sought lessons learn from elsewhere to succeed in the EDG replacement project. However, based on STUK's observations, TVO has not sufficiently ensured the coverage of the supplier's inspection activities, and there has been shortcomings in the timing and coverage of monitoring performed by TVO itself during the welding of the pressure equipment. In addition, there is room for improvement in the processing of TVO's own corrective and preventive measures regarding supplier deviations.

On the basis of the inspection, STUK presented two requirements. TVO must prepare a plan on how TVO intends to carry out adequate monitoring during manufacturing, and the plan must be submitted to STUK for information. In addition, TVO must add to its procedures the methods for processing minor deviations.

APPENDIX 4
Construction inspection programme of Olkiluoto 3 in 2019

The OL3 plant unit was dealt with both in the readiness inspections and inspections specified in the periodic inspection programme because many functions inspected are shared by all plant units of Olkiluoto. The inspections specified in the periodic inspection programme are described in more detail in Appendix 3. This appendix includes a short summary for OL3.

The inspections concerning solely the Olkiluoto 3 plant unit were made in accordance with the readiness inspection plan. The objective of the construction inspection programme (RTO) is to verify that the functions required by the construction of the facility ensure its high-quality implementation in accordance with approved plans, while following the official regulations and without jeopardizing the operating plant units at the plant site during the different stages of the construction project. The inspection programme of Olkiluoto 3 was launched in 2005 when construction of the unit started, and the last RTO inspection was performed in November 2017. Because the RTO programme ends in an operating licence and it was to be expected that OL3 gets the licence during spring 2018, no semiannual RTO plan was prepared for spring 2018. Instead, a readiness inspection plan was prepared. Due to delays in the project, the granting of the operating licence was transferred to the beginning of 2019. After the operating licence, fuel loading has been transferred several times, so STUK has updated and completed the inspection programme based on the project schedule and other inspection findings.

Readiness inspection plans are part of the verification of safe use required by Section 20 of the Nuclear Energy Act:

Operation of the nuclear facility shall not be started on the basis of a licence granted:
(1) until the Radiation and Nuclear Safety Authority (STUK) has ascertained that the nuclear facility meets the safety requirements set, that the physical protection and emergency planning are sufficient, that the necessary control to prevent the proliferation of nuclear weapons has been arranged appropriately, and that the licensee of the nuclear facility has, as provided, arranged indemnification regarding liability in case of nuclear damage.

During the year, readiness inspections were performed as follows:

Inspection	Date
Nuclear security	15—17 January 2019 26—28 February 2019 9—11 April 2019 5—6 June 2019 17—19 September 2019 26—28 November 2019 17—19 December 2019
Operations of TVO's mechanical quality assurance	7—8 May 2019
Spare parts management procedures, re-inspection	28 May 2019
Commissioning of the controlled area	The inspection was started on 31 October 2019 but it will be continued in 2020

The security arrangement inspections assessed the readiness of the Olkiluoto 3 plant unit from the point of view of the implementation of the security arrangements. The inspection scope included procedures related to key management and access and material control during the various phases of commissioning, the functioning of security surveillance systems as their installation and commissioning progresses, and the operations and training and exercise activities of the security organisation. The implementation of the security arrangements has progressed throughout the inspection period.

An unannounced surprise inspection was carried out on the operations of the mechanical side of TVO's quality control organisation. The inspection included interviews with TVO's quality control organisation inspectors and covered, among other things, managing the whole entity and situation, preparing for inspections and practical procedures related to deviations. On the basis of the inspection, STUK concluded that TVO's resource situation and staff experience are at a good level and orientation activities have been properly implemented. Based on the inspection, STUK presented requirements regarding, for example, better preparing for the inspections of TVO's quality control organisation, recording of inspection findings and plans for the transition to the procedures of an operating facility.

The inspection on the procedures for managing spare parts focussed on the spare parts ensuring the operating condition of equipment needed to manage long-term operational occurrences and accidents as required by the YVL Guides. On the basis of the inspection, it was concluded that a significant part of the required spare parts were not yet delivered to TVO. In the inspection, STUK set a requirement to TVO regarding the submittal of a report to be prepared on the spare parts inventory status. STUK will verify the existence of the spare parts required by the YVL Guides before the loading of fuel into the reactor of the Olkiluoto 3 plant unit.

