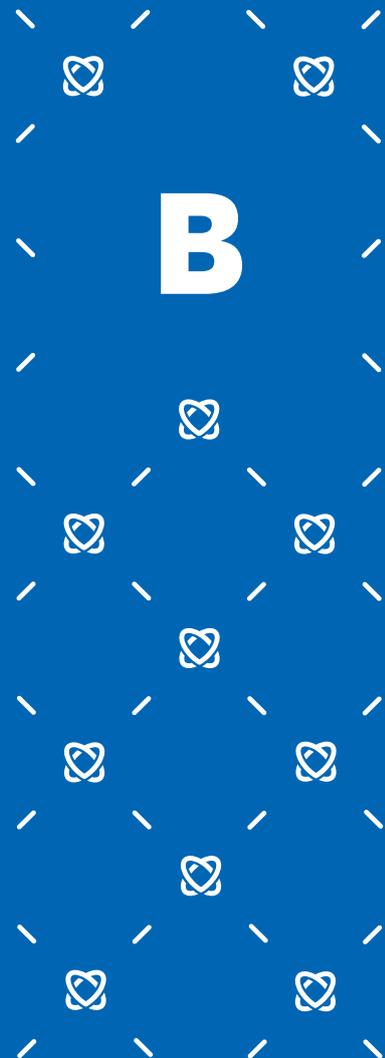




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Juha Häikiö (ed.)



Regulatory oversight of nuclear safety in Finland

Annual report 2021



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Introduction

This report is an account 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 (MEAE) once a year as required by Section 121 of the Nuclear Energy Decree (161/1988). 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 2021. STUK's nuclear safety regulation, as presented in the report, covers the essential oversight data related to the design, construction, commissioning, operation and decommissioning of nuclear facilities. In addition, the report covers similar data on other uses of nuclear energy, including nuclear waste management and nuclear materials. In addition to actual 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 report appendices contain significant events at 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 2021, as required by the Nuclear Energy Decree, is appended to the report.

STUK's Financial Statements and Annual Report 2021 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.



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I Development and implementation of the regulations

Amendments to the Nuclear Energy Act and the Nuclear Energy Decree

In 2021, the most significant part of STUK's regulation preparation work was formed by participation in the preparations for the comprehensive revision of the Nuclear Energy Act, which is under the responsibility of the MEAE. STUK took part in the efforts through meetings on a variety of topics and by preparing related background analyses and reports. In particular, the participants included content experts as well as lawyers. The participation in the comprehensive revision process is on-going, which requires STUK to have sufficient human resources for the relevant tasks.

STUK took part in the regulatory preparation process by issuing statements on an amendment to Section 7(a) of the Nuclear Energy Act (269/2021) to the MEAE and the Parliament's Commerce Committee. The amendment pertains to changes in the administration of National Nuclear Waste Management Funds (VYR) and the funding of safety research conducted through VYR. Even after the revision, the purpose of the Act will be to ensure the expertise of authorities in Finland. The change enables research programmes relating to safety and nuclear waste management to be consolidated into a joint research programme from the beginning of 2023. The amendment entered into force on 1 May 2021.

In addition to the regulatory preparations related to the Nuclear Energy Act, STUK took part in regulatory preparation pertaining to changes to nuclear liability legislation (HE 117/2021 vp) in 2021 and had representation in a hearing event held on the matter by the Parliament's Commerce Committee. The update concerned the staggering of liabilities of the licensee of a nuclear facility in proportion to radiation risks caused by the operations and the abolition of case-specific decision-making to reduce low radiation risk activities, such as transporting fresh nuclear fuel. For the licensee of a nuclear facility used for energy production, the amendment increased the liability at the same time. The Act on the Amendment of the Nuclear Liability Act (1060/2020) and the Act on the Amendment of the Act on the Amendment of the Nuclear Liability Act (1060/2021) entered into force on 1 January 2022, pursuant to VNA 1324/2021.

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

By virtue of Section 7 q of the Nuclear Energy Act, STUK is authorised to issue more specific regulations on the technical details of the principles and requirements laid down in Chapter 2a of the Nuclear Energy Act. STUK has issued five regulations under this authorisation:

- Radiation and Nuclear Safety Authority Regulation on the Safety of a Nuclear Power Plant (Y/1/2018)
- Radiation and Nuclear Safety Authority Regulation on the Emergency Arrangements of a Nuclear Power Plant (Y/2/2018)
- Radiation and Nuclear Safety Authority Regulation on the Security in the Use of Nuclear Energy (Y/3/2020)
- Radiation and Nuclear Safety Authority Regulation on the Safety of Disposal of Nuclear Waste (Y/4/2018)
- Radiation and Nuclear Safety Authority Regulation on the Safety of Mining and Milling Operations Aimed at Producing Uranium or Thorium (Y/5/2016)

No changes were made to regulations in 2021.

Update and implementation of the YVL Guides

Section 7r of the Nuclear Energy Act provides that STUK has the power to issue detailed safety requirements concerning the implementation of the safety level in accordance with the Nuclear Energy Act. According to this Section, STUK shall specify the safety requirements it sets in accordance with the safety sectors involved in the use of nuclear energy, and publish them as part of the regulations issued by STUK. STUK's nuclear safety guides (YVL Guides) are considered binding just as regulations are, but unlike with regulations, the possibility of deviating from the requirements is provided for. STUK's safety requirements are binding on the licensee, while preserving the licensee's right to propose an alternative procedure or solution to that provided for in the regulations. If the licensee can convincingly demonstrate that the proposed procedure or solution will implement safety standards in accordance with Nuclear Energy Act, STUK may approve it.

The series of updates to STUK's YVL Guides, which were made as part of the update to the nuclear safety regulations (2016–2018), was completed on 12 February 2021 when Guides YVL A.11 and A.12 were published. The changes made to the YVL Guides involved mainly clarifications, changes to the regulation references and minor changes to the requirements. A particular aim was to reduce the administrative burden.

The updated YVL Guides will be applied to new nuclear facilities as they are. However, with regard to operating nuclear facilities and facilities that are currently under construction, they will be brought into effect by means of separate implementation decisions by STUK. 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

justified assessment of the fulfilment of the requirements presented in the YVL Guides. Processing of the fulfilment assessments submitted by the licensees started at STUK in late 2019, and the majority of the implementation decisions taken based on them were completed during 2020 and 2021. The final implementation decisions will be completed in early 2022.

STUK's renewal of the nuclear safety regulations

In October 2020, STUK made the decision to begin preparing the structural and substantive renewal of the STUK regulations and YVL Guides (STUK's safety regulations) issued based on the Nuclear Energy Act. First of all, the structural renewal means that STUK's binding requirements (legal provisions, i.e. norms) and the advisory content (recommendations, justifications) will be separated. As regards STUK's regulations, the structural change also entails an examination of the regulatory levels pursuant to Section 80 of the Constitution of Finland, which involves the positioning of the requirements in relation to the Act, Decree and STUK's regulations. The structure will also be updated in other necessary respects. In terms of the substantive renewal, the starting point is to maintain the highest level of safety requirements. After the renewal, the phrasing and language of the safety requirements is, where possible, intended to be technology-neutral and less detailed in order to ensure that the requirements do not unnecessarily limit new acceptable solutions.

STUK has made preparations for the regulatory renewal under the SÄPPI2 project in 2021. Among other things, the project has analysed the current state of the regulations and the needs to change them, studied regulatory updates conducted by other authorities and consulted power companies on the impacts of the regulatory renewal from their perspective. Based on the SÄPPI2 efforts, a project plan was prepared to implement the renewal of the STUK regulations (SYTYKE project) between 2022 and 2027. The key aims of STUK's regulatory renewal is to emphasise operator responsibility, focus oversight based on risk significance and separate binding requirements from guidelines. The aims are related to STUK's efforts to develop oversight in accordance with its strategy. In this context, one of the goals is to improve the goal-oriented, risk-based and enabling nature of the nuclear safety regulations even further.

STUK's work to update the nuclear safety regulations as well as the related schedules are closely connected to the comprehensive revision of the Nuclear Energy Act, which is under the responsibility of the MEAE, because the Nuclear Energy Act and the STUK regulations based on it are linked. In terms of the Act, achieving the goals set for the regulation renewal and the development of STUK's regulatory activities requires basic regulations that include precise and clearly delineated authorities to issue regulations based on which safety requirements can be set and regulatory oversight can be implemented. This will require close cooperation, interaction and communication between reform projects.



2 Results of regulatory oversight of nuclear facilities 2021

The impact of the COVID-19 pandemic on the regulatory oversight of the use of nuclear energy

Over the course of 2021, the regulatory oversight of nuclear power plants was conducted by means of extraordinary procedures as the COVID-19 pandemic continued. The impacts of the pandemic were most significant on oversight activities conducted at STUK's plant sites and abroad. During the first half of the year as the situation around the pandemic was difficult, most inspectors worked remotely and the majority of the inspections were conducted by remote means. Within the STUK organisation, only inspections that were deemed necessary were carried out on location. These included inspections related to the annual outages of Olkiluoto 1 and 2 plant units and the commissioning of the Olkiluoto 3 plant unit. During 2021 more than normal, on-site oversight and inspections were handled by STUK's resident inspectors who work at the plant sites. Production control in other countries was conducted by means of substitutive arrangements, such as remote connections and by performing factory inspection at the plant site.

STUK responded to changes in the pandemic situation. As the vaccination coverage increased and restrictions began to be lifted in the autumn of 2021, more inspection and control visits were carried out at the plant site. The remote work recommendation was also removed temporarily. During the latter half of the year, control visits abroad were conducted on a discretionary case-by-case basis. Plant site control was primarily carried out in situations where remote arrangements would have been inefficient. When the pandemic situation deteriorated in December 2021, control and oversight activities were once again primarily performed remotely. In addition to this, plant site inspections and control visits were considered more carefully.

The work arrangements have not scaled back the control programme or impacted its quality. The majority of STUK's oversight is based on document reviews, which were continued remotely as normal. Inspections have been mainly carried out through remote or hybrid arrangements in which inspections have been performed partially remotely and partially on site. The precondition for remote and hybrid inspections is that STUK receives all the information it needs from the inspection and can use this information to assess the state of safety and verify compliance with the regulations. The experiences of remote and hybrid inspections have been largely positive.

STUK supervised the procedures of nuclear power plants to manage the COVID-19 pandemic. Despite the extraordinary circumstances, Finnish nuclear power plants operated normally throughout 2021, and the measures taken to prevent the spreading of the coronavirus have not been found to compromise operational safety in any way. The responsible actions of the licensees and nuclear power plant employees are more important than ever in abnormal situations, and STUK has not observed any shortcomings in this regard.

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 are safe to the employees, the population and the environment.

In terms of modifications, the installation work related to the partial renewal of the plant protection arrangements were conducted during the 2021 annual outage. The descriptions of the annual outages and the most significant events are presented in Appendix 2, and the summaries of the inspections in accordance with the periodic inspection programme (KTO) 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 2021 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 (0.093 manSv at Loviisa 1 and 0.147 manSv at Loviisa 2).

The radiation doses of the Loviisa power plant's personnel have decreased in the 2000s through the development of work methods and systems, for example, and because the amount of high activated substances in components connected to the primary circuit has been significantly reduced in accordance with the ALARA principle. The radiation doses are higher in even years, which is when an extensive annual outage is carried out at one plant unit (in 2021, both plant units went through short annual outage procedures).

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 highest personal dose received at the Loviisa power plant was 5.8 mSv and resulted from cleaning work.

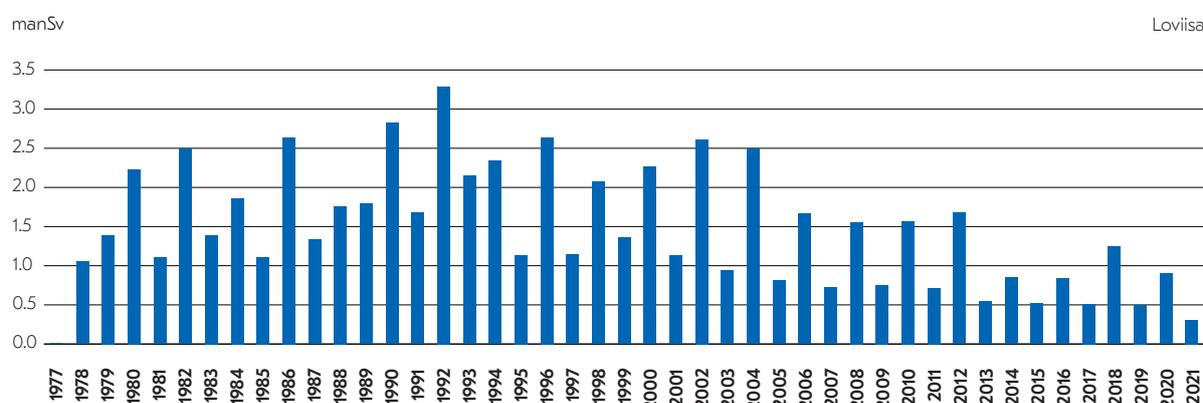


FIGURE 1. Collective occupational doses since the start of operation of the Loviisa nuclear power plant.

Radioactive releases into the air and sea remained clearly below the set limits, despite the minor fuel leak at Loviisa 2 and the planned discharge of evaporation waste. The calculated radiation dose of the most exposed individual in the vicinity of the plant was less than 1% of the limit of 0.1 mSv set in the Nuclear Energy Decree (161/1988).

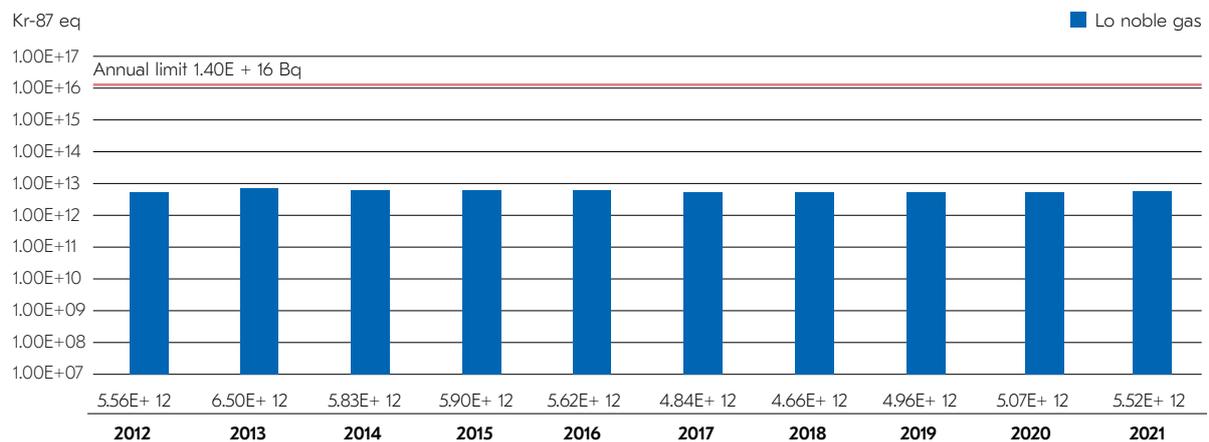


FIGURE 2. Noble gas releases to the atmosphere (Kr-87 eq), Loviisa.

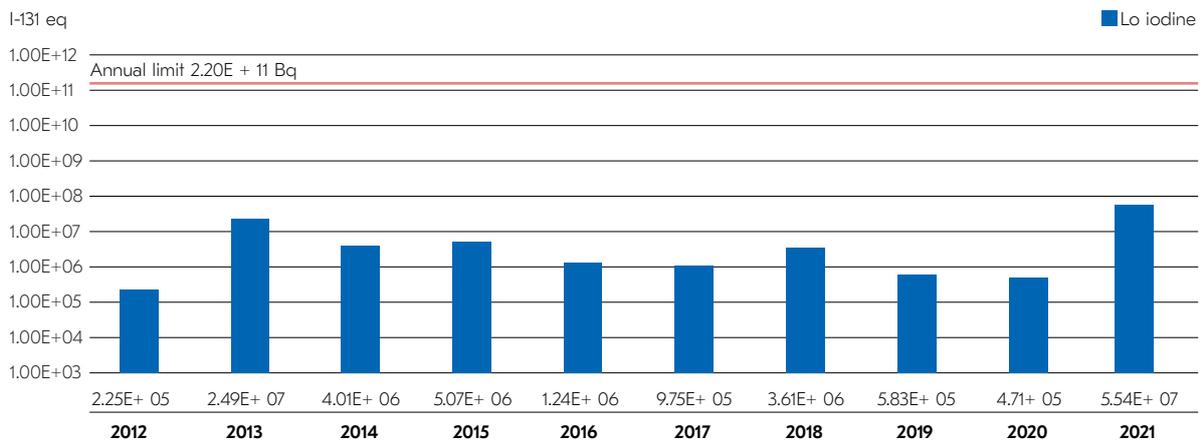


FIGURE 3. Iodine isotope releases to the atmosphere (I-131 eq), Loviisa.

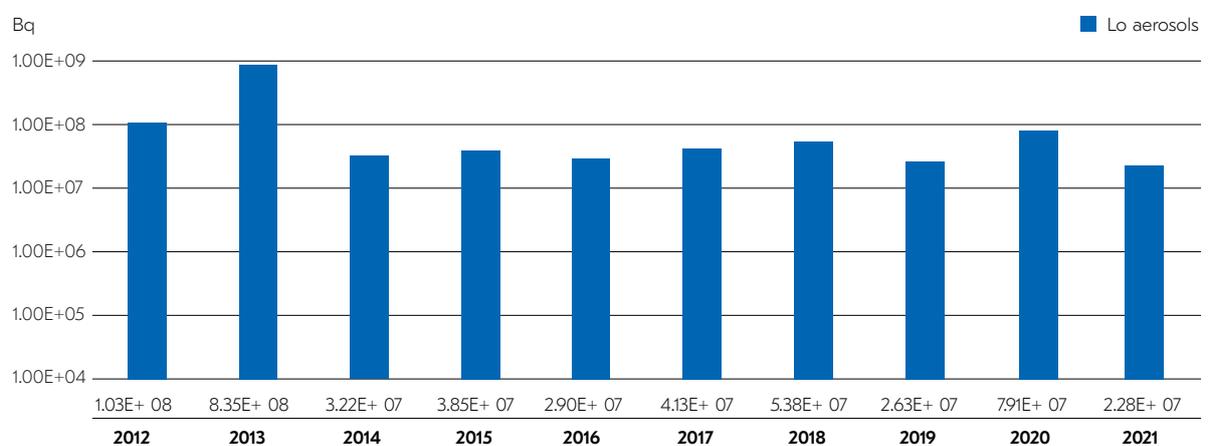


FIGURE 4. Aerosol releases to the atmosphere (Bq), Loviisa.

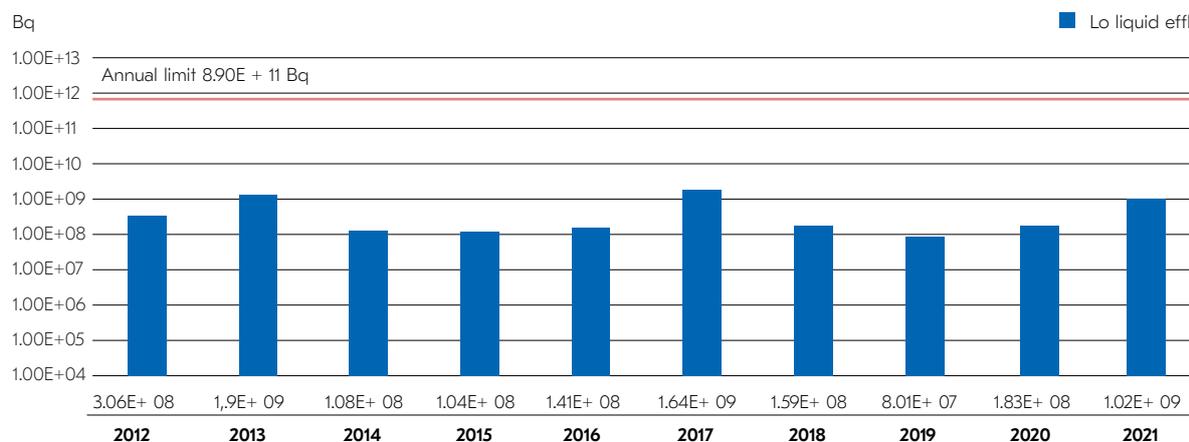


FIGURE 5. Gamma activity of the liquid effluents (Bq), Loviisa.

A total of approximately 440 samples were collected and analysed from the land and marine environment surrounding the Loviisa power plant in 2021. The measured concentrations were so low that they are insignificant in terms of the 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.

Operational events and operating experience feedback

Fortum notified STUK of eight events in 2021. In addition to this, STUK requested information on ten other events identified by Fortum. Four of them took place in 2021, five in 2020 and one in 2019. As a conclusion, STUK can state that Fortum identifies operational events at the plants and initiates event investigations to determine the causes and to improve the operation of the plant and the organisation. 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 investigations, STUK verified that Fortum has investigated the underlying causes of the events and initiated the necessary actions to correct technical faults and deficiencies in its organisation's operations and to prevent the reoccurrence of the events. By the end of 2021, STUK had reviewed 10 reports, 2 reports were under review, and 4 reports will be delivered in 2022. In one case, STUK required the possible cause to be investigated on a wider scale and the sufficiency of the measures determined by Fortum to be assessed. In other respects, STUK deemed Fortum's event investigations sufficient.

STUK also used the events to discern the status of the various controlled areas and focus its control measures. During the KTO inspection, STUK investigated Fortum's response to the radioactive particles found in the yard area. STUK required Fortum to identify development targets relating to the restraint of goods and transport arrangements and to present STUK with an action plan to improve the situation. STUK also oversaw the development of the process computer's operating systems, as some alerts and warnings were missed and therefore not responded to in the main control room during the annual outage, which caused deviations

from the Operational Limits and Conditions in some situations. In its request for clarification, STUK necessitated improvements in the development of operating systems for the process computer since it was found that the event-based measure had been delayed. Furthermore, it was found that some procedures and responsibilities related to the development of operating systems for the process computer had not been agreed.

STUK discontinued the efforts to intensify the oversight of the internal user experience activities it had initiated in 2018. In the future, STUK will oversee the development of management. In STUK's view, Fortum is doing a lot to learn from its own user experiences, but improvements are still needed in terms of results and impacts. This is because the same types of events have recurred and Fortum's responses to the recurrences have been lacking.

Based on event report experiences of 2020 and 2021, STUK request Fortum to lower the threshold of submitting operational event reports to STUK. In other words, Fortum was requested to more readily categorise events as events specified in requirements 707 and Ao8 of Guide YVL A.10 instead of internally investigated events specified in requirement 711 of Guide YVL A.10. Many of STUK's submission requests in 2020 and 2021 are indications that, at least in some areas, the information provided by Fortum has not met STUK's needs.

Annual outages and maintenance operations

The annual outages of the power plant were implemented as planned in terms of nuclear and radiation safety. Loviisa achieved the lowest radiation dose in the plant's history. Despite the COVID-19 pandemic, the annual outages were conducted at the scale specified in the original plans. In addition to refuelling and modifications, a large number of maintenance measures and inspections were carried out to ensure the safe and reliable operation of the power plant.

Important modifications in terms of the management of ageing included the partial update of the plant protection system and the automation update of an emergency diesel generator at Loviisa 1.

The annual outage also included inspecting the pressure equipment inspections specified in the periodic plan approved by STUK and continuing the investigation of observations relating to the foreign material control system of Loviisa 1's reactor pressure vessel.

More information on the annual outages is available in Appendix 2, and a summary of the periodic inspections carried out during the annual outage 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. The power plant's current development projects pertaining to waste management have progressed as planned, including the solidification of liquid waste, the commissioning of new premises for exemption measurements relating to the control of metal waste, the reassessment of the final disposal concept, and the development of procedures for waste records. The goal of the development projects is to increase operational efficiency and reduce the quantity of waste requiring final disposal.

Over the course of 2021, Fortum has continued transporting solidification waste packages to the final disposal facilities for solidified low and intermediate level waste. This has concluded the interim storage of solidification waste packages in the maintenance waste space for low and intermediate level waste.

The oversight and inspections by STUK indicate that power plant waste management at the Loviisa plant has been developed in a goal-oriented manner and the total arrangement meets the requirements.

Nuclear safeguards

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 2021, 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 positions of the fuel assemblies in the reactor core of Loviisa 1 and Loviisa 2 prior to the closing of the reactor covers. 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.

STUK also conducted a KTO inspection on the nuclear safeguards system, a summary of which is provided in Appendix 3.

The oversight and inspections by STUK indicated that the Loviisa plant fulfilled its nuclear safeguard obligations in 2021.

Security arrangements

The oversight indicated that the level of security arrangements at the Loviisa power plant has remained good and the security arrangements (including information security) have been developed persistently.

At the end of 2020, Fortum updated the plant's security plan, including the security standing order, security plan for the reactor waste repository (VLJ) and a safety arrangement plan on radiation sources, and its own assessment on the fulfilment of the requirements related to the design basis threat for nuclear energy use. As regards the final item on the list, STUK issued an implementation decision in February 2021. STUK also approved the general portion of the security plan, the security standing order and the security plan for the reactor waste repository in 2021, having first requested a statement from the Ministry of the Interior's Police Department on the security standing and the sufficiency of the Loviisa power plant's security arrangements. In late 2021, STUK issued implementation decisions on the updated Guides YVL A.11 and YVL A.12 for the Loviisa power plant.

STUK assessed these matters and documents in conjunction with the plant's periodic safety assessment inspection in 2021.

In 2021, STUK carried out two periodic inspections regarding nuclear security. One covered the nuclear power plant's physical security arrangements and the other addressed information security. Based on the inspections, no requirements have been presented for safety arrangements or information security. The summaries of the inspections are provided in Appendix 3.

Fire safety

Fire safety at the Loviisa power plant is at a good level. 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.

Fire safety was improved in 2021 by updating the instructions, for example. New instructions on penetrations and fire doors were adopted. Moreover, the general instructions on fire protection and fire rescue activities were updated.

2.1.2 Technical condition of the plant and preparing for exceptional events

Several reform projects that will improve plant safety are currently in progress at the Loviisa nuclear power plant. One of the most significant prior changes was the plant's I&C update, which was carried out in 2016–2018. In 2021, the modernisation of the I&C systems continued with smaller arrangements that ensure the service life of systems not covered by the 2018 update. In terms of protection I&C, the installation work encompassed by the partial update was conducted at both plant units. Loviisa 1's emergency diesel generator I&C was also updated with regard to one assembly, similarly to 2020 – the remaining two Loviisa 1 assemblies will be updated one at a time in the coming years. A corresponding update is yet to be decided upon for Loviisa 2. The parts obtained from Loviisa 1 will be stored and used as spare parts for Loviisa 2.

The cold cracking risk of the reactor pressure vessel was reduced by changing the containment-internal fire water line of both units by equipping the main line with a check valve and low-capacity bypass line to limit maximum leaks into the containment while continuously ensuring sufficient capacity for initial extinguishing and an emergency shower. This modification ensures that, in the event of a line break, large amounts of cold fire water do not spill on the side of the hot reactor vessel. The purpose of this is to prevent substantial thermal stress on the welds in the reactor pressure vessel's core area.

The redundancies of the power supplies for the pressuriser control valves' magnetic loads were improved at Loviisa 2, which also improved operational reliability. The magnetic loads ensure that the relief valves are opened and closed at exactly the right pressure. Corresponding measures for Loviisa 1 are planned to be carried out in 2022.

Reports and analyses

In the autumn of 2021, STUK provided Fortum with comprehensively updated seismic hazard reports that present the plant site's expected acceleration values at various intervals and vibration frequencies. The ground response spectrum determined in the hazard report is

needed for preparing seismic durability assessments of buildings and equipment. The updated reports are currently under review. STUK's review considers the results of the seismic hazard sensitivity analysis (SENSEI).

Once Fortum has completed the analyses assessing the seismic durability of buildings and equipment, the results will be used to update the probabilistic risk assessment on seismic events affecting the plant. Based on the results, Fortum will specify possible corrective measures that will ensure that the necessary devices will be able to withstand the plant's design earthquake. STUK has examined the matter as part of the Loviisa plant's periodic safety assessment. The analyses related to the probabilistic safety assessment will continue in 2022.

In 2020, Fortum also updated a considerable number of analyses related to the management of ageing, as part of the period safety assessment procedure in Loviisa. Fortum submitted the analyses to STUK for assessment at the end of 2020. These included the deterministic safety analysis of the reactor pressure vessel, fatigue and stress analyses, and analyses regarding the ageing of the main components. STUK checked the reports as part of Loviisa's periodic safety assessment in 2021.

Emergency response 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 2021.

An emergency response exercise was organised in December despite the special plant arrangements resulting from the COVID-19 pandemic. The exercise involved STUK's emergency response organisation practising emergency activities at STUK's emergency response centre. STUK took part in the efforts of the exercise planning group and assessed the activities of Fortum's emergency organisation in the context of the exercise.

In STUK's opinion, Fortum has systematically developed the emergency response activities of the Loviisa plant and the plant's emergency arrangements meet the relevant requirements.

2.1.3 Organisational performance and quality management

In 2021, STUK oversaw the safety culture and leadership, competence and resource management, and the suitability of the management system at the Loviisa power plant. The oversight focused on the preparation of a periodic safety assessment on the aforementioned areas. STUK particularly invested in the oversight of safety culture and leadership, with regard to verify their development in the right direction. The oversight was conducted by means of KTO inspections, additional inspections, numerous follow-up meetings on development measures, and meetings with the plant management to clarify the meaning of STUK's requirements.

The summaries of periodic inspections regarding the management system, human resources, competence, management system in are included in Appendix 3. The KTO inspection of human resources and competence was not included in the inspection programme in 2021.

The focus of the safety culture and leadership oversight has been on verifying the licensee's capability to openly and critically assess development targets in its own operating culture and manage the necessary changes in practices in such a way that everyone is committed to them and they are completed in a timely manner. STUK also commissioned an independent safety culture assessment which specifically focused on the management culture and its impacts on safety. STUK has continued to oversee the development of the independent safety oversight function, which was transferred from Fortum's NSO organisation to the Loviisa power plant's nuclear safety unit. The Loviisa power plant continues to develop the independent safety oversight methods and practices and specify the procedures. Based on the oversight, STUK finds that Fortum's management has an understanding of the strengths and weaknesses of the plant organisation's safety culture, and that the management is developing the organisational practices more systematically than before.

Over the course of 2021, STUK continued to oversee the progress of the Loviisa power plant's competence management project. The project concluded in the autumn of 2021, and Fortum has continued the efforts in the form of line work to achieve the set goals. The plant has deployed a competence management system, but not all of the information planned to be included in it has yet been stored in the system. The system will enable improved management and monitoring of the competence of the power plant's personnel.

The KTO inspection of the management system covered the planning and monitoring of operations, developing the independent oversight of nuclear safety, and the integration of KELPO activities (development of the licensing and qualification of serially manufactured standard devices) into the power plant's management system. Based on the oversight, STUK states that the Loviisa power plant has procedures for planning and improving the management system and instructions, but development is sometimes slow.

STUK conducted an extra inspection in order to verify the fulfilment of requirements regarding the management of Fortum's safety-related human factors, which were specified due to changes in the STUK regulations. As a result of the inspection, STUK found that Fortum has procedures to manage human factors (with regard to event investigations and the planning of major changes concerning the main control room, for example), but the procedures must be used more to ensure the appropriate management of human factors in practice. Among other things, the revised regulations require the management of human factors in the design of plant modifications on a wider scale. Fortum must develop its operations to achieve this goal.

2.1.4 More extensive assessments at the plant

Periodic safety assessments of the plant units and the repository of low and intermediate level waste

In June 2020, Fortum delivered the majority of the reports and accounts required for the periodic safety assessment prescribed by the operating licence terms of the Loviisa power plant, and the remaining ones at the end of 2020. Fortum must prepare a period safety assessment at least every ten years. The deadline for the documents delivered in this context was the end of 2023. The operating licence of the Loviisa power plant will remain valid until 2027 for LO1 and 2030 for LO2.

Fortum supplied additional clarifications, as required by STUK, during the period from the summer of 2021 to the end of the year. STUK is currently finalising its own safety assessment, and it aims to issue a decision in early 2022.

In the autumn of 2020, Fortum also provided STUK with a periodic safety assessment on the repository of low and intermediate level waste (VLJ repository) in Loviisa. STUK completed its own inspections and safety assessment in 2021 and issued a decision on 22 December 2021, which stated that the state of safety at the repository is good and that Fortum may continue to use the repository.

Fortum also initiated an Environmental Impact Assessment (EIA) in the autumn of 2020 with regard to the Loviisa power plant and the connected repository of low and intermediate level waste. The assessment programme applies to the possible continued operation, or possibly the decommissioning, of the Loviisa nuclear power plant. STUK delivered its relevant radiation impact statement to the MEAE in November 2021.

2.2 Olkiluoto 1 and 2

STUK oversaw the safety of the Olkiluoto nuclear power plant units Olkiluoto 1 (OL1) and Olkiluoto 2 (OL2) 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 2021 are included in Appendix 3.

On the basis of this regulatory oversight, STUK can state that as regards radiation exposure, the plant's activities are 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 2021 was 0.346 manSv at Olkiluoto 1 and 0.639 manSv at Olkiluoto 2. Most of this was caused by work completed during the annual outages (0.284 manSv at Olkiluoto 1 and 0.601 manSv at Olkiluoto 2).

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 annual dose at the Olkiluoto nuclear power plant was 8.1 mSv caused by plant maintenance work.

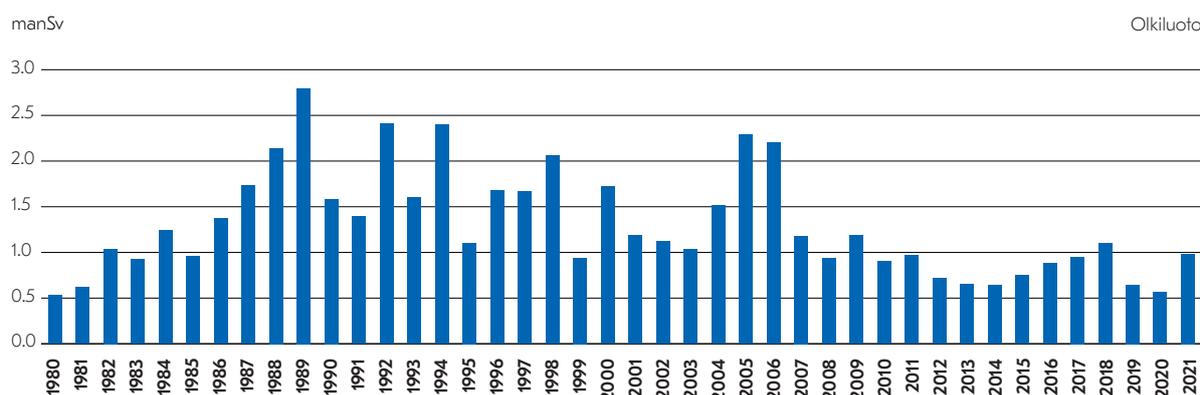


FIGURE 6. Collective occupational doses since the start of operation of the Olkiluoto nuclear power plant.

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 0.1 mSv set in the Nuclear Energy Decree (161/1988).

A total of approximately 450 samples were collected and analysed from the land and marine environment surrounding the Olkiluoto power plant in 2021. 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 the 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.

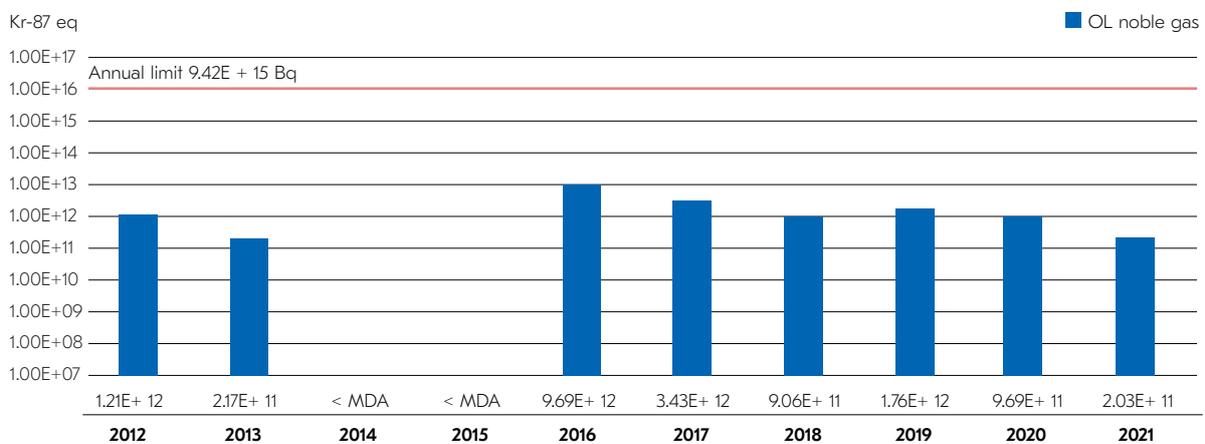


FIGURE 7. Noble gas releases to the atmosphere (Kr-87 eq), Olkiluoto.

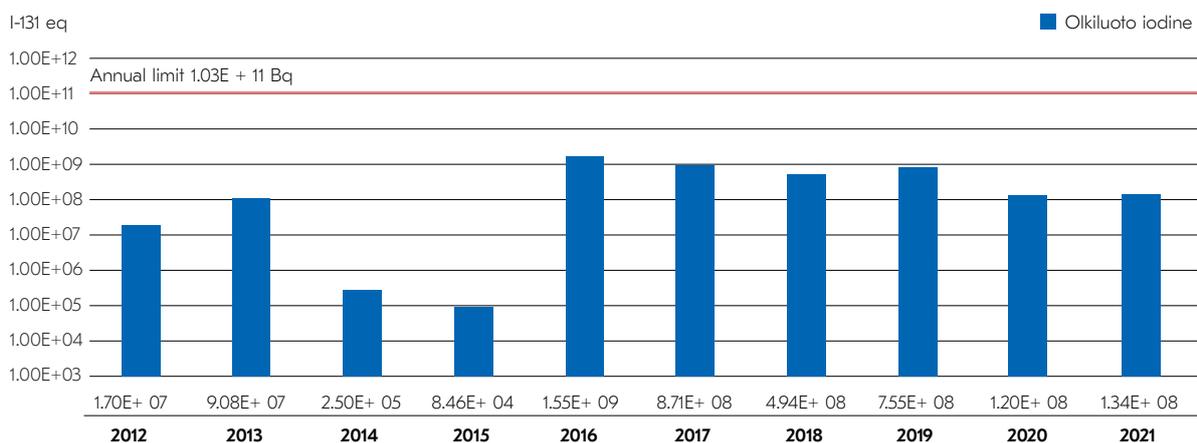


FIGURE 8. Iodine isotope releases to the atmosphere (I-131), Olkiluoto.

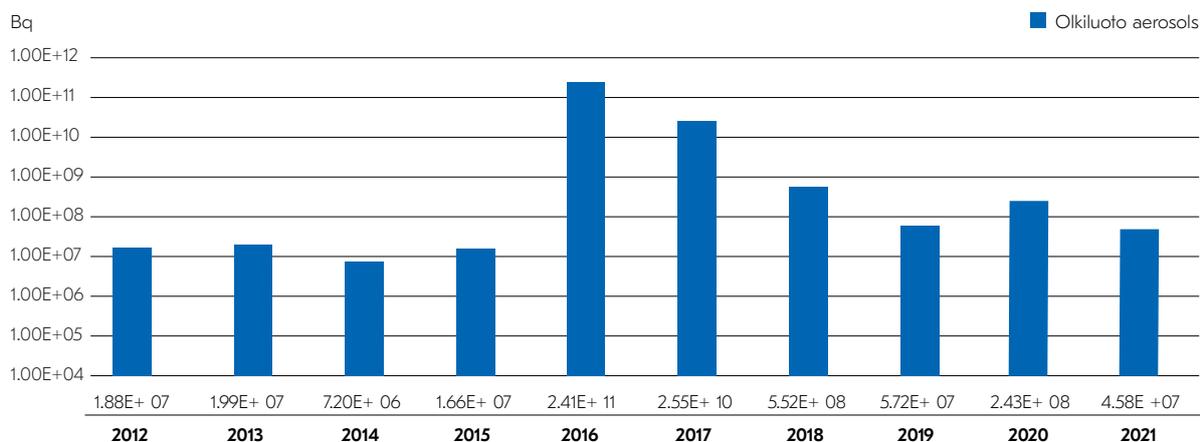


FIGURE 9. Aerosol releases to the atmosphere (Bq), Olkiluoto.