During the year, matters concerning the OL3 plant unit were addressed, for example, in the below periodic inspections. The inspections are described in more detail in Appendix 3. Below is a brief presentation of the most essential things with regard to the OL3 plant unit.

Periodic inspections that also covered the OL3 plant unit:

Inspection	Date
Chemistry	29–30 January 2019
Radiation Protection	20–21 March 2019
Emergency arrangements	3–4 April 2019
Operating experience feedback	18 October 2019
Human resources and competence	3–4 December 2019

The periodic inspection of chemistry covered the activities of the chemistry unit at the OL3 plant, the monitoring of hydrochemistry and radiochemistry of the loading pool and the human resource situation. On the basis of the inspection, STUK concluded that the activities are at a good level, and no requirements were set based on the inspection.

The periodic inspection of radiation protection focused on dosimetry. The inspection covered the dose measurement process and practical procedures and instructions. In terms of the Olkiluoto 3 plant unit, the inspection targeted in particular the introduction of the primary neutron sources into the plant and their installation in the fuel assemblies. Based on the inspection, several requirements were set regarding the dose measurement procedures at all power plant units.

The periodic inspection of the emergency response arrangements covered emergency preparedness procedures, facilities and equipment, the emergency response organisation and related training. Also the fulfilment of the new requirements of STUK Regulation Y/2/2018 and the readiness level of the emergency response arrangements in view of starting the Olkiluoto 3 plant unit were verified. Based on the inspection, it was concluded that the development and training of TVO's emergency response organisation has been allocated in view of starting the plant unit, but equipping the emergency response premises is still incomplete. On the basis of the inspection, STUK also stated that the emergency readiness plan must be updated with respect to the assembly and evacuation arrangements applied at Olkiluoto 3, and more personnel must be appointed and trained for specific tasks of the emergency response organisation.

The periodic inspection of operating experience feedback targeted the processes and organisation of operating experience feedback and the related procedures. The inspection assessed in particular the utilisation of external operating experience feedback. The inspection concluded that the organisation of and instructions for TVO's external operating experience feedback have been developed and the operations improved in line with the changes in the operating environment.

The periodic inspection of human resources and competence focused, as regards the OL3 unit, on the development of competence of mechanical maintenance. The inspection found that although the procedures have been developed, the workers' sense of control over their work could be better. This is also due to the fact that there has yet been little actual maintenance work to be done at the plant, work tasks have mostly involved preparations and planning. One requirement was set in the inspection regarding the impact assessment of organisational changes.

APPENDIX 5
Inspections pertaining to the processing of Fennovoima's construction licence application 2019

STUK performs reviews and assessments of the management systems of Fennovoima and the other organisations participating in the project. Furthermore, STUK performs inspections of the organisations to ensure that their actual operations comply with what is specified in the management systems and that they meet the necessary requirements.STUK launched the inspections included in the regulatory inspection programme (RKT) in September 2015. The RKT inspections are planned every six months, and STUK carried out six inspections according to its inspection programme in 2019. Two of the four inspections included in the regulatory inspection programme (RKT) related to the processing of the construction licence and planned for the first half of 2019 were decided to be carried out in the autumn. The results of the audit targeted by Fennovoima on Atomproekt showed that the requirements previously set by STUK are not yet met. For this reason, it was decided to postpone STUK's RKT inspection at Atomproekt until the end of 2019, and as the selection of the main I&C supplier moved forward, STUK did not see fit to carry out the inspection. The I&C RKT inspection of Fennovoima was transferred to the beginning of 2020. The results of the RKT inspections will be used by STUK when preparing a safety assessment and statement on the construction licence.

Summaries of the inspections performed in 2019 are presented below.

Fennovoima: Inspection of electrical engineering

The electrical engineering inspection focused on design monitoring and processing of the construction licence material by Fennovoima. The inspection assessed the general situation of Fennovoima's electrical engineering with its resources, the current situation of design and construction licence material and examined the organisation of electrical engineering quality management procedures.

On the basis of the inspection, STUK required that Fennovoima verify the coverage of the quality and qualification plans and that the said plans have been complied with in the preparation of design documentation in the construction licence phase. Fennovoima must also assess the need to update its inspection procedure and its participation in the phase reviews of electrical design. On the basis of the verification carried out in the inspection, one previously set requirement was closed.