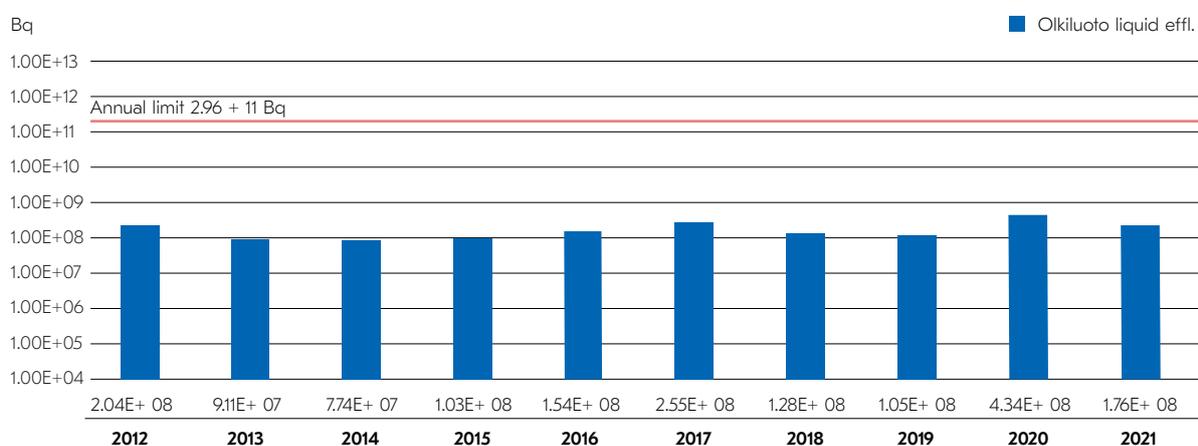


FIGURE 10. Gamma activity of the liquid effluents (Bq), Olkiluoto.

Operational events and operating experience feedback

TVO notified STUK of 13 event at Olkiluoto 1 and Olkiluoto 2 in 2021. Three of these took place in December 2020, while the rest occurred in 2021. 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 operation of the plant and the organisation. Most of the events revealed areas for improvement in procedures and activities.

By reviewing the results of the event investigations, STUK verified that TVO has investigated the underlying causes of the events and initiated the necessary actions to correct technical faults and deficiencies in its organisation's operations and prevent reoccurrence of the events. By the end of 2021, STUK had reviewed 10 reports, one report was under review, and one report was delivered in 2022. STUK required TVO to reassess the nature of one event and, thereby, the results of the event investigation. The event in question related to radioactive particles that ended up in the uncontrolled area during the transfer of spent nuclear fuel. In other respects, STUK deemed TVO's event investigations sufficient.

STUK utilised the results of the event investigations to discern the status of the various controlled areas and focus its control measures. STUK targeted a few inspections at two cross-technological areas (management of projects and modifications, management of spare parts) where several events have occurred in recent years. STUK was aware that TVO had initiated improvement measures with regard to these issues. However, the occurrence of new events as well as other observations made indicate that the measures have not had sufficient effects in all respects. STUK required TVO's management to steer the improvement measures by actively responding to challenges related to the measures, for example. Furthermore, STUK required TVO to develop the analysis of recurrence and the occurrence of causes as part of the event investigations. In planning its investigations, STUK also considered events related to areas such as radiation safety and the decision-making situations faced by shift managers (annual outages and repair outages).

Annual outages and maintenance operations

The annual outages of the plant units were implemented as planned in terms of nuclear and radiation safety. Despite the COVID-19 pandemic, all planned maintenance and inspection tasks were completed as intended. The 2021 schedule included a refuelling outage for Olkiluoto 1 and a wider maintenance outage for Olkiluoto 2.

STUK oversaw the annual outages from their design to the start-up of the plant units. During the annual maintenance, STUK conducted the mechanical equipment inspections prescribed in the YVL Guides normally at the plant site. STUK carried out more on-site control measures than during the 2020 annual outage, but the scope was still smaller than before the COVID-19 pandemic. The control activities focused on targets that were most significant in terms of safety. According to STUK's findings, the annual outages were performed safely.

A large number of maintenance measures and inspections were also carried out during the 2021 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. More information about annual outages of the plant units and STUK's regulatory oversight is available in Appendix 2. During the annual outage, STUK carried out a periodic inspection of annual outages. 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. TVO continued the analysis and investigation efforts related to harmonising the waste solidification process of all three plant units, and it completed the environmental impact assessment regarding the near-surface disposal of very low level waste.

In 2021, STUK conducted a KTO inspection on processing, storage and record keeping related to low and intermediate level waste at all Olkiluoto plant units. The inspection summary is provided in Appendix 3.

Nuclear safeguards

STUK granted TVO four licences concerning the use of nuclear commodities for the Olkiluoto plant units in operation (See 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. In December, TVO provided the European Commission with updated Basic Technical Characteristics (BTC) on Olkiluoto 1, Olkiluoto 2 and the spent nuclear fuel storage.

A total of 15 nuclear safeguards inspections were performed on the material balance areas of TVO's operating plant units and the spent fuel storage facility's material balance area, including inspections of the entire plant site. 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 positions of the fuel assemblies in the reactor core of Olkiluoto 1 and Olkiluoto 2 prior to the closing of the reactor covers. STUK also performed interim 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 on short notice in February. No remarks were made in the inspections.

The oversight and inspections by STUK indicated that the operating Olkiluoto plant units fulfilled their nuclear safeguards obligations.

Nuclear security

In 2021, STUK carried out three KTO inspections regarding nuclear security at the Olkiluoto power plant. In addition to the normal annual inspection, two extra inspections were carried out to ensure the fulfilment of the open requirements. The summaries of the inspections are provided in Appendix 3.

The nuclear security system of the power plant comprises an extensive package of administrative, technical and operational arrangements. The overall security arrangements at Olkiluoto power plant are at the required level. In order to maintain and improve both physical security and information security, several development projects are ongoing at Olkiluoto. In STUK's opinion, these projects are effective and necessary.

Fire safety

In 2021, STUK oversaw the fire safety of the power plant by means of inspections and annual outage visits and by reviewing reports submitted by TVO. Fire safety at the Olkiluoto power plant is at an acceptable level. A summary of the KTO inspection on fire safety is presented in Appendix 3.

2.2.2 Technical condition of the plant and preparing for exceptional events

Development of the plant and its safety

The project to update the emergency diesel generators of the Olkiluoto 1 and 2 plant units continued in 2021. The project will involve updating all eight of the plant units' original diesel generators. In addition to this, an additional ninth emergency diesel generator was deployed in 2020 to enable diesel generator replacements during the power operation of the plants. In the spring of 2021, the first new type of diesel generator was deployed at Olkiluoto 1. The remaining diesel generators will be installed and commissioned one by one by the spring of 2025. The new diesel generators can be cooled with seawater and air. The current ones can be cooled only with seawater. STUK oversaw the upgrade and inspected related design documents and commissioning reports over the course of 2021. In addition to this, STUK oversaw construction technical and mechanical work and the diesel generator test runs at the plant site.

STUK has required TVO to equip the reactor water level measurement, which is essential in accident situations, with an alternative solution that is based on a different operating principle in order to ensure the operability of the essential safety systems in the event of a common cause failure in normal level measurement. In the context of the 2018 operating licence renewal, TVO proposed a float chamber-based trip solution that fulfils the diversity principle and suggested that the update be carried out between 2019 and 2021. However, the project has been delayed as TVO has reassessed the risks related to the float chamber solutions against the possible benefits achieved through the update. In June 2021, TVO provided STUK with a clarification on safety improvements to replace the float chamber solution. The proposed solution would improve plant safety in the context of level measurement failures where the reactor's maximum level limit is tripped unintentionally. The update would involve installing manual switches in the control room for bypassing any harmful functions resulting from an unintentional safety limit trip. New alarms and measurements to support failure detection in level measurement would also be added. In August 2021, TVO submitted an action plan update to STUK for approval. The update suggested abandoning the previously proposed float chamber solution. In the application, TVO indicated that it is continuing to investigate alternative options for fulfilling the diversity principle with regard to the low level trip. As regards the high level trip, TVO deemed the planned measures to be sufficient. At the end of 2021, the processing of the materials delivered to STUK was almost complete.

The second safety improvement necessitated in the context of the 2018 operating licence renewal pertained to reducing the risk of common cause failure in the protection system's terminal relays. STUK required TVO to analyse the significance of the common cause failure of these devices with regard to the reliability of the safety functions activated by the system and core damage frequency and, based on this, to determine the measures required to reduce the core damage risk. In October 2021, TVO submitted to STUK for approval an account of measures that can be used to reduce the risk of common cause failure. STUK was almost finished with processing the account at the end of 2021.

STUK paid focus on the challenges observed in implementing the aforementioned safety improvements that had been identified as important and, for this reason, investigated the matter further by means of an in-service inspection in April 2021. The aim of the inspection

was to determine how the organisation has addressed safety-significant development targets and to clarify the decision-making levels and related work groups. Based on the inspection, STUK concluded that, as regards the examined safety improvements, there have been deficiencies in the oversight and steering of project progress. STUK presented a requirement ordering TVO to develop guidance activities related to significant safety development targets in such a way that ensures sufficient organisational steering starting from the preliminary analysis phase.

The planning phase of the project aimed at updating the plant units' refuelling machines progressed as planned in 2021. 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. STUK approved the pre-inspection documentation on the planning of the new refuelling machines in April 2021. STUK will oversee the design, construction, installations and commissioning of the new refuelling machines. According to TVO's plans, the updating efforts are intended to be completed over the course of 2025.

Emergency response 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. A KTO inspection was conducted in relation to emergency response activities (see Appendix 3).

An emergency response exercise was organised in December, but it was smaller in scope than originally planned due to the COVID-19 pandemic. The exercise involved STUK's emergency response organisation practising emergency activities. STUK also took part in the efforts of the exercise planning group and assessed the activities of the TVO's emergency response organisation during the exercise on site.

In 2020, one situation that warranted the initiation of emergency response activities occurred at the Olkiluoto power plant. TVO submitted assessment summary reports on the emergency situation to STUK. No events requiring emergency response actions took place at the Olkiluoto power plant in 2021.

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

2.2.3 Organisational performance and quality management

Based on STUK's oversight and control activities, TVO is committed to safety and has also emphasised safety in the handling of the COVID-19 pandemic. According to STUK observations, TVO adheres to its own procedures and the nuclear safety regulations. STUK's oversight has covered TVO's self-assessment measures, including the assessment report on the management system and safety culture. TVO identifies the weaknesses in its own operations

and highlights them as necessary. This makes it possible to develop the operations in the right direction.

TVO has an advanced management system which meets the requirements imposed on corresponding systems in the nuclear sector. The consolidation of the OL1/OL2 and OL3 management systems is currently under way as a result of the commissioning of the Olkiluoto 3 plant unit. As regards TVO's organisational performance, STUK sees challenges in the management of modifications and projects. In its oversight activities in 2021, STUK has focused particularly on the management of modifications.

The KTO inspection related to leadership and safety culture observed that TVO did not analyse in sufficient detail the underlying causes of prolonged challenges in certain work processes. The inspection summary is provided in Appendix 3.

In terms of all plant units (OL1, OL2 and OL3), STUK has found the human resources and competence to be at a good level. In some areas, however, there are resource deficiencies and difficulties with substituting special expertise in the event of a sudden need. These issues may manifest themselves as report delays, for example. STUK's KTO inspection on human resources and competence in June 2021 focused on supervisory activities, aptitude assessment and the oversight and application of HOF (Human and Organisational Factors) research data (see Appendix 3). Based on the observations, TVO puts effort in supporting supervisory work.

Throughout early 2021, STUK systematically oversaw the sufficiency and competence of Olkiluoto 3's human resources in order to ensure their adequacy in terms of refuelling the plant unit and making the reactor critical. STUK experts from a variety of fields assessed the capability, which was found to be sufficient. TVO's own competence analyses were also reviewed by STUK. Olkiluoto 3 shift supervisors were found to be under a substantial work load, but TVO managed to improve the situation over the course of the year. The maintenance personnel is in the process of transferring duties from the plant supplier to TVO, which requires competence development at TVO.

The impacts of organisational changes were examined in the KTO inspection of the management system. Personnel indicators were utilised in assessing the success of organisational changes at TVO's Engineering and Expert Services (see Appendix 3). The changes have involved deconstructing the organisational matrix, clarifying the decision-making responsibilities between the Electricity Production and Engineering and Expert Services, and improving the performance of the Engineering steering group. The changes have been largely positive based on the personnel indicators.

2.3 Olkiluoto 3

STUK oversaw the preparations for fuel loading at the Olkiluoto 3 (OL3) plant unit and the following nuclear commissioning phase. Based on the inspections, STUK granted permission for fuel loading in March 2021 and for closing the reactor pressure vessel cover in April 2021.

The nuclear commissioning phase began with fuel loading, followed by pre-criticality tests (i.e. hot function tests). Once they were completed, STUK granted permission to make OL3 critical in December 2021 and perform low-power tests, following which the reactor was made critical for the first time – i.e. the plant was started-up. Low-power tests were conducted at the

plant after the start-up, after which power was increased in a controlled manner towards the 5% level.

In 2022, the nuclear commissioning will involve further power increases, during which the planned operation of the plant will be tested and verified. During the power tests, STUK's permission will be required to progress beyond the 5%, 30% and 60% power levels. The nuclear commissioning phase will be followed by regular electricity production at the plant, i.e. commercial operation.

Summaries of the inspections included in the inspection programme for 2021 are presented in appendices 3 and 4. Appendix 3 covers the inspections conducted as part of the inspect programme for operating plants. Appendix 4 lists the inspections that have focused on verifying OL3's readiness for fuel loading.

2.3.1 Readiness for the fuel loading

During the first third of the year, STUK oversaw preparations for the OL3 plant unit's fuel loading, the test runs preceding the fuel loading and TVO's preparations for the upcoming commissioning phase by reviewing materials submitted by the licensee, preparing an inspection plan, conducting inspections as per the YVL Guides and oversight activities at the plant site. Based on the inspections, STUK granted permission to fuel loading in March 2021. TVO started the fuel loading on 27 March 2021, at which point OL3 became an operational nuclear power plant unit. Fuel loading is part of the nuclear commissioning phase.

STUK carried out several inspections relating to operational preparations and readiness for fuel loading. For example, the inspections covered progress and readiness related to safety arrangements, control room operations, the management system and operating instructions. STUK also oversaw the commissioning tests important to safety as well as repair, maintenance and modification work. Based on these oversight measures, STUK observed that most of TVO's procedures and operations are at a good level.

Operability of the emergency diesel generators

STUK oversaw the commissioning tests of the emergency diesel generators during the first half of 2021 and inspected repairs and modifications related to faults found during test operation. After the granting of the test operation licence, the emergency diesel generators have gone through multiple modifications and repairs. The most essential one has been examining the high vibration levels of the generators' permanent magnet machines and conducting the requisite modifications. The modifications were completed during the first third of 2021. They reduced the vibrations, but the original approval criterion was not fully met. As such, after the modifications were complete, a 168-hour test run was carried out on one emergency diesel generator, followed by the necessary inspections, to indicate that the structure withstands the fatigue load caused by the vibration. A shorter test run was also carried out on the other emergency diesel generators, once the modifications were complete. STUK conducted relevant mechanical inspection at the plant site and processed the modification work documentation as well as the root cause analysis related to the vibrations of the permanent magnet machines,

among other materials. As a result, further modifications to reduce the vibration levels were conducted later in the year.

One fuel injection nozzle failed during the commissioning tests performed after the aforementioned modifications that took place early in the year. The factory tests of the diesel motors also revealed a corresponding failure in two nozzles that were part of the same production batch as the failed nozzle. Nozzles of this batch are used in two emergency diesel motors. STUK demanded that the nozzles from the same production batch as the failed ones be replaced with new ones before the first criticality of the OL3 plant unit. After the modification work, the operability of the emergency diesel generators was verified by means of a commissioning inspection before fuelling.

Modification of the mechanical control valves of the pressurise safety valves

During the valve tightness tests conducted in the spring of 2020, TVO and the plant supplier found a leak in the mechanical control valve of one of the pressuriser's safety valves. There are a total of three pressuriser safety valves, which are needed for the overpressure protection of the plant unit's primary circuit. Two mechanical control valves are connected to each safety valve, one of which is isolated. The reliable opening and closing of the safety valve requires the mechanical control valve to operate reliably. In order to investigate the observed leak, the control valve was opened, at which point TVO and the plant supplier found that the valve stem had been broken. As a result, the remaining five control valves were opened and cracks were found in two of them. The damaged parts were delivered to the Framatome Technical Centre in Germany in order to determine the root cause for the damage. Based on the analyses, the failures were caused by stress corrosion.

Before fuel loading, the parts were replaced with corresponding ones and temporary measures were deployed for the duration of the nuclear commissioning phase to maintain the requisite level of cleanliness. In addition to this, the plant supplier initiated modification planning aimed at ensuring the reliability of the control valves in long-term use. In the first third of 2021, STUK processed and approved an action plan on the development of the control valve structure. Section 2.3.2 describes the phases following fuelling during which the control valve modification was completed.

Vibrations in the pressuriser connecting line

The root cause of the vibrations in the pressuriser's surge line have been investigated extensively. The vibrations are most likely due to excitations caused by turbulent flows in the primary circuit that are close to the structural natural frequencies of the pressuriser surge line. Viscous dampers were installed in the pressuriser surge line to dampen vibrations. The installation work was completed during the final third of the year. The verification of the vibration levels will continue after loading the nuclear fuel in connection with hot tests conducted before first criticality (Section 2.3.2), at which point the vibration levels of the surge line will be measured in different operating states of the plant.

During the first third of 2021, STUK processed and approved TVO's clarification on the initial assumptions of the strength analyses.

Other matters

Analyses on conductor insulation damage found in I&C cables during 2020 were still under way at the end of the year. During the first third of the year, STUK processed and approved TVO's pertinent measures.

2.3.2 Supervision of pre-criticality tests and checking readiness for criticality

The fuel loading of OL3 began at the end of March 2021. STUK oversaw the commencement and progress of the fuel loading at Olkiluoto. The fuel loading was completed successfully, followed by pre-criticality tests (i.e. hot functional tests) which involved heating the primary circuit and pressurising it with the main control pumps to reach the operating conditions. During the hot functional tests, the operation of the plant and its systems were tested thoroughly in terms of aspects that could not be tested without fuel in the reactor and aspects that required new tests after the modifications.

STUK checked the plans and instructions for the tests and oversaw the most important tests at Olkiluoto. In addition to this, STUK examined the results of the conducted tests. During the test runs, STUK also assessed the operations of the licensee and plant supplier and, particularly, the maturity of plant status management.

The purpose of the commissioning tests is to indicate that the systems and the plant function as planned, and it is normal for needs to make changes to emerge during the commissioning phase. The needs for changes that were found during OL3's commissioning delayed the commissioning process, but the issues were resolved thanks to the appropriate actions of TVO and the plant supplier: the issues were resolved, the necessary changes were made and the functionality was verified by means of retests. STUK oversaw the progress of the test runs and troubleshooting, checked the most important modification plans and conducted the necessary checks on items that were either repaired and modified. The modification needs and delays resulting from the jamming of the turbine rotor during the hot functional tests enabled the modifications planned for later phases to be pushed forward. For example, the structure of the mechanical control valves was improved by switching in new valve components with different materials and design to reduce stress corrosion.

The operating tests conducted before initial criticality (including new tests following modifications) indicated that the plant operates as designed. During the hot functional tests, it was also indicated that the surge line vibration was brought to a sufficiently low level thanks to the dampers added to the pressuriser connecting line.

The commissioning process also provides valuable lessons to all those involved. TVO examined the abnormal operational events that occurred during the test runs, conducted immediate measures based on them and investigated the most significant events. The events did not cause a nuclear safety or radiation safety hazard. In terms of the safe use of the plant and operational improvements, it was important for TVO to systematically go through the events and make the necessary changes to the plant and its operating method. The corrective measures included changing the triggering limits of the safety functions handled by the plant's I&C systems.

TVO submitted STUK with a criticality permission application on 8 December 2021, which STUK approved with a decision on 16 December 2021. After this, STUK verified the start-up readiness on 18 December 2021, after which the plant was permitted to reach initial criticality.

Modification of the mechanical control valves of the pressuriser safety valves

Before fuel loading, the damaged control valve parts were replaced with corresponding new parts and temporary measures were implemented to maintain the requisite level of cleanliness during the pre-criticality tests. A modification programme initiated by the plant supplier progressed in parallel to this, and the new parts specified by it were tested and qualified in the test field. The parts were installed during the turbine maintenance outage between the hot functional tests phase and tested during the pre-criticality tests in connection to the plant ramp-up. The modification involved improving the structure of the mechanical control valves by switching in new valve components with different materials and design to prevent stress corrosion.

STUK processed and approved the new planned qualification and conducted the part replacement and valve test inspections at Olkiluoto.

Aubert & Duval material forgery

At the end of 2020, STUK processed the deviations found in the operations of the material manufacturer Aubert & Duval and the accounts regarding their impacts on material deliveries related to OL3. The manufacturer's suspicious activities have drawn widespread attention on an international level. The plant supplier analysed the manufacturer's operations extensively and TVO assessed the manufacturer's deliveries in detail based on the plant supplier's analyses and its own inspection visits. It was TVO's conclusion that the deviations did not impact the safety and usability of the OL3 components. STUK assessed the analyses and approved them at the end of 2020. In its decision, STUK required TVO to control components manufactured from the materials in question in accordance with the condition monitoring procedures.

In 2021, Framatome Fuel BU worked with Aubert & Duval to conduct a further analysis by investigating possible forgeries or deficiencies in the manufacturing documentation after the plant supplier analyses that were completed in 2020. TVO submitted the deviations related to the further analysis to STUK for processing at the end of 2021. STUK assessed the deviations and verified their acceptability.

Damage in the heat exchangers of the intermediate cooling system

During the turbine maintenance outage that occurred over the course of the hot functional tests in 2021, extra inspections were conducted on the heat exchangers of the intermediate cooling system due to their weakened heat transfer capacity. The inspections revealed that the flow guide plate had either fully or partially been detached from all four heat exchangers. The purpose of the flow guide is to ensure that the taprogge balls which maintain cleanliness are evenly distributed in the heat transfer pipes. Repairs that involved removing the flow guides were conducted on the heat exchangers.

STUK checked and approved the repair plans, the root cause analysis and the analysis on the long-term use of the heat exchangers without the removed flow guides. In the same context,

STUK required user experiences to be collected on the cleanliness of the heat exchangers and maintaining heat transfer capacity, and necessitated the heat transfer capacity calculations to be submitted by the end of 2022.

Fan damage

During the hot tests conducted in 2021, a failure was found in the fan of the ventilation system of the auxiliary building, as a result of which other similar fans were inspected and found to be damaged. Due to this, the inspections were expanded to more extensively cover the fans provided by the same manufacturer (34 in total). STUK checked the repair plans, conducted the necessary structural inspections at Olkiluoto and oversaw the handling of the situation.

Experiences at other EPR facilities

Neutron flux fluctuation

Earlier on, reactors of the same type have been found to exhibit neutron flux fluctuation that is higher than expected. The fluctuation has been found to be caused by the lateral movement of the fuel assemblies due to reactor coolant flow, which slows down neutron movement in the reactor.

The analysis provided by the plant supplier analysed the fluctuation predicted for OL3's first operating cycle and involved justifications for the reactor's operational safety regarding the fuel safety and the validity of the safety analyses up to a power level of 80%.

The use of full power will require I&C changes to avoid unnecessary reactor trips. STUK approved the related modification plans and safety analyses towards the end of 2021. The approved application entailed the I&C parameter changes due to neutron flux fluctuation and the safety analyses carried out to ensure safe use. The analyses and safety justifications presented in the documentation will be valid early on in the first operating cycle, if the neutron flux fluctuation measured at the plant is as expected. If the neutron flow vibration deviates from the assumptions of the analyses, STUK will require a reassessment of the situation.

The I&C changes, safety justifications and analyses will be updated to cover the end of the first operating cycle and the following operating cycles in early 2022, for which TVO will request STUK's approval by means of a separate application.

Impact of Taishan fuel leaks on the OL3 plant unit

TVO investigated the possibility of the occurrence of fuel leaks observed at another EPR facility at OL3 towards the end of 2021. Based on the analysis, STUK finds that the occurrence of fuel leaks resulting from the same cause is improbable since the plants are different in terms of fuel, structure and operating conditions. As a precaution, TVO will conduct extensive visual inspections on fuel in the reactor and specify the procedures related to fuel use and the conditions of use.

Deviations in the fatigue analyses of the pressuriser supports

At the end of 2021, TVO supplied STUK with a report on a deviation in the fatigue analysis of pressuriser supports. Based on strength calculations made for another EPR unit, deviations were discovered in the weld fatigue analyses calculated for OL3, which reduced the calculated

service life of the supports from 60 years to 11 years. STUK approved the report and did not find anything to prevent plant criticality. However, the decision included requirements on measures aimed at ensuring the pressuriser's service life in accordance with the design principles. In addition to this, STUK required an analysis of the deviation's impacts with regard to the vaporisers as well.

2.3.3 Oversight of the first criticality and low-power tests

OL3's first criticality was achieved in 21 December 2021 when the plant was started-up for the first time. STUK oversaw the start-up on site at Olkiluoto. At OL3, start-up is achieved by diluting the boron content of the reactor water and controlling the control rods. TVO's operating personnel conducted the planned measures in a controlled and safe manner. It was therefore more important than ever for TVO to assume responsibility of the situation and the plant, which it did in a very clearly defined manner. The plant supplier (a consortium formed by AREVA GmbH, AREVA NP SAS and Siemens AG) will be involved in the operations during commission, but TVO bears the responsibility for nuclear and radiation safety. Only TVO's licensed control room operators who have been approved by STUK may control the plant from the control room.

After the plant start-up, TVO and the plant supplier conducted low-power tests. This was to ensure that the reactor core behaves as expected and matches the assumptions laid down in the safety analyses. Low-power tests were conducted using several control rod positions measuring values related to reactor physics (critical boron content, isothermal temperature coefficient and the reactivity impact of the control rods).

STUK checked the low-power test plans and instructions and oversaw the performance of the tests at Olkiluoto. In addition to this, STUK examined the results of the conducted tests. The tests were conducted successfully at the end of 2021. The reactor's behaviour matched the advance calculations quite accurately, and the predefined safety criteria were fulfilled. After the low-power tests, the power was increased towards 5%. The completed commissioning tests have indicated that the plant operates as planned and it will be safe to increase its power towards the level required by the next commissioning phase.

Once the commissioning tests at 5% are complete, TVO will submit an application to STUK at the beginning of 2022 with regard to progressing to 30% power in the context of commissioning. After this, the nuclear commissioning of OL3 will continue in 2022 in the form of elevating the power from 5% towards 30% in tiers. During this time, the aim is to ensure that the plant operates as planned at different power levels and to test the behaviour of the plant during operational occurrences. At this point, the electrical generator of the plant will be synchronised with the national mains grid for the first time, which will mark the beginning of power production. The tests will be conducted based on tests and instructions that have been checked by STUK. STUK will oversee the most significant tests at the plant site and inspect the test run results. The following points at which STUK's permission will be required are the 30% and 60% power levels.

The nuclear commissioning phase will be followed by regular electricity production at the plant, and commercial operation.

2.3.4 Oversight of nuclear materials

STUK granted TVO five licences concerning nuclear use items for the Olkiluoto 3 project in operation (Appendix 7). In December, TVO submitted to the European Commission the updated Basic Technical Characteristics (BTC) of the Olkiluoto 3 plant unit. 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.

In 2021, STUK conducted a total of three nuclear material inspections on Olkiluoto 3. In April, STUK inspected the positioning of the fuel assemblies in the reactor core. In addition to this, STUK took part in the short-notice inspection conducted by the IAEA and the European Commission in December on Olkiluoto 3. No cause for remarks was found in the inspections. The oversight and inspections by STUK indicated that TVO fulfilled its nuclear safeguards obligations at Olkiluoto 3 in 2021.

2.4 Hanhikivi I

In 2021, STUK continued the processing of the documents to be provided to STUK during the construction licence phase. STUK did not yet have at its disposal comprehensive information on the plant and system design complex reports 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. Towards the end of the year, the delivery of materials to STUK increased in frequency and FV was able to deliver a significant portion of the preliminary safety analysis report to STUK.

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 and other requirements of the licence applicant. 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.

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. In order to draw up the safety analysis report, the plant supplier and lead designer set up a separate project (PSAR Localisation Project, PLP) to produce a safety report that would meet the Finnish requirements. The project has acquired extensive nuclear and radiation safety expertise from Russia, Finland and other European countries. Overall, the purpose was to submit a safety report to STUK in 15 parts.

The first-phase sections of the safety report (Safety Case Completed, SCC), which have been submitted to STUK, are based on the first phase of the plant's basic design, and they have not fully met the level of maturity prescribed to construction phase PSARs by Finnish requirements. The sections of the safety analysis will be updated and supplemented later in phase 2 (Safety Analyses Completed, SAC). STUK has issued requests for clarification on all delivery batches it has processed so far. There were approximately 500 clarification requests at the end of the year, some of which were classified as critical with regard to the fulfilment of Finnish safety requirements.

Fennovoima started the delivery of the Preliminary Safety Analysis Report batches produced by the PLP project to STUK at the beginning of December 2019. Seven batches were delivered to STUK in 2021. At the end of 2021, the preliminary safety analysis lacked, among other things, a section on safety analyses and the licence applicant's own safety analysis. Fennovoima plans to supplement its preliminary safety analysis based on STUK's feedback and as the planning process progresses during the SAC phase of 2022.

A batch of descriptions on the containment and systems designed for severe reactor accidents, preliminary safety report descriptions related to habitability and lighting and pertinent topic-specific reports, and a severe accident management strategy and related materials were submitted to STUK for processing after mid-June. In relation to these, presentation meetings were held with the licence applicant and the plant applicant. Clarification requests were issued on the documents during the autumn of 2021.

During the second third of the year, STUK issued requests for clarification on the sections of the preliminary safety analyses that pertained to the sewer system and the turbine plant. The maturity of the delivered materials was not at an adequate level for the safety analyses.

The section regarding the electrical and auxiliary power systems of the safety analysis was submitted to STUK for processing in February. STUK's inspection observations were delivered to Fennovoima in May. Following the processing meetings on the observations, the clarification request was completed in July. The section regarding safety analysis on the overall architecture of the power and auxiliary power systems was somewhat incomplete. The general architecture of the power system meets STUK's requirements, but there are details about the planning process that remain open, including the dimensioning of the emergency diesel generators, the grounding systems, the power grid analysis and the dimensioning of the power grid in the plant area.

In relation to the previous delivery batches, STUK has held clarification meetings with Fennovoima and the plant supplier after the submission of requests for clarification. These meetings have involved discussing the observations made, providing background for any requirements, if needed, and presenting plans for responding to the requirements.

During the first third of the year, Fennovoima provided to STUK for approval system descriptions regarding the reactor, fuel, fuel processing, the handling of radioactive waste, sewerage systems, normal operating systems, ventilation and air condition systems and lifting devices as well as related topic-specific reports and other materials. At the end of December, STUK was provided with structural descriptions regarding design principles on structures and sections of the safety analysis that pertained to commissioning.

In December, sections of the preliminary safety report, regarding the deterministic safety analyses as well as topical reports, were provided to STUK processing. Safety analyses were previously provided to STUK in 2018, at which point STUK, based on its processing, presented clarification request requirements to Fennovoima, based on its internal processing. Some of these analyses were resubmitted as unchanged topic-specific reports, which is why they do not consider the prior requirements issued by STUK. In the same context, STUK was provided with the first analyses regarding the containment building.

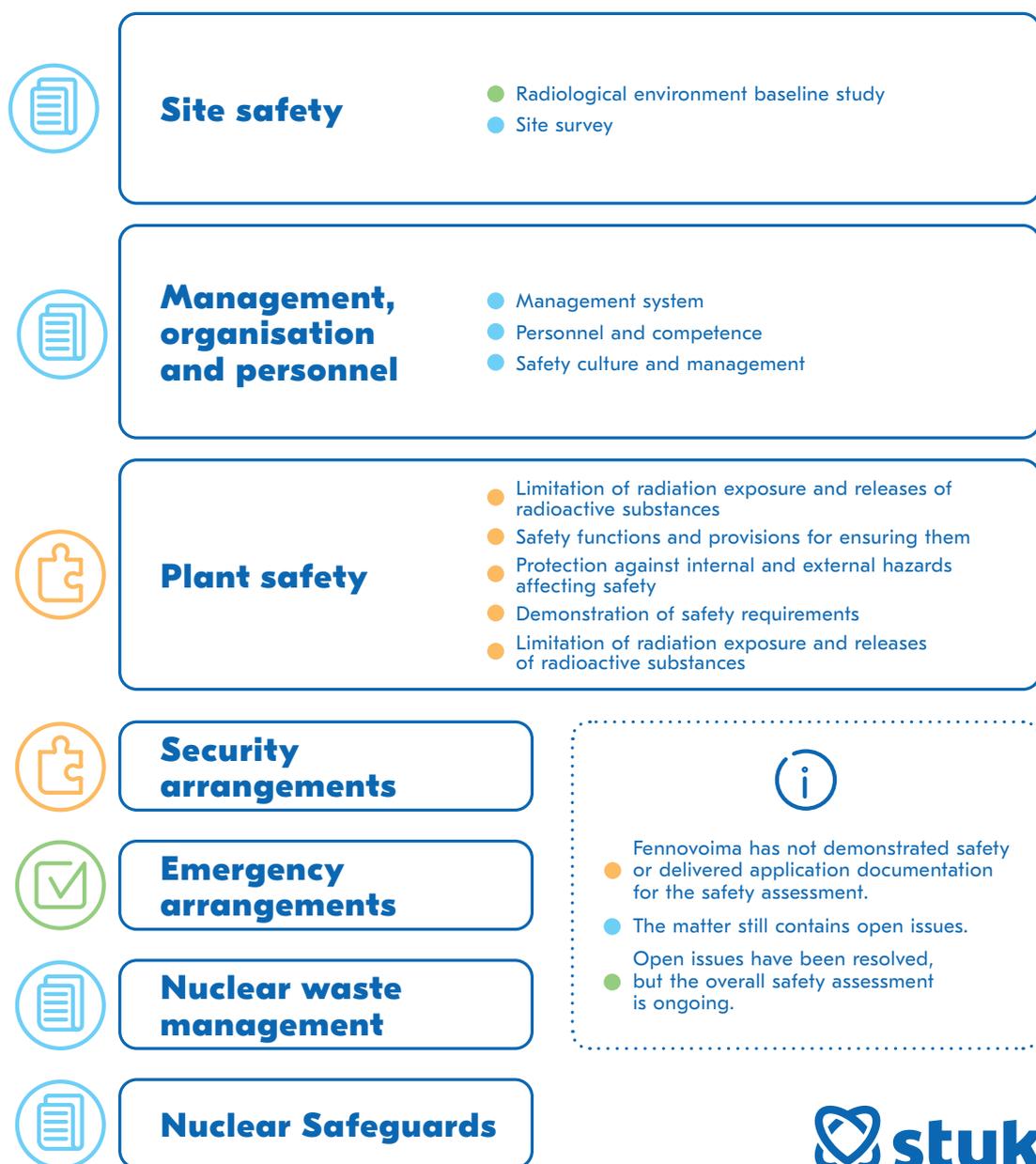


FIGURE 11. Status of Fennovoima Safety Assessment 31.12.2021

In terms of reviewing the deterministic safety analyses, comparative safety analyses have a significant role. These are mostly commissioned by STUK independently of the plant supplier and plant applicant. In this context, STUK received initial information that served the commissioning of topical comparative analyses during the spring of 2022.

The delivery of the probabilistic risk analysis (PRA) has been delayed. Based on the information received by the end of 2021, the planned delivery to STUK will take place in February 2022. At the end of 2021, PRA was submitted for Fennovoima inspection, and Fennovoima had submitted their findings for external unbiased peer review.

STUK's Preliminary Safety Assessment (2014) during the decision-in-principle phase highlighted, among other things, the necessity of indicating the operability of the emergency cooling systems' suction filters (i.e. sumps) by means of tests and later also tests regarding a new kind of separation device system for the containment airspace. The planning of test-based specifications did not progress as planned in 2021. The test-based indication is required in the construction license phase, and it can be supplemented once the construction permit.

As regards mechanical devices, STUK has inspected the plans required for the material manufacturing of Fennovoima's long-production-time components, which Fennovoima has provided. These plans have been prepared by the main designer of the primary circuit (Gidropress) and the main designer of the plant (Atomenergoproekt). The components processed are the reactor pressure vessel's cover and internals, the so-called core catcher related to the management of severe reactor accidents, related safety class 1 and 2 materials and the material testing organisations.

The STUK has had discussions with Fennovoima on a 5,000-hour durability tests on the main circulation pump. STUK aims to participate in the oversight of the tests in 2022. A plan and schedule have been provided to STUK on the qualification related to the pump housing cladding welding. The qualifications will be needed for the new pump version in which the forging and housing cladding differ from the previous main circulation pumps of VVER plants.

The first batch of security arrangement plans related to the power plant and its operating environment were delivered STUK at the end of 2021. Fennovoima has informed that the remaining licence materials related to security arrangements will be delivered in early 2022. The security arrangements or areas closely related to them were addressed briefly in a few topic-specific meetings during the reporting period.

Discussions were continued with Fennovoima on the phased delivery of plans related to the construction licence application and the goals of the various phases in order to form a better overall view. So far, the phased processing of the construction phase materials has been challenging for STUK, since the submitted document packages do not always form a clear and independent whole that proceeds principles to details. STUK has also emphasised to Fennovoima the timely and sufficient consideration of STUK's prior requirements in the planning of the plant – from the perspective of STUK's inspection and the safety assessment, measures to be taken based on STUK's requirements and the Government's observations in the decision-in-principle phase have progressed slowly. Fennovoima updated its licensing plan towards the end of 2021. Fennovoima has planned to leave enough time for the appropriate arrangement and structuring of the organisations between the construction licence phase and the beginning of construction. Fennovoima has not yet provided a specific plan on how

it will respond to the requirements in the requests for clarification presented by STUK in the construction licence phase, which is why STUK has been unable to assess the impacts on STUK's safety assessment. Fennovoima has also changed its licensing organisation. STUK will continue assessing the change.

STUK has initiated the phased preparation of its safety assessment. In its safety assessment, STUK evaluated the fulfilment of requirements imposed by acts, decrees and STUK's requirements in the construction licence phase. In terms of the preparation of STUK's safety assessment, it is important to receive responses to the clarification requests regarding delivery batches as updates to the preliminary safety analysis report.

Fennovoima was reorganised in the spring of 2019 and is currently developing procedures in line with its new management principles. STUK followed the progress of the work through topic-specific meetings and inspections on management and inspection procedures. Fennovoima has developed its management system, and the majority of the highest-level processes have now been described. In its new operations, Fennovoima aims to distribute responsibilities more clearly than before.

STUK continued to evaluate the management systems and performance 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 in 2021 STUK carried out inspections according to its inspection programme. The results of the inspections will be used by STUK when preparing a safety assessment and statement on the construction licence application. Summaries of the inspection programme's inspections related to the processing of the construction licence carried out in 2021 are presented in Appendix 5.

2.4.1 Nuclear waste management

STUK assesses the safety of the interim storage for spent fuel in two phases. 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 interim storage 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.

2.4.2 Nuclear safeguards

Fennovoima submitted the nuclear safeguards reports and notifications it was responsible for in time. 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.

In 2020, Fennovoima applied for approval for a nuclear safeguards manual and a person to assume responsibility for nuclear safeguards. STUK has processed and approved these applications. All of the requirements presented in the RKT inspection of November 2020 have been acceptably processed. There have also been discussions with the plant on taking the needs of nuclear safeguards into account in the plant design. These matters will still be covered with Fennovoima, IAEA and the European Commission before the construction licence is granted.

2.5 Research reactor

On 17 June 2021, the Government granted a permit, pursuant to Section 20 of the Nuclear Energy Act, to VTT Technical Research Centre of Finland for dismantling the FiR 1 research reactor. VTT has continued specifying the detailed plans on dismantling the reactor and preparing the documents required by STUK in its safety assessment in 2019. According to current plans, document processing at STUK can begin in the spring of 2022.

VTT submitted to the MEAE a waste management diagram regarding the research reactor in June 2021 and a nuclear waste management plan in September 2021. The MEAE requested a statement from STUK on the documents. As regards the waste management diagram, STUK stated that it corresponds with the current state of the project. In STUK's view, the delivery of spent nuclear fuel to the United States for further use at the end of 2020 reduced the cost-related uncertainties of waste management significantly. However, there are still uncertainties related to the timing of the total costs of waste management due to the progress of the licensing of the Loviisa final disposal facility. The Loviisa final disposal facility needs a new operating licence for it to be able to receive radioactive waste generated by the dismantling of research reactor.

As regards the nuclear waste management plan, STUK stated that VTT has progressed well in the planning of the nuclear waste management measures. STUK stated that delivering the spent nuclear fuel from the research reactor to the United States for further use at the turn of 2020–2021 was a significant leap, which eliminated the most significant uncertainties related to the research reactor's decommissioning schedule and costs. In its statement, STUK indicated that VTT still holds a small quantity of fresh nuclear fuel, the management of which it does not describe in its nuclear waste management plan. In STUK's opinion, VTT should determine

how the management of the fresh nuclear fuel will be handled, if it cannot be delivered for further use and it will remain permanently in Finland. STUK's statement also indicated that there are still uncertainties with regard to the research reactor's dismantling schedule, which must be taken into account in planning the dismantling processes and updating the nuclear waste management plans. In STUK's view, VTT must secure sufficient resources and prepare plans for the possible eventuality that its nuclear waste management obligation does not end within the coming three years, as is the current plan.

Inspections have been continued at the research reactor to ensure that sufficient reactor maintenance and monitoring and VTT's preparedness to begin the reactor dismantling phase as planned towards the end of 2022. STUK has prepared a separate oversight plan for the dismantling phase.