Fennovoima's management and organisational operations and procedures in handling safety issues

The inspection covered the activities of Fennovoima's management and organisation in identifying, monitoring and processing of safety issues. STUK also verified the status of issues left open in previous inspections and key management system processes, such as the processing of safety issues, competence and resource management, HR activities, configuration and requirement management, including change management and safety culture. STUK's inspectors also followed Fennovoima's staff meeting, to which a representative of the lead designer had been invited to speak.

STUK stated in its inspection that Fennovoima has not finished the description of its management system or its organisational manual after the reorganisation, which is why the responsibilities and decision-making within the organisation have not yet been recorded. STUK observed that Fennovoima's knowledge of the supplier's key organisations is weak in parts. However, the inspection showed that the quarterly management reviews of Fennovoima are more risk-based than before.

STUK did not present any new requirements in the inspection, but many requirements, which have been open for a long time, remained still open. Fennovoima has sought and STUK has granted time extensions for many open RKT requirements. In the inspection, STUK stated, however, that it is important for Fennovoima to understand that solving the issues in the last leg of the race, before the granting of the construction licence as planned in the project schedule, can involve risks. STUK presented in its inspection decision a topical meeting for October in view of monitoring the open requirements regarding the management system. In the meeting, Fennovoima's management would present to STUK the key documents and contents of its management system.

Fennovoima: Supply chain management

STUK inspected Fennovoima's organisation and procedures in the management of supply chains. The inspection covered Fennovoima's operating principles, supply chain management-related strategies, organisation and division of responsibility, as well as the capabilities and readiness of suppliers. The inspection concluded that Fennovoima has not assessed the operations of the organisational unit responsible for the preparation of the Preliminary Safety Analysis Report. STUK required Fennovoima to plan and carry out an assessment by the end of 2019. The issues to be observed in the assessment include the organisation's competence, resources, management relationships and operational guidance.

The inspection also covered Fennovoima's safety culture work at the site. STUK observed that safety culture work at the site and monitoring the development of the main contractor's, Titan-2, safety culture is active.

Principle Designer Atomproekt

STUK's inspection concerned the management and operations of the lead designer, JSC Atomproekt, and covered the actions and procedures of Atomproekt in identifying, monitoring and processing safety issues and in assessing and managing suppliers. The inspection verified,

with the help of examples, the functioning of the above-mentioned processes in accordance with the related procedures.

During the inspection, STUK observed positive developments in many of the lead designer's operations and procedures. The inspection found, however, that Atomproekt does not monitor the progress of the design process phases – for example, the phase review of the concept design phase has not been carried out, although the basic design phase work has already been started. Therefore, Atomproekt must assess the adequacy of the assessment of the current design process monitoring and management procedures, phase reviews and quality plan implementation and that of the independent assessment of the system requirements.

In the inspection, STUK drew attention to the fact that Atomproekt does not comply with its own procedures in operations regarding safety-related human factors.

STUK also required that the STUK Regulations and YVL Guides in force used in the design must be presented in the licensing documentation in a way to ensure comprehensive observation of all relevant requirements in the design of the facility. The Preliminary Safety Analysis Report of the Hanhikivi 1 facility must also be based on the same, frozen baseline of plant design.

Fennovoima: Security arrangements and information security

In the inspection of the security arrangements and information security, STUK verified the corrective actions taken by Fennovoima on the basis of the findings of the previous inspections. Approximately half of the previous observations were closed. In the inspection, STUK also set new requirements on the basis of which Fennovoima appointed, among other things, a new responsible person for the special status used for processing safety-classified official documentation and for the related document processing.

Fennovoima: Management and the handling of safety matters

The inspection covered the activities of Fennovoima's management and organisation in identifying, monitoring and processing of safety issues. As a result of the inspection, STUK stated that Fennovoima is developing its operations extensively and changes in operating methods must be taken into account in the management system processes. The inspection resulted in the closure of requirements relating, among other things, to quality control (QC) and the development plans of the licensee.

APPENDIX 6
Construction inspection programme for the encapsulation plant and the disposal facility 2019

In 2019, STUK's licensing and construction oversight project PORA regarding Posiva's spent fuel disposal project continued systematically the inspections included in the construction inspection programme. The aim of these inspections was to assess the functionality of Posiva's management system as well as the sufficiency and appropriateness of the procedures for implementing and controlling the plant construction work and for taking the safety requirements into account in the project. Inspections included in the programme may also be targeted at Posiva's suppliers that are important to safety. The 2019 inspections only focused on the licensee's operations.