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 plant 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 2021, STUK conducted one nuclear safeguards inspection in the research reactor's material balance area with the IAEA and the Commission. It focused on determining whether or not the plant's basic technical characteristics (BTC) and nuclear material inventory are up to date. The oversight and inspections by STUK indicated that the material balance area of VTT's research reactor fulfilled its nuclear safeguards obligations in 2021.

2.6 Spent nuclear fuel encapsulation and disposal facility

In 2021, Posiva continued the construction of the nuclear waste facilities. Posiva completed the quarrying of the central tunnels and began the quarrying of the first final disposal tunnel. The outer surfaces of the encapsulation plant building are nearly complete, and the construction of the interior sections continues. Some of the encapsulation plant systems have been installed. Over the course of 2021, Posiva began the manufacture of lifting and transfer equipment and the capsules.

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. Posiva's nuclear waste facility is about to transition into the commissioning phase. STUK will oversee Posiva's activities during the commissioning by inspecting the commissioning plan, test operation plans and results, and by conducting commissioning inspections on devices, structures and systems.

2.6.1 Construction of the disposal facility

In 2021, Posiva continued the quarrying of the final disposal facility's central tunnels and began the quarrying of the first five final disposal tunnels in May. During 2021, Posiva also continued the construction of the concrete structures in the capsule receipt area and progressed to the production of safety-classified structures. Over the course of 2021, Posiva has submitted rock engineering plans concerning the central tunnel of the disposal area and the final disposal tunnels to STUK for processing. STUK conducted rock engineering inspections in the completed tunnels. Due to the prevalent pandemic situation, some of the inspections were organised remotely.

The construction of the encapsulation plant progressed as planned in 2021. STUK processed materials related to the construction and fire protection of the encapsulation plant. The construction inspections to be conducted at the encapsulation plant's construction site were primarily transferred to the inspection body.

In 2021, a large number of construction plans for lifting and transfer equipment was submitted to STUK for processing. The inspection body will assist in the review of these documents to balance STUK's work load.

2.6.2 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 overseen compliance with the requirements set based on the construction licence application review and Posiva's plans to ensure compliance with the requirements.

In 2021, Posiva particularly submitted documents related to long-term safety for preliminary processing and to enable the closure of requirements presented in the construction licence phase. This also provided STUK with the opportunity for an advance review of the content of the safety case documentation provided towards the end of the year.

2.6.3 Organisational operations and quality management

STUK has overseen the activities of Posiva's organisation in inspections included in the construction inspection programme (RTO programme). The inspections have assessed quality assurance and requirement management at Posiva's nuclear facilities, the safety-critical functions of the final disposal facility, the suitability criteria and monitoring of the rock, the security arrangements, the construction of technical barriers and its monitoring, commissioning and management. The inspections specified in the construction inspection programme are covered in more detail in Appendix 6.

Based on the inspections under the RTO programme, it can be stated that Posiva's procedures in the various areas are largely at a good level. There are some needs for specifications, and requirements have been presented through inspections, as needed.

This year, management system oversight focused on quality assurance and the management of requirements during the life span. Posiva is effective in ensuring the sufficiency of its own inspection resources during constructions and is aware of the inspection organisations used by the delivery chain during construction. STUK found deficiencies in the production monitoring plans and the processing of the planning materials, which concern the operations of multiple organisations. STUK presented requirements on these through an inspection.

STUK has continued to oversee Posiva's auditing activities. During the pandemic, auditing has been less frequent than normal, but it has been possible to continue the operations.

2.6.4 Preparations for the operating licence phase

STUK has overseen Posiva's preparations for the commissioning phase. The oversight has focused on Posiva's organisation, resources, training, instructions and related procedures. Posiva submitted a commissioning plan to STUK for approval. A request for clarification was prepared on the commissioning plan, because it did not meet the requirements of the YVL guides. Among other things, the request for clarification necessitated additions to personnel training and matters related to the performance of test runs.

In its operations, Posiva aimed to be able to submit its operating licence application at the end of 2021. STUK oversaw Posiva's preparations for submitting the licence application and the fulfilment of the criteria Posiva set for itself.

STUK has prepared for reviewing the operating licence materials by preparing an inspection plan and resource plans. The review of the operating licence materials will require more inspection resources than normal. For this reason, STUK will use external experts as additional resources for reviewing the materials. The additional resources are used in a systematic manner, and agreements have been drawn up to ensure that the experts are available at the right time.

2.6.5 Nuclear safeguards

STUK implemented nuclear safeguards for the final disposal in compliance with the national regulatory plan. STUK inspected the plant site which was reported by Posiva to be compliant with the Additional Protocol of the Safeguards Agreement and the construction activities in a periodic inspection of nuclear safeguards. Due to the coronavirus restrictions, the plant area inspection was postponed from spring to autumn, which partially supports the reviewing of the 2022 report.

During 2021 in the context of preparations for the operating licence phase, STUK provided Posiva with comments on its account on arranging the necessary control to prevent the spreading of nuclear weapons. Posiva updated the nuclear safeguards manual as part of the operating licence application, which it submitted at the end of the year. Alongside preparing for the operating licence application, Posiva provided the nuclear safeguards reports and notifications under its responsibility on time and updated the Basic Technical Characteristics (BTC) to be delivered to the Commission and STUK. The oversight and inspections by STUK indicated that Posiva fulfilled its nuclear safeguards obligations in 2021.

STUK continued its close cooperation with 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 and construction of the facility and also meet national requirements. Regular technical meetings were held with Posiva, the European Commission and the IAEA in 2021. In addition to this, the IAEA and the Commission conducted two technical visits to TVO's spent nuclear fuel storage and encapsulation plant to plan monitoring measures for the fuel to be transferred for final disposal. In the context of the periodic review of the Basic Technical Characteristics in November, a hybrid meeting was held, which enabled more people than just the inspectors to take part in the planning of the monitoring measures. The encapsulation plant's monitoring equipment plan prepared by the IAEA and the Commission is almost complete and has been incorporated into Posiva's plant design. The IAEA and the Commission have also presented a draft of the encapsulation plant's monitoring equipment plan. Some of the monitoring is intended to be carried out in the lifting equipment and ventilation buildings.

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 did not convene during the 2021 calendar 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. Both devices were used to conduct fuel measurements in Olkiluoto in July 2021, and the PGET device was used in Loviisa in November 2021. The measurements with both methods succeeded well. In the case of the PGET method, development continued also on the software side. The analysis algorithm was developed in cooperation with the University of Helsinki, Helsinki Institute of Physics and VTT.

2.7 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 line with the respective applications, STUK approves the responsible managers or deputies. In addition to international nuclear safeguards, operators must also adhere to the European Commission's nuclear safeguards regulation, which requires the plant's Basic Technical Characteristics (BTC), contact information and the nuclear material inventory to be up to date.

With regard to uranium producers, STUK reviewed the reports and notifications submitted by the Kokkola and Harjavalta metal works and the Sastamala ore processing plant. There were no significant changes in the activities of these operators. The responsible persons changed in Harjavalta, and STUK interviewed the new responsible manager remotely before their approval. In Kokkola, Umicore Oy, which intends to get rid of the uranium separated from the cobalt factory's production process, gained ownership of Freeport Cobalt Oy at the end of 2019. In 2021, STUK inspected the sending of one uranium batch in Kokkola and granted permission for importing uranium-bearing process solution from Umicore's factory in Belgium.

All operators submitted the nuclear safeguards reports and notifications required from them. Among the operators that submit monthly reports to the Commission, STUK inspected the nuclear safeguards practices of VTT's Centre for Nuclear Safety and the University of Helsinki's Department of Chemistry, since the responsible persons were changed and STUK found it necessary to review the nuclear material accountancy in detail in the context of the new responsible persons being approved. STUK inspected VTT's accounting procedures in February, and the University of Helsinki's nuclear material inventory was inspected in cooperation with the Commission and the IAEA in September. During the same week in September, STUK and the Commission first inspected the nuclear material inventory of VTT's Centre for Nuclear Safety, followed by which the IAEA, the Commission and STUK conducted a short-notice inspection visit to VTT in order to inspect plant area reporting and VTT's research activities related to nuclear fuel cycle. The University of Helsinki and VTT updated the manuals based on the feedback provided during the inspections, and the manuals were approved.

As regards bodies in possession of small quantities of nuclear materials, the IAEA, the Commission and STUK inspected the compliance, accounting and inventory of the Finnish Defence Research Agency. As part of the Commission's material balance area, the Agency

is covered by the IAEA's oversight. The IAEA has intensified the oversight of bodies in possession of small quantities of nuclear materials and initiated spot checks (3–4 per year) with the Commission. The Commission oversees a total of roughly 300 of these operators in 13 countries, which means that these types of spot checks are rare in Finland. The Finnish bodies in possession of small quantities of nuclear materials, of which there are currently 12, fulfilled the nuclear safeguards obligations and submitted annual reports on time.

STUK inspected the annual reports on nuclear fuel cycle related research and development activities and produced a report on their basis for the IAEA. In the autumn of 2020, the IAEA requested a clarification on equipment production and the autoclaves that had been delivered from Finland in accordance with the Additional Protocol. STUK responded to the request in cooperation with the equipment supplier at the end of 2020. In December 2021, the IAEA conducted a supplementary inspection visit to Platom to ensure the accuracy of the clarification and the coverage of Finland's report. As regards the possession and processing of information material subject to a licence, STUK granted three new licences in 2021 (see Appendix 7) and approved two manual updates and one change of a responsible person.

STUK supervised the trial operations 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. STUK and the Commission conducted an inspection at Terrafame in September 2021, during which the IAEA inspectors took a sample of the uranium solution for testing at the IAEA. The IAEA's role in Terrafame's oversight will be specified before the beginning of the actual collection activities. The Government granted permission for uranium extraction in February 2020, and the licence became legally valid in the summer of 2021. The licence states that Terrafame must begin its operations by the summer of 2024 and, well before beginning its operations, supplement the materials provided to STUK. The oversight and inspections by STUK indicated that Terrafame fulfilled its nuclear safeguards obligations in 2021.

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 safety obligations. In 2021, STUK approved a total of 11 nuclear safeguards manual updates related to these activities.

The more frequent IAEA inspection visits in 2021 is likely to be the result of the IAEA being in the process of updating the concept of oversight targeted at Finland (state-level concept). For this reason, more inspections were conducted on operators related to the nuclear fuel cycle on short notice. The number of unannounced inspections of nuclear materials and nuclear power plants was normal.

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 year 2021 was the third year of operation of the four-year research programmes SAFIR2022 and KYT2022. The planned research projects were carried out successfully and the short-term effects of the COVID-19 pandemic on research and international research cooperation were minor. In 2021, the research programmes organised a joint interim seminar, which was implemented remotely. Altogether 450 experts of the nuclear sector from around the world participated in the seminar.

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 (990/ 1987), research funded by the Finnish State Nuclear Waste Management Fund (VYR) aims at ensuring that the authorities have sufficient expertise and methods at their immediate disposal if it is necessary to assess the safety significance of new issues that may emerge. 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 Finnish Meteorological Institute, the Geological Survey of Finland and Lappeenranta-Lahti University of Technology (LUT University).

The SAFIR2022 safety research programme consists of 36 projects that were selected in the autumn of 2020 based on a competitive bidding. The available VYR funding for the research was around EUR 4 million. The volume of the SAFIR2022 safety research programme is around EUR 6.4 million and approximately 42.4 research years. As shown in Figure 7, the programme is divided into four research areas of the programme: 1) overall safety and management of design, 2) reactor safety, 3) structural integrity and materials, and 4) research infrastructure. The VTT Technical Research Centre of Finland and LUT University will use around 17% 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 investment objects. The SAFIR2022 research programme has specified eight Excellence projects. The SAFIR2022 management group is committed to the long-term funding of these projects. The Excellence projects represent the programme's research areas extensively. The total VYR funding of the Excellence funds was nearly a third of the entire share available for free competition. The research programme covers all issues integral to nuclear safety, and it will establish and maintain the expertise, analysis methods and experimental readiness to resolve any unforeseen safety issues.

The SAFIR2022 research projects are guided by eight technical reference groups in addition to the four research areas. The technical reference groups take care of the academic control

of research. Members of the technical reference groups were responsible for the scientific and technological guidance of the research and infrastructure of the use of nuclear energy. The technical 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 technical reference groups were assigned based on the research areas. All of the projects included in one technical reference group are usually part of a single research area.

The projects included in the SAFIR2022 programme for 2021 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.

The SAFIR2022 projects include several projects for developing capabilities, e.g. for avoiding situations similar to the one that lead to the accident at the TEPCO Fukushima Dai-ichi nuclear power plant in 2011 or 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 and compare results globally.

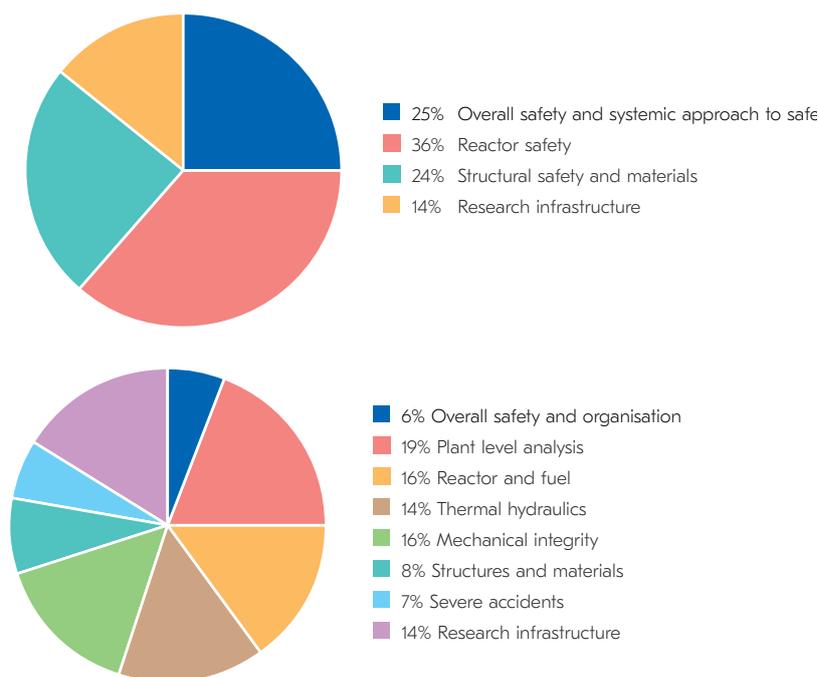


FIGURE 12. Research areas of SAFIR2022 programme and their shares of the total funding in 2021.

In addition to the above, the SAFIR2022 management group may fund small projects aimed at helping the development of research projects with new topics into becoming members of 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 small project in 2021 aimed to determine lessons to be learned regarding the Boeing 737 Max and Deepwater Horizon accidents in order to develop regulatory oversight, possible hydrogen production by means of nuclear power, and opportunities for international cooperation around the human–technology interaction (HTI). One small project was used to fund a management programme regarding the planning of a new research project set to begin in 2023.

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 operation 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.

The four-year KYT2022 research programme was launched in 2018. The research topics consist of the assessment of overall safety, the management of spent nuclear fuel, power plant waste, decommissioning waste and other radioactive waste, the feasibility of nuclear waste management and social research. The themes related to overall safety and fuel life span are shared with the SAFIR2022 programme. The programme consisted of research areas which are important for national expertise. It is aimed at extensive coordinated multidisciplinary research projects, 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. Research infrastructure funding was also continued in

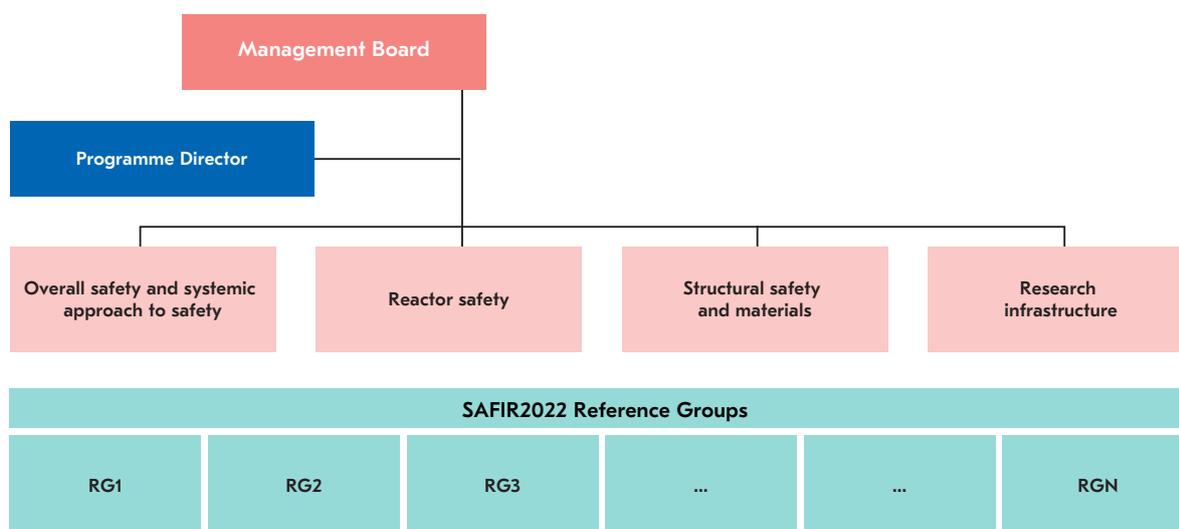


FIGURE 13. The administrative structure of SAFIR2022 research programme.

the KYT2022 programme. The research programme projects are not aimed at nuclear waste management development tasks or licensing required by nuclear energy act of individual licensees, but the results can be utilised and applied in nuclear waste management in a broader sense.

The KYT2022 management group issued financing recommendations regarding research in 2021 to the MEAE, with the help of research project assessment prepared by support groups. Among other things, the assessment of the research projects will focus on the suitability of each research topic for the KYT programme, the applicability of the results, the quality of the research plan, the possible educational impacts of the project, and cost efficiency. In 2021, the funding of the KYT2022 programme from the National Nuclear Waste Management Fund (VYR) was approximately EUR 1.9 million. In 2021, the research programme funded 32 research projects. The six excellence projects selected in 2019 received funding for 2021 as per the application.

In February 2021, the MEAE initiated the planning of a new joint project for nuclear power plants and safety research regarding nuclear waste management. Chapter 7a of the Nuclear Energy Act on ensuring expertise was amended in 2020 in order to ensure that the synergies between nuclear power plants and research on nuclear waste management can be utilised. The ministry appointed a planning group, which included representatives of all key interest groups. The new research programme, which is referred to as SAFER2028, will last six years. The aim is to finish the framework plan by the end of July 2022 and a competitive bidding in August 2022. The planning of the new programme has progressed well despite the limitations imposed by the COVID-19 pandemic.

An international assessment of the current SAFIR2022 and KYT2022 research projects and the upcoming SAFER2028 research project was prepared in 2021. The aim is to conduct the assessment in February 2022.

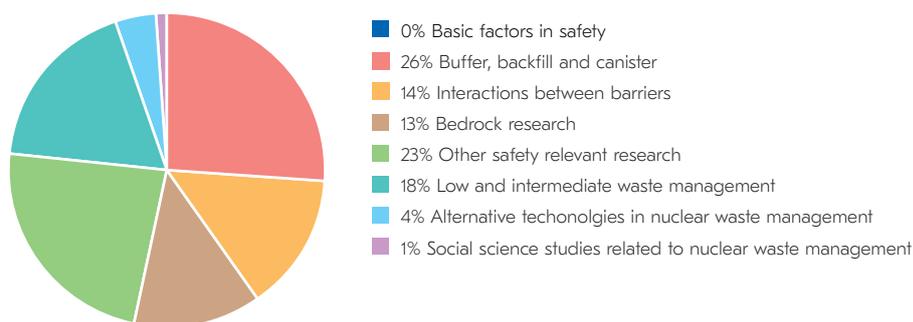


FIGURE 14. Distribution of VYR funding by research area in 2021.

4 Oversight of nuclear facilities in figures

4.1 Processing of matters

A total of 2,876 matters were submitted to STUK for processing in 2021. Of these, 673 concerned the nuclear power plant under construction and 304 concerned the disposal facility for spent nuclear fuel. The review process of a total of 2,929 matters was completed, including matters submitted in 2021, 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 61 days. The number of matters and their average review times in 2017–2021 are illustrated in Figure 15.