The 2019 programme included five inspections on current activities important to the safety of the construction phase. The number of inspections remained at the level of the previous year. No significant changes have taken place in Posiva's operations since that time, and for this reason STUK decided to focus its 2019 inspections on Posiva's basic operations. Based on the results of STUK's inspection, it was noted that Posiva's operations and management system procedures in the assessed areas of operation are sufficiently compliant with STUK's requirements

Brief descriptions of the inspections as well as the key observations made, based on which STUK has required Posiva to carry out improvements and development actions, are presented below.

Design of the rock construction of the final disposal facility

The objective of the review concerning the design of the rock construction of the final disposal facility was to ensure that Posiva is able to produce design documents that are in line with the requirements. The inspection covered the phases of the design process from initial data specification to the inspection of result documentation and the interfaces of processes directly linked to design. In addition, the inspection addressed the management of outsourced design services.

On the basis of the inspection, Posiva's procedures are mostly good and sufficiently well defined. Based on the inspection, Posiva was presented with three requirements regarding resourcing and competence and the specification of initial data.

Construction of the nuclear waste facility

Posiva was about to start the construction of the encapsulation plant in summer 2019. The objective of the inspection was to ensure Posiva's organisational readiness to start the construction. The inspection covered the procedures regarding the management of construction activities and verified that adequate procedures were established for the functioning of the site. The inspection addressed the suppliers' quality management procedures, resource management and verified the construction competence requirements. As regards the construction site of the encapsulation plant, the organisation of the site was checked, and the design modification procedures, non-conformance management, reporting and communications were examined. The inspection concluded that Posiva has sufficient organisational capacity to proceed to the construction phase of the encapsulation plant. The requirement presented as a result of the inspection regarded the submittal of updated project documents to STUK for processing.

Impact of changes to the final disposal concept on the preparation and management of the safety case

The inspection focused on the impact of changes to Posiva's final disposal concept and on the preparation and management of the safety case. The inspection assessed Posiva's procedures and activities employed to meet the requirements of the YVL Guides in terms of preparing the safety case.

The inspection assessed the functionality of the safety case management; the preparation of the safety case and the management of changes by Posiva. In addition, the inspection assessed the resource management procedure employed by Posiva in the preparation of the safety case. Posiva has specified procedures for managing changes in general and in view of the safety case preparation. On the basis of the cases examined as examples during the inspection, the procedures are functional. Based on the inspection, Posiva has procedures in place for managing resources, both in terms of adequacy and in terms of ensuring competence.

Security arrangements of the encapsulation plant

The section on the security arrangements of the readiness inspection related to the construction of the encapsulation plant. The inspection covered issues in relation to the previous requirements. On the basis of the inspection, one requirement and nine observations were made. The observations concerned, among other things, the up-to-dateness of documents, cooperation with the police, structural shielding and spent fuel transports and transfers. The requirement concerned the access procedures and key management of the vital areas. The inspection did not reveal any obstacles to the continuation of the encapsulation plant site.

Management and safety culture

The construction inspection programme targeting management assessed Posiva's procedures for the management of the final disposal project and processing safety issues. The inspection verified that Posiva processes changes to the plant concept approved in the construction licence at the appropriate organisational level in view of safety. The inspection also verified that the safe implementation of the nuclear facility is taken into account in the management of the schedule for Posiva's nuclear facility project. The inspection covered Posiva's actions to develop the safety culture of its own organisation and to ensure that the suppliers involved in the construction observe good safety culture. The inspection also verified the fulfilment of the requirement concerning Posiva's resource planning.

Posiva has developed its safety management procedures, for example, by strengthening the role of the programmes and setting up dedicated steering groups for the programmes. The overall management of programme tasks, resources, schedule and risks has been developed, which enables Posiva to better assess the project as a whole than in the past. In order to ensure the smooth progress of the project and the implementation of the rock facilities according to the requirements, Posiva must comprehensively assess the development needs of the rock engineering process and the design review process and to ensure the functioning of the process before the rock engineering design documentation for the final disposal tunnel is submitted to STUK. STUK set a requirement to Posiva on this matter.

In the inspection, design change examples were used to verify that the design changes have been dealt with at a sufficient level in accordance with the design change process. Based on the inspection, the changes affecting safety have been processed as specified in the management system and at an appropriate level within the organisation.