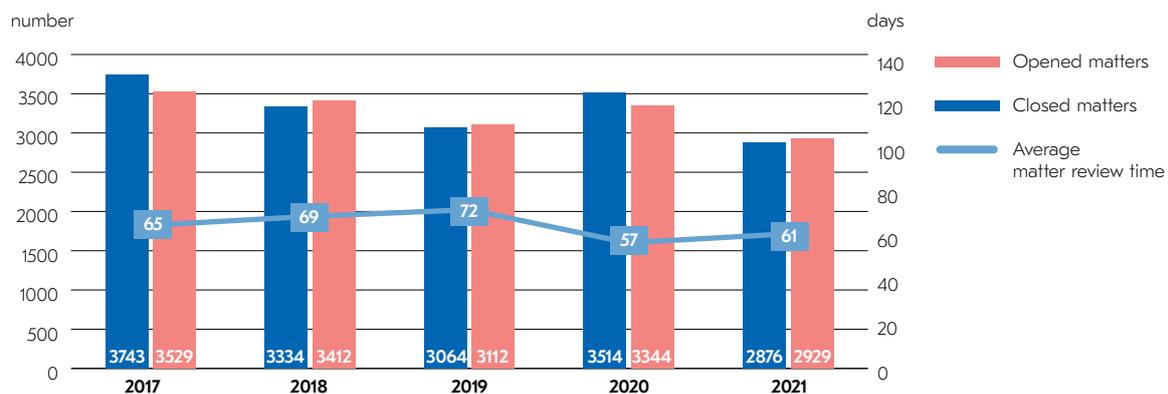


FIGURE 15. Average review time of opened and closed matters.

Figures 16–19 illustrate the review time distribution among matters from the various plant units and matters about Posiva.

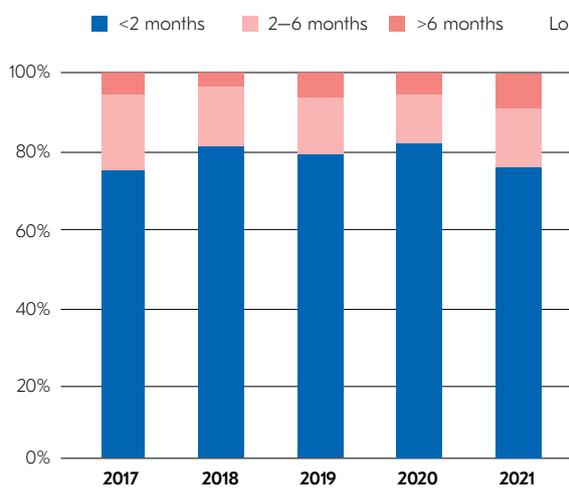


FIGURE 16. Distribution of time spent on preparing decisions on the Loviisa plant.

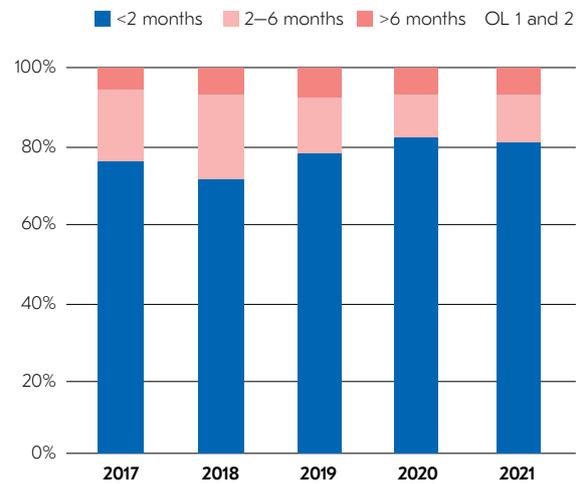


FIGURE 17. Distribution of time spent on preparing decisions on the operating plant units of Olkiluoto.

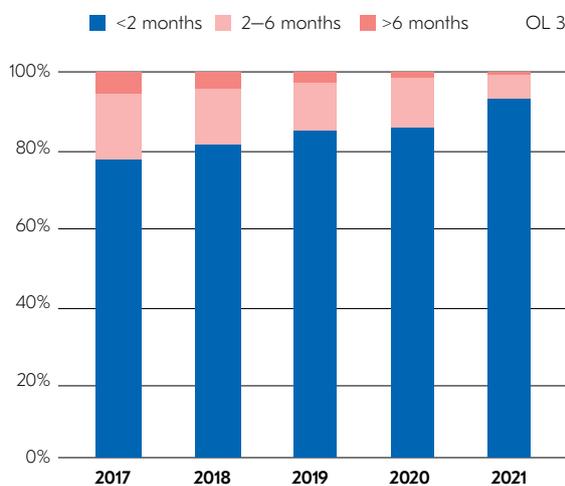


FIGURE 18. Distribution of time spent on preparing decisions on Olkiluoto plant unit 3.

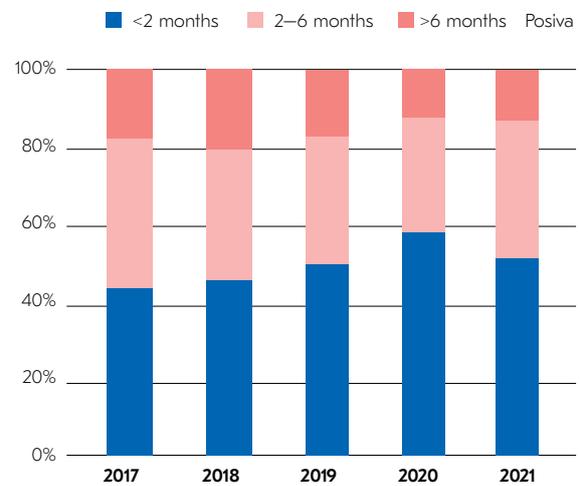


FIGURE 19. Distribution of time spent on preparing decisions on Posiva.

4.2 Inspections at nuclear facility sites and suppliers' premises

Inspection programmes

A total of 19 inspections at the Loviisa plant and 22 inspections at the Olkiluoto plant were carried out under the 2021 periodic inspection programme (Appendix 3). In addition to this, five inspections were conducted on OL3 under the start-up readiness inspection programme (Appendix 4). There were seven inspections pertaining to the processing of Fennovoima's construction licence application (Appendix 5). Six inspections of the encapsulation plant and disposal facility construction inspection programme were carried out in 2021 (Appendix 6). The key findings of the inspections are presented in the appendices and the chapters on regulatory oversight.

Other inspections at plant sites

A total of 1,912 inspection protocols were signed on site or on the suppliers' premises in 2021 (other than the above-mentioned inspection programme inspections and the nuclear safeguards inspections, which are separately described). Of these inspections, 953 were part of the oversight of Olkiluoto 3 and 937 of the other operating plants. The oversight of the construction of Posiva's final disposal facility included 22 inspections.

The numbers of on-site inspection days in 2017–2021 are illustrated in Figure 20.

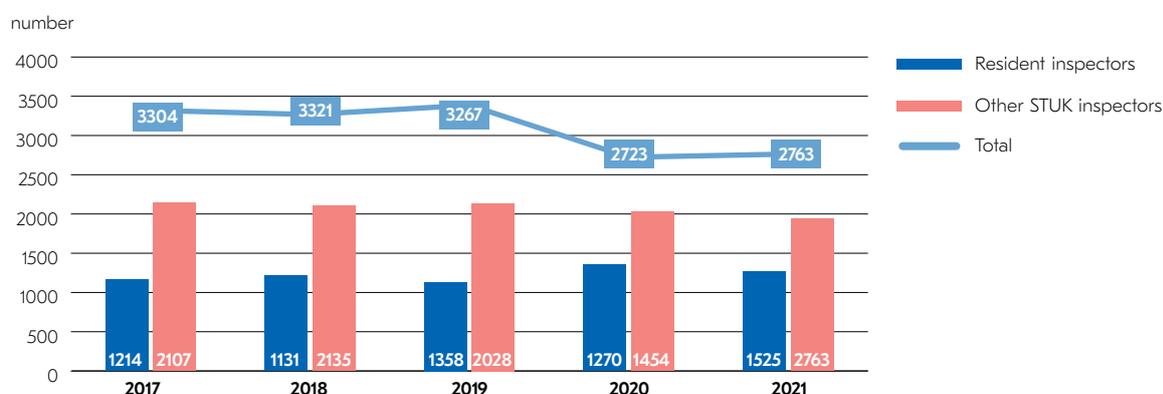


FIGURE 20. Number of inspection days onsite and at component manufacturers' premises.

4.3 Finances and resources

The duty area of regulatory oversight of safety in the use of nuclear energy includes basic operations subject to a charge as well as those free of charge. Basic operations subject to a charge mainly consist of the regulatory oversight of nuclear facilities, and their costs are charged from those subject to the oversight. Basic operations free of charge include international and domestic cooperation, participation in legislation development efforts, emergency response operations and communications. Basic operations free of charge are publicly funded. Overheads arising from the preparation of regulations and support functions (e.g. administration, supervision development, competence development, reporting, and participation in nuclear safety research) are carried over into the costs of basic operation subject to charge and free of charge and service activities in relation to the number of working hours spent on each function.

Consequently, the cost correlation of regulatory oversight of safety in the use of nuclear energy was 100%. Attainment of the cost price for the oversight 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 the use of nuclear energy subject to a charge were EUR 19.7 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 the use of nuclear energy were EUR 20.5 million. This figure includes the costs of regulatory oversight of the use of nuclear energy subject to charge as well as free of charge. The share of activities subject to a charge accounted for 96% of the total costs. Figure 21 shows the annual costs of regulatory oversight of the use of nuclear energy in 2017–2021.

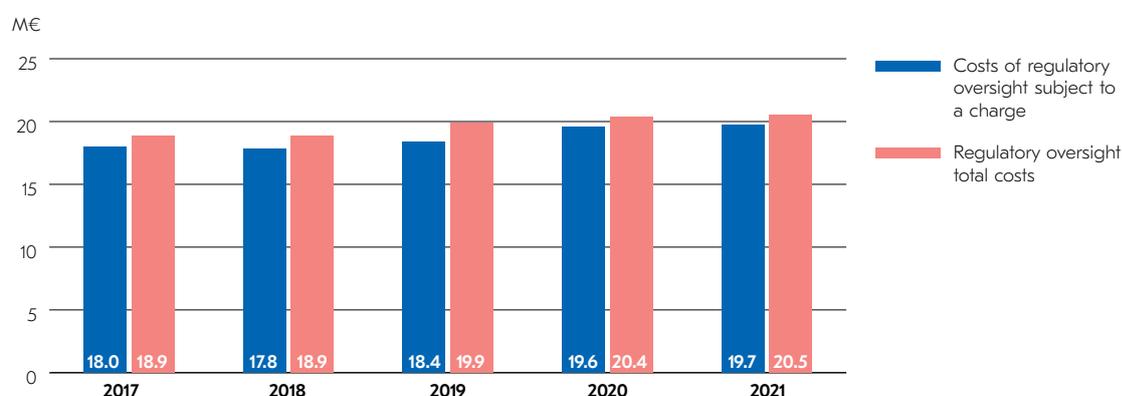


FIGURE 21. Income and costs of nuclear safety regulation.

The time spent on the inspection and review of the Loviisa nuclear power plant was 14.2 man-years or 10% of the total working time of the personnel supervising the use of nuclear energy. The time spent on the inspection and review of the Olkiluoto units 1 and 2 was 15.4 man-years or 10.8% of the total working time. In addition to the monitoring of the operation of the nuclear power plants, these figures include the control of nuclear materials. The time spent on the inspection and review of Olkiluoto 3 was 16.6 man-years or 11.6% of the total working time. Work related to the Fennovoima plant project amounted to 12.8 man-years or 8.9% of the total working time. A total of 10.1 man-years or 7.1% 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 0.4 man-years. Figure 22 shows the division of working hours of the personnel engaged in controlling the use of nuclear energy (in man-years) by subject of oversight during 2014–2021.

Where necessary, STUK commissions independent assessments and analyses in support of its oversight. Figure 23 illustrates procurement costs in 2017–2021. The acquisitions in 2021 were associated with the sensitivity analyses of the sites' seismic design bases, Hanhikivi 1 accident analyses and the safety assessment of Posiva's spent nuclear fuel disposal project.

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

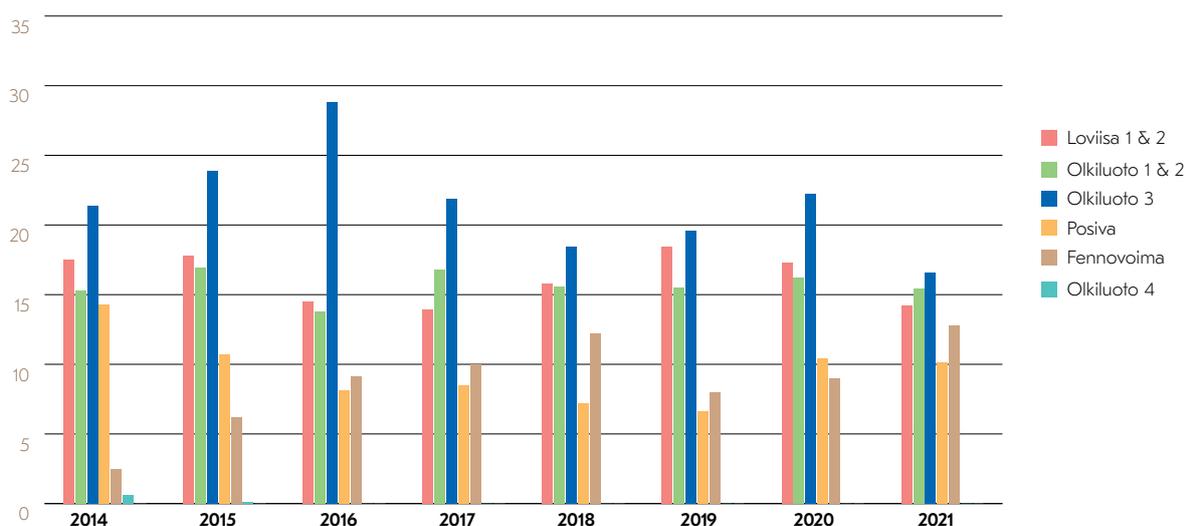


FIGURE 22. Distribution of working time (person-years) of the regulatory personnel by subject of oversight in 2014–2021. Nuclear waste oversight of operating plants is combined with other regulatory oversight.

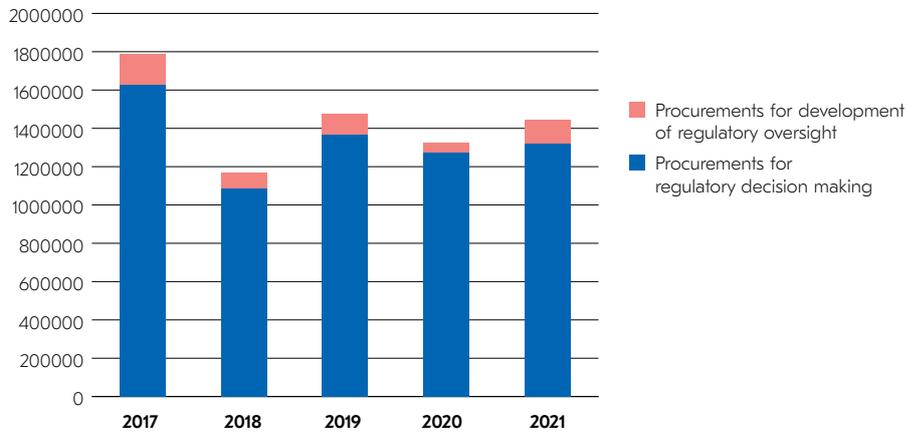


FIGURE 23. The acquisition costs of assessments and analyses.

Duty area	2017	2018	2019	2020	2021
Basic operations subject to a charge	72.0	71.0	68.7	75.8	71.9
Basic operations not subject to a charge	4.0	4.8	6.3	4.0	3.0
Service activities	4.3	3.7	1.1	0.5	0.7
Regulation work and support functions	42.9	44.1	45.2	44.7	42.6
Holidays and absences	26.9	26.3	26.0	23.3	23.7
Total	150.1	149.9	147.4	148.3	142.0

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



5 International cooperation

Impact of the COVID-19 pandemic on international cooperation

International travel remained challenging due to the COVID-19 pandemic and several international meetings were arranged remotely. Some meetings were also postponed or cancelled, if remote arrangement were infeasible. STUK actively participated in international meetings held remotely. In the autumn of 2021, STUK also took part in a few face-to-face meetings, before the coronavirus situation deteriorated once again. Remote meetings functioned reasonably well, although they were not able to fully replace all interactions at face-to-face meetings. Remote meetings can still be utilised in certain situations in the future, even after travelling is possible again.

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. Starting from 1999, Finland has produced national reports which are compliant with the Convention on Nuclear Safety every three years. The latest report was produced in 2019. The fulfilment and reporting of the obligations of the convention will be assessed at an international review meeting between the contracting parties. 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. The following meeting will take place in 2023. The meeting was scheduled for March 2020, but was cancelled due to the COVID-19 pandemic. In October 2021, STUK participated remotely in an organisation meeting held in preparation for the actual meeting.

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. In 2020, STUK coordinated the compilation of a national report required by the Convention, which reported on matters related to nuclear waste management in Finland. Because of the COVID-19 pandemic, the Nuclear Waste Convention's organisation meeting was held remotely in autumn 2020. The new organisation of the Nuclear Waste Convention decided that, due to the circumstances, the 2021 evaluation meeting would be postponed by about a year to summer 2022.

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**), the Emergency Preparedness Committee **EPreSC** 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 15 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-type nuclear power plant has been built 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. The planning of the operations for the MDEP's next five-year term was also initiated in 2021. Finland served as the chair of the planning group.

WENRA's (Western European Regulator's Association) Reactor Harmonisation Working Group (RHWG) convened three times in 2021, and due to the COVID-19 pandemic, the meetings were held remotely. Over the course of the year, the group's most important tasks were initiating the periodic assessment of reference levels and preparing a technical content description for the topic-specific peer review prescribed by the Nuclear Safety Directive, which now focused on fire safety. STUK was actively involved in the efforts and the RHWG subgroups.

WENRA's Working Group on Waste and Decommissioning (WGWD) convened twice in 2021 by remote means. Self-assessments and peer reviews of reference levels associated with disposal were continued during the year, as were self-assessments and peer reviews of the reference level report on nuclear waste processing facilities. STUK was actively involved in the group's efforts.

In 2021, WENRA established a new working group, the **SRL Steering Group**, with the purpose of examining the capabilities of harmonising the reference levels of WENRA's various working groups and coordinate the preparation of possible shared reference levels. The working group convened six times in 2021 by remote means. STUK was actively involved in the group's activities.

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). In March 2021, STUK prepared a final report on the national measures related to the EU stress tests that had been initiated due to the Fukushima incident. All of the measures have been completed at the Finnish nuclear power plants. 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. At the end of May 2021, STUK updated the national action plan prepared based on the peer review. Two of the five measures have been deemed closed. One of the measures was related to considering concrete structures in the ageing management programme of the Olkiluoto 3 plant unit, which is currently being commissioned. The other measures pertained to developing a separate ageing management programme for electrical cables at Olkiluoto 1 and 2. The three measures that remain open

are related to the further development of ageing management programmes at the operating nuclear power plants and the specification of ageing management procedures for possible longer outages. In line with the Nuclear Safety Directive, the peer review will be organised every six years in the future, and the planning of the next review is under way. In 2020, fire safety was selected as the topic of the second peer review. WENRA's **RHWG** is developing a technical content description as a basis for national reports, and ENSREG's nuclear safety group is developing procedures for conducting peer reviews. The preparation of national assessment reports will begin in 2022.

ENSREG's **nuclear waste management group** conducted a survey on the practices of the Member States with regard to specifications related to the start of nuclear power plant commissioning and the end state of the commissioning. The processing of indicators for progress in national nuclear waste management continued in a workshop organised by the European Commission. An analysis was initiated on practices related to waste generated outside the nuclear sector, but the actual work will take place in 2022. STUK participated in the joint **IRRS** and **ARTEMIS** peer review optimisation project of ENSREG's nuclear safety and nuclear waste management groups. In addition to ENSREG, the IAEA was involved in the discussions. The work will continue over the course of 2022.

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. The workshop planned for 2020 in Finland was postponed until 2022. In 2021, the group held a few remote meetings to prepare for the managers' meeting and to plan the meeting to be organised in Finland in 2022.

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 2021, STUK participated in the working group activities of the VVER forum. The forum's annual meeting was held remotely 30 November–2 December 2021 and hosted by Hungary.

Bilateral cooperation between authorities

Cooperation with the new German Federal Waste Management Authority, Das Bundesamt für die Sicherheit der nucleren Entsorgung (BASE), was launched with two webinars, the first on waste management and related regulatory control in each country and the second on the commissioning and expansion of disposal facilities and acceptance criteria for the waste brought into the disposal facility.

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 and later with the United Kingdom's nuclear safety authority, Office for Nuclear Regulation. 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, Flamanville 3 and Hinkley Point C) have been discussed. In 2021, STUK held several information exchange meetings with ONR, ASN and IRSN, which involved discussing test operation observations at various EPR units and current topics related to operational preparations, operation and mechanical components. The meetings were held remotely due to the prevalent COVID-19 situation.

Cooperation with the Russian nuclear safety authority, Rostekhnadzor (RTN), was significantly reduced compared to previous years due to travel restrictions resulting from the COVID-19 pandemic. The biannual meetings with the resident inspectors of RTN's Leningrad and Kola nuclear power plants were held by means of video conferencing. The annual directors' meeting was held remotely in early 2021.

The Hungarian radiation and nuclear safety authority (HAEA) continued the assessment of the construction licence application for the AES-2006 nuclear power plant (PAKS-2 project) in 2021. As the plant type is similar to the one Fennovoima is planning to construct in Hanhikivi, STUK continued its close cooperation with HAEA. Due to the COVID-19 pandemic, the meetings were held remotely in 2021 and organised by STUK. The meetings involved comparing the licence processing situation and related challenges and sharing evaluation and inspection findings on issues such as site surveys, plant design and the submission of official licence documents. HAEA received the PAKS-2 construction licence application at the end of June 2020 and requested the IAEA to provide an independent safety assessment to support its own assessment. Hungarian legislation provides a 1.5-year processing period for construction licence permits, which HAEA announced would be extended to resolve open safety issues. Material studies related to the management of the pressure vessel's ageing were also discussed separately in 2021.

Cooperation for the prevention of the proliferation of nuclear weapons

The Non-Proliferation Treaty 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 one was scheduled for April–May 2020. The meeting was initially postponed by six months due to the COVID-19 pandemic. According to current plans, the review conference will be held in August 2022. According to the Non-Proliferation Treaty, nations must enter into a Safeguards Agreement with the International Atomic Energy Agency (IAEA). The first Comprehensive Safeguards Agreement between Finland and the IAEA entered into force on 9 February 1972.

The Nuclear Suppliers Group (NSG) forms a multinational control system whose members are nuclear supplier countries. The group aims to prevent the proliferation of nuclear weapons by controlling the export of materials, equipment and technology used in the manufacture of nuclear weapons. The group consists of 48 countries. Finland is represented in the Nuclear Suppliers Group by the Ministry for Foreign Affairs. STUK usually participates in the meetings of the Technical Experts Group (TEG), which are held in April and November. In 2021, both meetings were cancelled. In October, however, an information meeting by the chairs' of the NSG working groups was held as a virtual meeting, attended by a STUK expert.

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 oversight methods, the preparation of oversight plans and the training of the IAEA inspectors. The Finnish support programme had a review meeting with the IAEA in November 2021. The meeting was held remotely. In 2021, the support programme had 17 on-going projects.

STUK is a member of ESARDA (European Safeguards Research and Development Association) and it has appointed experts to the association's committees, several working groups and editorial committee. STUK is also a member of ESARDA's Steering Committee and Executive Board. STUK's experts served as deputy chairs of the Implementation of Safeguards working group and the Export Control working group. ESARDA held its symposium, which is intended to be held every other year, in cooperation with the Institute of Nuclear Materials Management (INMM) in the form of a webinar in August–September 2021. In addition to this, ESARDA's working groups convened separately in November. The objective is to continuously monitor and respond to the needs of ESARDA's members and further the nuclear safeguards goals on a national and international level.

The 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 the representatives of the IAEA, European Commission, Sweden and Finland. The LLLC EPGR work group would be a cooperation group and ensure good communications and cooperation between all parties and report regularly to the LLLC. The preparation of the safeguards oversight concepts has started simultaneously with the development of the final disposal concepts and technologies. The observation of safeguards-by-design in plant design is possible through close cooperation of the plant designers, plant operating personnel and authorities. The tenth EPGR meeting planned for 2021 was postponed to early 2022. The main topics of last year's meeting included the plans for the safeguards-by-design oversight of Posiva's encapsulation plant and the underground final disposal facility and the preparations for implementation. Instead of the actual EPGR meeting, two tripartite meetings (Finland, EC and IAEA) were held on the oversight of the repository and several technical meetings on the detailed plans for the technical supervision of the encapsulation plant.

APPENDIX I

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	10.10.1979	920/890	Boiling water reactor (BWR), Asea Atom
Olkiluoto 2	18 Feb 1980	1.7.1982	920/890	Boiling water reactor (BWR), Asea Atom
Olkiluoto 3	21 Dec 2021	—	Approx. 1,600 (net)	Pressurised water reactor (EPR), Areva NP

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

Hanhikivi nuclear 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

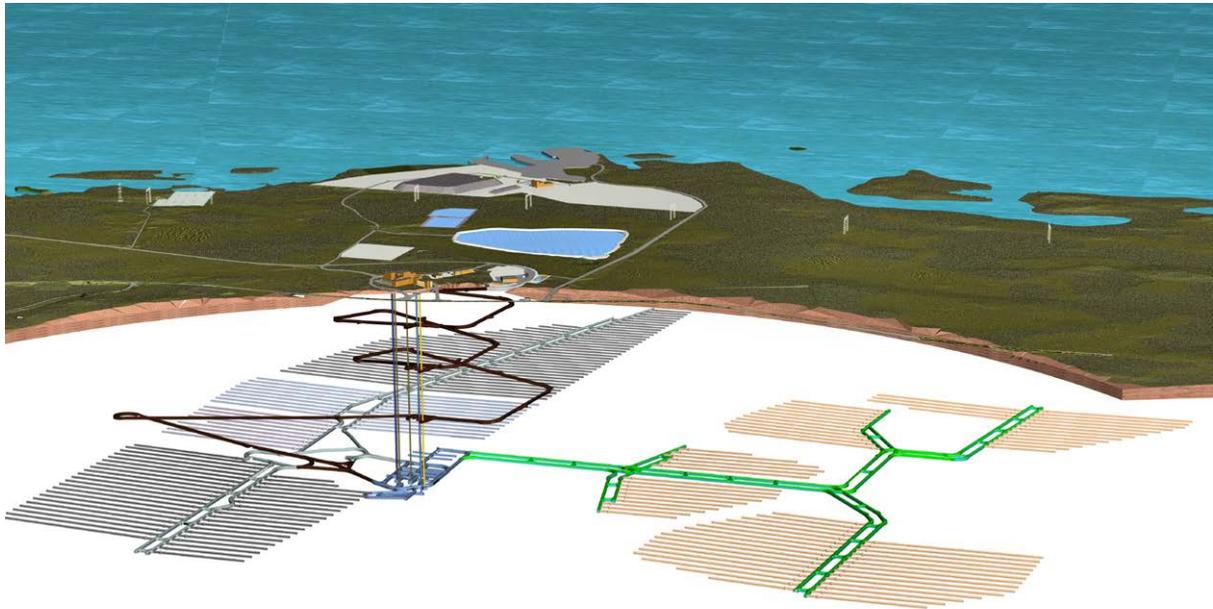


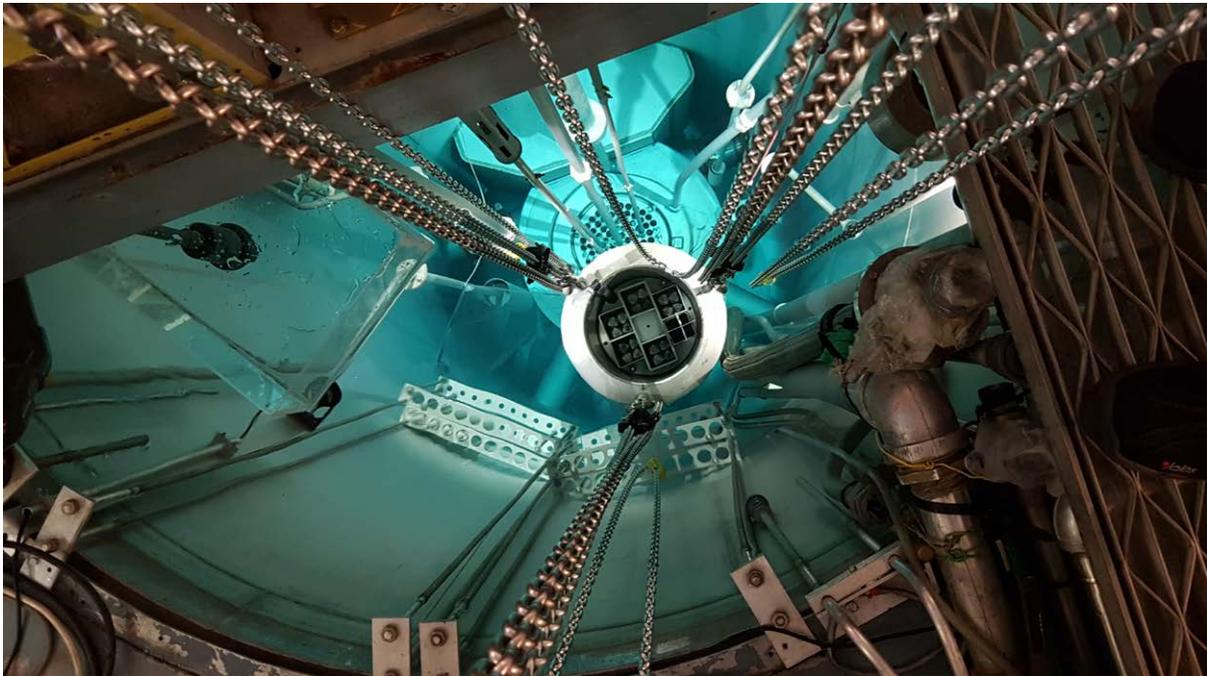
Diagram of the Olkiluoto encapsulation and disposal facility (Posiva Oy).

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. The construction of the disposal facility started at the end of 2016. 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.

The encapsulation plant is an above-ground facility for the encapsulation of spent nuclear fuel that is constructed above the disposal facility. The construction of the encapsulation plant was started in summer 2019. From the encapsulation plant, the capsules will be transferred along an elevator shaft to the disposal facility to be disposed of in the disposal holes in underground tunnels.

Posiva submitted an operating licence application to the Government at the end of 2021. Once the test runs are complete and the operating licence has been granted, operation is estimated to begin in 2025.

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. The licence was granted in June 2021.

Other objects of regulatory control

In accordance with Section 2 of the Nuclear Energy Act (990/1987), the regulatory control of the use of nuclear energy covers the nuclear material used, for example, in certain 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 control of the use of nuclear energy covers mining and milling operations aimed at producing uranium or thorium. Terrafame's uranium extraction plant is part of this group. The intermediate products of metal industry containing uranium are also included in the regulatory control 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 power plant

Loviisa's annual outages 22 August–4 October 2021

Both units of the Loviisa nuclear power plant had short so-called refuelling outages, which involved replacing some of the reactor fuel with fresh fuel and conducting the necessary inspections and repairs. In addition to these, Fortum continued the updates of the plant's protection and I&C systems as well as other smaller tasks to improve plant safety.

The COVID-19 pandemic did not impact the progress of the annual outages – Fortum observed the updated measures and plans that had been found appropriate in the previous year. STUK carried out the inspections deemed necessary on site and supervised various sites with the help of remote connections.

Loviisa achieved the lowest radiation dose in the plant's history. Furthermore, individual doses and the numbers of contamination cases were very low.

The annual outages of the Loviisa nuclear power plant started with the stopping of the Loviisa 2 unit on 22 August 2021. Fortum had observed minor fuel leak at Loviisa 2 during the spring of 2021, due to which it decided to test all fuel elements. The tests revealed one leaking fuel element, which was replaced with a new one.

The annual outage of the Loviisa 1 unit began on 11 September 2021. Loviisa 1 continued the investigations of discrepancies (increased sound observations) found in the reactor pressure vessel's foreign material monitoring system. The investigations had begun in 2019.

Extensive check-ups were carried out during the 2020 annual maintenance. During the 2020–2021 operating period, the number events corresponded with the 2019–2020 period, based on which Fortum replaced absorbers (15 pcs) as extra tasks during the 2021 annual outages and also inspected the area of the guide sleeves of all intermediate shafts. Unfortunately, the root cause was not yet determined. At this point, the phenomenon is not significant to safety, but it is important to determine the cause to ensure that preparations for any changes can be made in good time. Fortum will monitor the situation and examine the absorbers removed from the reactor during the 2021–2022 operating period. STUK is supervising Fortum's measures.

The most significant modifications in terms of safety were as follows:

- Performed on both plant units
 - Partial update of the plant protection system (LASU), for which the preliminary work was conducted in 2020.

- Changes to the containment-internal fire water line UJ13 by equipping the main line with a check valve and low-capacity bypass line to limit maximum leaks into the containment but continuously ensure sufficient capacity for initial extinguishing and an emergency shower. The modification reduces the risk of large amounts of cold fire water spilling on the side of the reactor pressure vessel, thereby directly increasing the cold cracking risks of the vessel.
- Performed on Loviisa 2
 - Improving the redundancies of the power supplies for the pressuriser control valves' magnetic loads (Paha-Mango project).
 - The cooling water pipes of the generators EY01 and EY04, which were updated in 2018, were finalised by adding rubber hoses and additional supports, which ensures matching cooling water pipes for all four Loviisa 2 emergency diesel generators. The update of the Loviisa 1 cooling water pipes is in the planning phase.
- Conducted during Loviisa 1's annual outage
 - The second phase of the emergency diesel I&C update (DAUT project), which involved renewing the control systems of the EY01 diesel generator. The work also entailed improving the separation of the diesel generator's safety operating system and the control systems that are used during periodic tests and are not important to safety. In addition to this, some final work was carried out on the I&C of the EY03 unit, which was updated last year. The updates will continue one diesel generator at a time during the following years.

The 2021 annual outage was supervised 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. No safety deficiencies that would have required immediate intervention by STUK emerged during the inspection. The inspection summary is provided in Appendix 3. Based on the inspection and regulatory control by STUK, the annual outages were carried out safely, and all planned work important in terms of safety was completed.

Radioactive particles were found in the outer areas of the Loviisa plant unit in 2021 as well

Fortum's radiation protection unit found one radioactive particle in April 2021 and two radioactive particles in September during the contamination measurements in the yard area between the plant units. The particle found in April was near the outer door of Loviisa 1's transport route, and the radiochemistry laboratory measured its total activity to be 59 kBq. During the yard measurements in September, an active particle was first found in front of the outer door of Loviisa 2's material transport route and, a little later, a contaminated spot was detected near the outer door of Loviisa 1's transport route. The total activities of these findings were 11 kBq and 0.5 kBq. Fortum removed all observed active particles from the yard area. Fortum continued the yard measurements after goods transport in October following the annual outages. During that time period no more radioactive particles were found.

Based on the laboratory analyses, the nuclide distribution of the April 2021 finding was similar to the particles found in 2020, at which point ten radioactive particles were found in the yard. According to Fortum’s estimate, the radioactivity detected in 2020 most likely originated from moving the spent fuel transfer cask. The investigation did not reveal the origin of the two particles found in September 2021. However, the visual appearance and nuclide distribution of the particle detected first in September deviated from other observations, which is why it was assumed to originate from a relatively recent event.

Based on the events of 2020, Fortum launched investigations in order to discover the origin of the radioactive particles and find out why they ended up in the yard. The measures defined based on the investigation are focused on cleaning the spent fuel transfer cask, protection of the cask during transport through the yard area, reducing the contaminants in the cask’s storage pools, developing contamination measurements in the yard areas and possibility to transfer radioactive plant components in made-for-purpose transport shields. The measures are partially incomplete and will be continued in 2022. Fortum will also investigate possibilities to improve the discharge measurement of goods and transports as well as contamination management.

The external radiation exposure caused by particles in the yard cover is insignificant. If the particles were to remain on bare skin or inside the body, they could cause an abnormal radiation dose.

The event was rated at level 1 on the International Nuclear and Radiological Event Scale (INES), indicating that it is an anomaly with safety impacts.

Situations in breach of Operational Limits and Conditions

Over the course of 2021, three events in breach of the OLCs were found. On the international INES scale, they were classified as INES 0 events that were insignificant in terms of safety.

- On 27 January 2021, Fortum observed that particle and activated carbon filters of Loviisa 2’s process gas monitoring had not been replaced for three weeks due to a mix-up in the filter replacement programme. The mix-up was caused by the year 2020 having 53 weeks. The OLCs require the filters in question to be replaced and analysed at the radiochemistry laboratory every two weeks. A week’s extension to the analysis interval on one occasion did not have a practical impact on the accuracy of the analysis result, and the longer interval was taken into account in the analysis.

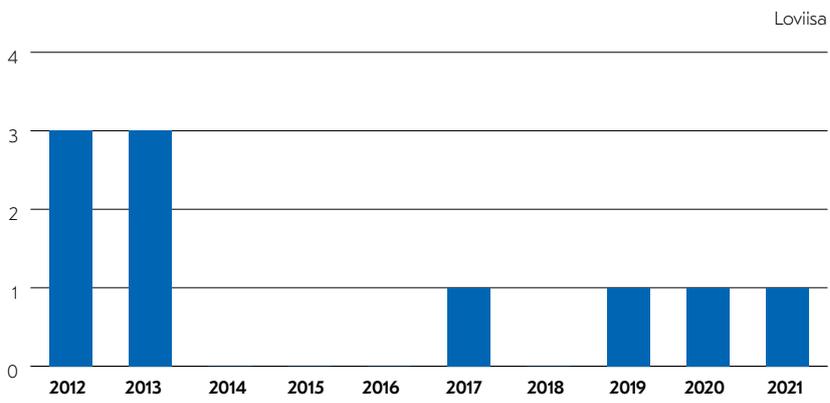


FIGURE A2.1 INES classified events at the Loviisa plant (INES Level 1).

- On 12 April 2021, Fortum observed that one the insulation resistor of one of the ignition plugs in the steel containment's hydrogen burning system was below the approval limit specified in the maintenance instructions. During the investigation, Fortum noticed that the insulation resistor had already been below the approval limit in the previous measurement in January 2021. At the time, the failure was not responded to in accordance with the OLCs (i.e. it was not repaired within three weeks). Instead, the repair was set to be conducted during the next annual outage in the autumn 2021. The acceptability of the ignition plug's inoperability for several months was not indicated at this time or processed through the OLCs exemption procedure. This resulted in a situation that breached the OLCs. In Fortum's estimation, the ignition plug in question meets its safety function (i.e. produces a sufficient temperature to ignite the hydrogen in the air when needed) even if the insulation resistor does not meet the approval criteria of the test procedure. The other 39 ignition plugs in the steam generator space are in order.
- Loviisa 2 was in the middle of its annual outage on 1 September 2021 when the boron content of the primary circuit water dropped below the OLCs limit on three occasions. According to the continuously operating boric acid analysers, the content was 5.9 g/kg at its lowest. The OLCs require a content of 13–15 g/kg. The durations of the shortfalls were 24 minutes, 12 minutes and 16 minutes, meaning that the values measured by the boric acid analysers dropped quickly but also returned to the original level rapidly. This kept clean water that would have diluted the boric acid content from flowing in to the primary circuit for an extended period. As such, the event was not significant to safety since it would have been impossible for a small amount of water with no or very little boron to flow into the reactor without first mixing with water with a higher boric acid concentration. Boron is used to manage reactivity.

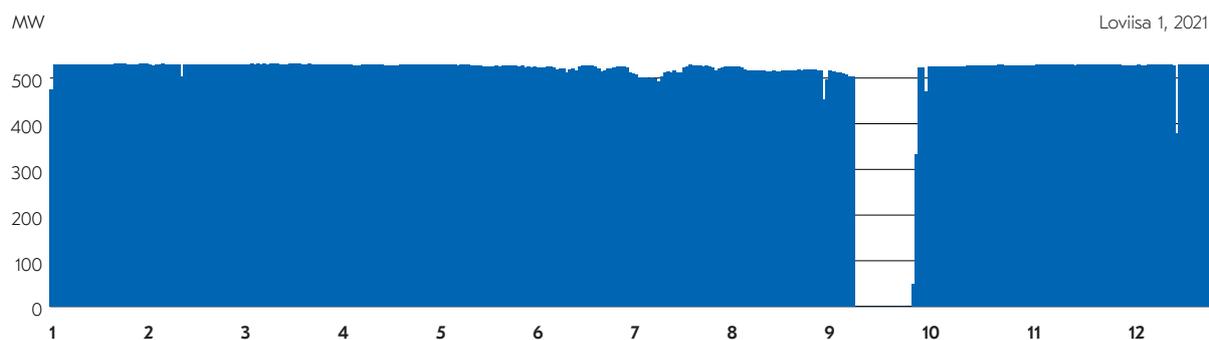


FIGURE A2.2 Daily average gross electrical power of the Loviisa 1 plant unit in 2021.