The inspection concluded that Posiva is able to identify development areas of safety culture, select concrete measures and prioritise them in a fairly consistent and transparent manner. The goal-orientedness of developing safety culture is supported by the fact that the development of Posiva's safety culture is also strongly linked to the company's current strategic development challenges.

Posiva has procedures in place aiming to ensure the suitability of the suppliers it uses for the nuclear sector and their understanding of the specific operational requirements of the sector. Based on the inspection, Posiva's procedures for compiling observations about the safety culture of the suppliers and responding to shortcomings were somewhat fragmented. Posiva is taking measures to assess and develop the safety culture of the suppliers (at the site) and has identified site monitoring as one of the development areas for next year.

Posiva has developed its procedures for project management. Developing the resource management procedures improves schedule management and better highlights resource needs. STUK considers that the resources management procedures as part of the project management are sufficient.

APPENDIX 7
Licences STUK has granted in accordance with the Nuclear Energy Act in 2019

Teollisuuden Voima Oy

- 1/C42214/2019, 15 February 2019: OL1, OL2 – Import of software used in refuelling planning from Japan. Last date of validity 31 December 2030.
- 1/G42214/2019, 13 March 2019: OL3 – Import of spare parts for the fuel transfer machine from France. Last date of validity 31 December 2022.
- 4/C42214/2019, 2 April 2019: Export of decommissioned OL1/OL2 components to Sweden for processing. Last date of validity 31 December 2020.
- 2/G42214/2019, 24 April 2019: OL3 — Import of a control rod actuator from France. Last date of validity 31 December 2019.
- 3/G42214/2019, 24 May 2019: OL3 — Import of control rod actuator drive shafts from France. Last date of validity 31 December 2020.
- 4/G42214/2019, 7 August 2019: OL3 — Import of neutron detectors for the boron concentration measurement system from France. Last date of validity 31 December 2020.
- 5/C42214/2019, 15 August 2019: Possession of sample fuel rods. Last date of validity 31 December 2039.
- 6/C42214/2019, 11 October 2019: Import of fresh nuclear fuel with Euratom obligation code "D" from Spain (batch OL1 e 42). Last date of validity 31 December 2020.
- 1/D42214/2019, 11 October 2019: Import of fresh nuclear fuel with Euratom obligation code "P" from Spain (OL2 e 40). Last date of validity 31 December 2020.
- 2/D42214/2019, 11 October 2019: Import of fresh nuclear fuel with Euratom obligation code "S" from Spain (OL2 e 40). Last date of validity 31 December 2020.
- 5/G42214/2019, 28 October 2019: OL3 — Import of a neutron detector for the boron concentration measurement system from France. Last date of validity 31 December 2020.
- 7/C42214/2019, 27 November 2019: Import of fresh nuclear fuel with Euratom obligation code "C" from Spain (OL1 e 42). Last date of validity 31 December 2020.

Fortum Power and Heat Oy

- 1/A42214/2019, 1 March 2019 Export of radioactive waste (contaminated scrap metal) to Sweden. Last date of validity 31 December 2019.
- 2/A46201/2019, 10 April 2019: Transport licence for a fresh fuel assembly. Last date of validity 31 December 2019.
- 2/A42214/2019, 29 April 2019: Import of an optimised uranium-free test assembly from Russia. Last date of validity 31 December 2020.
- 6/A42214/2019, 13 December 2019: Import of neutron flux sensors from France. Last date of validity 31 May 2020.

Posiva Oy

- 1/H42214/2019, 22 August 2019: Possession and transfer of fuel documentation subject to the particular safeguards obligation. Last date of validity 31 December 2023.

Others

- 2/H42214/2019, 22 August 2019, Posiva Solutions Oy: Possession and transfer of fuel documentation subject to the particular safeguards obligation. Last date of validity 31 December 2023.
- 1/Y42214/2019, 14 May 2019, Dragon Mining Oy: Licence for the production of nuclear material. Last date of validity 31 March 2029.
- 9/Y42214/2019, 7 August 2019, Palotekninen insinööritoimisto Markku Kauriala Oy: Import and possession of nuclear information subject to the particular safeguards obligation. Last date of validity for import 31 December 2022 and possession 31 December 2024.
- 11/Y42214/2019, 16 December 2019: Norilsk Nickel Harjavalta Oy: Licence for the production, possession and storage of nuclear material. Last date of validity 31 December 2029.

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