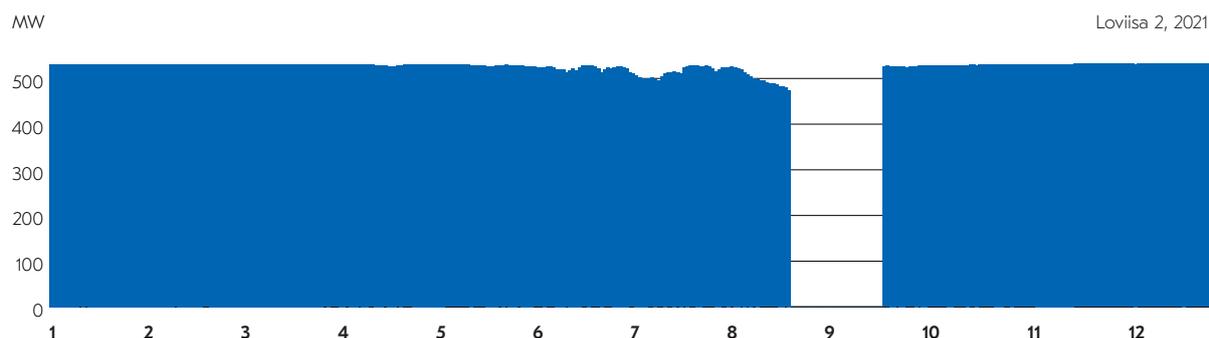


FIGURE A2.3 Daily average gross electrical power of the Loviisa 2 plant unit in 2021.

Olkiluoto power plant

Olkiluoto annual outages 24 April – 18 June 2020

The annual outages of the plant units were implemented as planned in terms of nuclear and radiation safety. Despite the pandemic, all planned maintenance and inspection tasks were completed to their full extent. The annual outage also included some tasks that were postponed due to the pandemic during the 2020 annual outage. As was the case in the previous year, strict procedures were in place during the annual outages to prevent the spreading of coronavirus infections. For example, contractors arriving at the plant were required to provide a negative COVID-19 test before the commencement of any work. The procedures were effective, and COVID-19 pandemic did not cause significant detriment during the annual outages.

The annual outages took place between April and June. The OL1 plant unit’s programme included a refuelling outage and OL2 went through a more extensive maintenance outage. In addition to the normal maintenance work and inspections encompassed by the refuelling outage, a pressure test of the primary circuit was performed at OL1. STUK required both plant units to carry out a pressure test in conjunction with operating licence renewal of 2018. The pressure test succeeded well and the results met the approval criteria set for the test. The maintenance outage at OL2 involved several modifications in addition to the refuelling. The cooling system pump of the reactor that was shutdown was replaced with a new type of pump during the annual outage. The pump update, which was the first of its kind, was a challenging construction and radiation protection process. The OL1/OL2 plant units use four

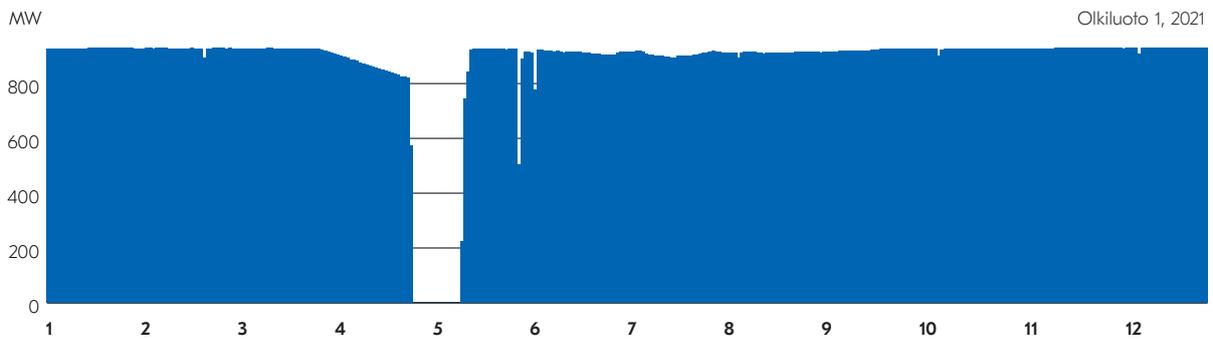


FIGURE A2.5 Daily average gross electrical power of the Olkiluoto 1 plant unit in 2021.

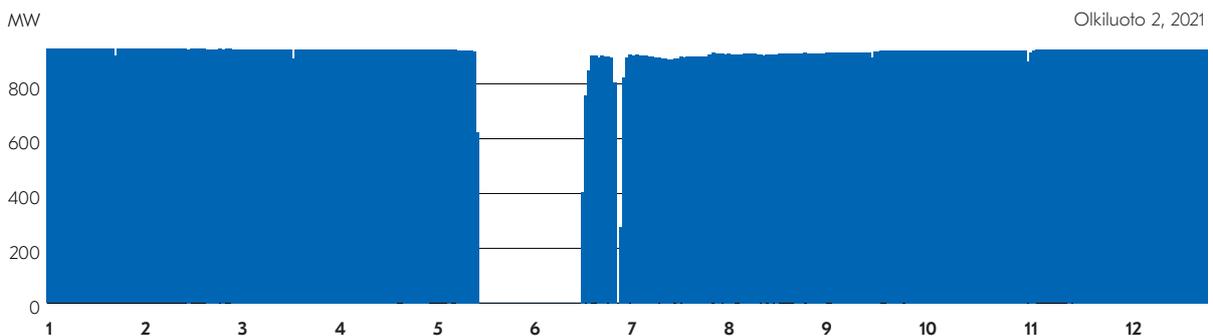


FIGURE A2.6 Daily average gross electrical power of the Olkiluoto 2 plant unit in 2021.

corresponding pumps in total. The remaining three will be updated during upcoming annual outages. The bottom of the reactor pressure vessel was inspected with new equipment that enables the vacuuming of foreign materials. The equipment was used to remove multiple foreign materials from the reactor. The containment's electrical penetration modules were updated at both plant units. The replacements of the penetration modules will be continued during future annual outages as planned until 2028.

The radiation doses caused during the annual outages stood at 283.7 manmSv for OL1 and 600.7 manmSv for OL2. The total dose of the annual outages was 884.4 manmSv. The doses were higher than anticipated at both plant units (OL1 overshoot 23%, OL2 overshoot 26%). According to TVO, the most likely cause of the higher-than-anticipated dose accumulations is the increase in work amounts from the time at which the dose estimate was made. Furthermore, the replacement of the cooling system pump of the shutdown reactor turned out to be more challenging than expected. The planned work methods related to the pump replacement had to be changed, which resulted in radiation doses that were clearly higher than anticipated. Based on measurements taken with an electronic dosimeter, the highest individual dose during the annual outages was 7.4 mSv.

STUK oversaw the annual outages from their design to the start-up of the plant units. During the annual maintenance, STUK conducted the mechanical equipment inspections prescribed in the YVL Guides normally. The resident inspectors conducted general oversight at the plant site during the annual outages. Overall, STUK carried out more on-site control measures than during the 2020 annual outage, but the scope was still smaller than before the COVID-19 pandemic. Control activities focused on targets that were most significant in terms of safety, such as inspection related to verifying the start-up readiness of the plants. STUK posted several inspectors to OL1 to oversee the primary circuit pressure test. During the annual outage, STUK carried out a KTO inspection of annual outages. A summary of the inspection is presented in Appendix 3.

According to STUK's findings, the annual outages were performed safely. During the annual outage, STUK received a report of one event in breach of the OLCs, in the context of which protection function intended to ensure reactor subcriticality had been deactivated in violation of the OLCs. The safety significance of the event was estimated to be minor, since subcriticality

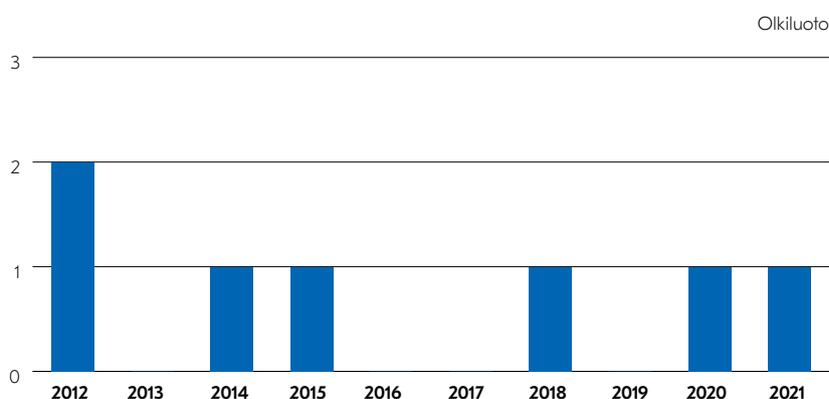


FIGURE A2.4 INES classified events at the Olkiluoto plant (INES Level 1).

at the time of the event was also ensured by means of several other functions. TVO conducted an investigation on the event and submitted an event report prepared based on it to STUK for approval. The event is described in more detail in the section “Situations in breach of Operational Limits and Conditions”.

Radioactive particles in the yard area due to transfer of spent nuclear fuel

TVO found radioactive particles in the uncontrolled area of the Olkiluoto power plant in the context of transfers of spent nuclear fuel in October–November. During the transfer of spent nuclear fuel from the OL1 plant unit to the spent nuclear fuel storage (KPA storage), radioactivity ended up in the transfer cask’s transport equipment, the transport route of the KPA storage’s uncontrolled area and the transfer route in the yard area. A total of 16 radiation particles were found, two of which were found in the yard area. TVO removed the radioactive particles and delivered some of them to the chemistry laboratory for analysis. At the same time, TVO decided to initiate an event investigation to prevent the event from recurring.

The spreading of the radioactive particles resulted from a particularly contaminated transfer cask, which could not be sufficiently cleaned despite efforts and had to instead be covered with plastic for the transfer. It was later found that the transfer cask’s surface contamination partially exceeded the limit value for surface contamination set in the KPA storage’s Operational Limits and Conditions (OLCs).

The event did not cause individual contaminations or abnormal radiation doses. The external radiation exposure caused by the floor or yard cover is insignificant. If the particles were to remain on bare skin or inside the body, they could cause an abnormal radiation dose.

STUK rated the event at level 1 on the International Nuclear and Radiological Event Scale (INES), indicating that it is an anomaly with safety impacts. TVO is investigating the event and will provide a more detailed report during 2022.

Situations in breach of Operational Limits and Conditions

Three situations in breach of the OLCs were observed during 2021. The safety significance of the events was estimated to be low.

- On 23 May 2021, during Olkiluoto 2’s annual outage, the S chain was found to be overcoupled in violation of the OLCs. The purpose of the S chain is to prevent the control rods from being extracted unnecessary, which can lead to reactor criticality. According to Section 7 of the

OLCs, the S chain must be in working order during refuelling. Due to the overcoupling, the protection would not have worked if needed. Reactor unloading was under way at the time of the event. The overcoupling was done when three fuel elements remained in the reactor. The situation was found to be in breach of the OLCs when the remaining three fuel bundles had been moved from the reactor to the fuel pool. The event was found to be caused by the shift manager's human error, as a result of which the S chain was overcoupled too soon when there was still fuel in the reactor. In accordance with plans, the overcoupling in question would have been needed in a later phase of the annual outages. The safety significance of the event was estimated to be low. All control rods were fully inside the reactor during the event. Furthermore, the extraction of the control rods was prevented as the control rod actuator switches were open, with the exception of one rod, the switch fuses had been removed and the fuses of the actuator motors had also been removed. The INES level of the incident was INES 0.

- On 29 September 2021, one of Olkiluoto 1's four emergency diesel generators was found to be in breach of the OLCs as regards the pressure differential measurement of the compressed air filter. The measurement in question failed because the measurement point valves were in the wrong position (closed). In addition to this, the measurement set point had been set too high and the alarm measurement had malfunctioned similarly. The emergency diesel 1.653G401 had been replaced in the emergency diesel update project, which is currently under way at Olkiluoto 1 and Olkiluoto 2. The breach of the OLCs lasted from the commissioning of the emergency diesel generators on 11 June 2021 until the faults were detected and rectified on 29 September 2021. During the period in question, there were no situations where the emergency diesel generators would have been needed. The erroneous operation of the compressed air filter's pressure measurement could have impacted the diesel generator's operability in a situation where the generator's normal air intake from outside becomes clogged, which requires air to be taken from the machine room. In this event, the incorrectly functioning measurement would not have detected the clogging of the filter and would not have switched air intake to the machine room. The INES level of the incident was INES 0.
- During the spent fuel transfers in October 2021, the contamination of the transfer cask was found to exceed the limit value specified for the KPA storage in the OLCs. The event is described in more detail in section "Radioactive particles in the yard area due to transfer of spent nuclear fuel" of this appendix. The preliminary INES level of the incident is INES 1.

APPENDIX 3

Periodic inspection programme of nuclear power plants 2021

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 2021 inspections.

Basic programme	Inspections in 2021	
	Loviisa 1 and 2	Olkiluoto 1, 2 and 3
I&C technology	x	
Human resources and competence		x
Management and safety culture	x	x
Management system	x	x
Disposal facilities	x	
Chemistry	x	x
Mechanical technology		
Interim storage of spent nuclear fuel	x	
Operating experience feedback		x
Operation	x	x
Plant maintenance	x	x
Fire protection		x
Utilisation of the PRA	x	
Structures and buildings	x	
Electrical technology	x	
Radiation protection	x	x
Nuclear security	x	x
Safety design		x
Safety functions	x	x
Emergency response arrangements	x	x
Power plant waste		x
Annual outage	x	x
Nuclear safeguards	x	

Basic programme	Inspections in 2021	
	Loviisa 1 and 2	Olkiluoto 1, 2 and 3
Special subjects		
Operating experience feedback of OL3		x
Phase C hot functional tests of commission of OL3		x
Management of spare parts		x
LOMAX data and role in management of functions	x	
Improving the operations of the line organisation through learning from the plant's own operating experiences	x	

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

Operation, 20 January 2021

The inspection focused on operations at the Loviisa power plant. The inspection analysed and verified the following:

- The independent safety control of operations as conducted by Fortum
- Training and competence development of the Operations unit
- Resources of the Operations unit
- Deviation management as regards the Operations unit.

The independent regulatory control of operational safety is carried out by the Plant Safety Group. The inspection covered the Plant Safety Group's control instructions, participation in decision-making, information receipt and observation records. Based on the inspection, the independent control of operational safety carried out by Fortum's Plant Safety Group meets the requirement level laid down in Guide YVL A.6. STUK sees the efforts of the Plant Safety Group as an important element in maintaining a high level of safety culture and ensuring the safe operation of the plant. Control room visits also during operation and transitioning to using an electronic diary for information transfer within the group were brought up as possible improvements to consider.

Due to the COVID-19 pandemic, training days were postponed from spring to autumn, but all training events have still been held using extraordinary arrangements. Based on the inspection, the training and competence development efforts of the Operations unit meet the requirements of Guide YVL A.4. Overall, the resources of the Operations unit were found to be at an acceptable level. Especially the resource situation of the operators appears to be good based on the inspection. No comments or requirements were necessary with regard to deviations under the responsibility of the Operations unit and their management.

STUK did not issue any requirements based on the inspection.

Additional inspection: Improving the operations of the line organisation through learning from the plant's own operating experiences 16 March 2021–22 April 2021

The aim of the additional KTO inspection was to verify the fulfilment of STUK's prior requirement regarding improving the line organisation's operations in the context of learning from the Loviisa plant's own operating experiences. The inspection findings indicate that

changes have been made in the right direction, but the overall arrangement still requires development. STUK has required relevant improvements since 2017. In STUK's opinion, the slow rate of improvements carried out by Fortum and the relatively minor impacts of the improvements are an indication that the changes have not been managed effectively. As a conclusion based on the inspection, STUK stated that there are deficiencies in the process of the Loviisa power plant learning from its own operating experiences. STUK required the management of the Loviisa power plant to take action to rectify the situation.

Management and safety culture, 29–31 March 2021

This inspection pertained to the development of management and safety culture at the Loviisa power plant. The inspection indicated that the Loviisa plant organisation conducts more development measures than before in relation to its operating methods and these measures are initiated by the management, formed into projects and communicated to the personnel on a continuous basis. However, in its development projects, Loviisa's plant management does not clearly describe the attitudes, thought processes or operating methods it specifically wants to change and why. This means that assessing the impacts is another development target. The connection between the development targets identified in the safety culture assessments and the development projects defined by the management is not always clear. Based on the inspection, the safety culture process does not optimally support the management, meaning that the process outputs are not used effectively for management purposes. For this reason, STUK set two requirements for improving the efficiency of the safety culture efforts.

Safety functions, Fuel cooling and residual heat removal, 28 April 2020 and 17 May 2021

The inspection assessed the licensee's procedures used to ensure that the systems implementing safety functions are in a state required for safety (inspections, tests and maintenance) and that their basis is correct (analyses and studies). The inspection was conducted remotely in two parts. The first day covered the state of the Loviisa power plant's air conditioning and ventilation systems on a general level and reviewed the instructions and results of the periodic tests conducted on select systems. The second day involved checking the status of the systems with a primary focus on ageing management and examining the situation based on the observations made during the first day.

In STUK's opinion, the situation of the inspected area was appropriate and no requirements were presented in the context of the inspection. The most significant observation that remained open pertained to assessing the correctness of the approval criteria listed in the period test instructions upon instruction updates. The issue will be revisited during the 2022 inspection.

Radiation protection, 18–19 May 2021

The inspection concerning radiation protection focuses on radiation protection, radiation measurements and release and environmental monitoring at the nuclear power plant. The main focus of the 2021 inspection was radiation measurement.

The inspection analysed the operability fault statistics of fixed radiation measurement devices, and the periods of inoperability of radiation measurement devices covered by the

Operational Limits and Conditions (OLCs). The operability of the radiation measurement devices was assessed to be moderately good. The aim of Fortum's RAMONE programme (Radiation Monitoring Lifetime Extension) is to find a long-term solution for ensuring the operation of the radiation measurement devices and examine the prioritisation of device updates. As an individual target, the spare parts situation of the steam line (RA) radiation monitors was examined, as development needs had been observed earlier. Fortum had begun analyses regarding the availability of RA radiation monitor spare parts, which had improved the spare parts situation significantly. A project aiming at updating all radiation measurements required during incidents is currently under way at Fortum.

The other inspection targets included portable measurement devices, the measurement of alpha radiation, the sufficiency and competence of the radiation protection organisation's personnel, radiation protection instructions and the utilisation of a radiation safety expert. The inspection also covered the most important operational events of recent years with regard to radiation protection. Among other things, this included operational event reports on particle and activated carbon filters of the process gas system covered by the OLCs and the radioactive particles found in the yard area.

In STUK's opinion, the situation of the inspected area was appropriate and no requirements were presented in the context of the inspection.

Security arrangements – physical protection, 24–28 May 2021

The inspection focused on the plant's security arrangements, which are considered to include structural, technical, operational and organisational arrangements to detect, delay and prevent illegal or unauthorised activities.

With regard to security arrangements, both the topic areas related to physical security arrangements and the interfaces and the interface issues related to information security were examined. In addition to these, human resources, competence levels and the currency of instructions were examined in relation to security arrangements. No requirements were presented based on the inspection. As regards the inspected area, human resources, competence levels and the currency of pertinent instructions were appropriate and sufficient at Fortum's Loviisa nuclear power plant.

Security arrangements – information security, 25–28 May 2021

The inspection focused particularly on administrative information security; technical information security was analysed with regard to specific targets. The focus of the inspection was on procedures for managing information security and the documentation of these procedures.

One of the specific targets was the information security of the nuclear material records and monitoring system and its implementation. In addition to this, human resources, competence levels, training and instruction updates related to information security were inspected. In STUK's opinion, information security at the plant has been handled appropriately, which is why no requirements were presented in the context of the inspection.

Chemistry, 7 June 2021

The inspection focused on the maintenance and development of hydrochemical conditions in the primary and secondary circuits, the monitoring of the radiochemical conditions of the primary and secondary circuits, and laboratory activities. The inspection covered any such deviations in the hydrochemistry of the primary and secondary circuits that were related to the Operational Limits and Conditions (OLCs). In the primary circuit, deviations had been observed in the total potassium content of the end cycle. In the secondary circuit, deviations had been found in impurity concentrations. During the inspection, STUK found that the deviations had been reported appropriately and that they had been limited to situations where the deviation margin was small and the deviation did not last long. As such, the deviations in question were not significant in terms of safety.

Another one of the inspection themes was the number of personnel, competence levels, the currency of instructions and sufficient guidance, which were deemed to be appropriate. One requirement was presented during the inspection, necessitating instructions to be prepared for measures related to the nuclide-specific measurement of the activity of the primary circuit surfaces. Fortum coordinated the measurements carried out during the annual outage, but the actual measurement service was outsourced. Instruction documents ensure that competence is retained even if employees change.

In STUK's opinion the integrity of the primary and secondary circuits has been ensured through appropriate chemistry management and there are no mechanisms that would threaten the integrity of the circuits.

Safety functions, Management of the containment and severe accidents, 8–9 June 2021

The 2021 inspection focused on the containment and the management of severe accidents. The systems selected for the inspection were ones that ensure hydrogen management in the containment during a severe accident (recombinators and ignition plugs of the hydrogen burning system) and the external cooling of the reactor pressure vessel (lowering mechanism of the reactor pressure vessel's heat shield). 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. As regards the basis, recent studies related to Loviisa's SAM (Severe Accident Management) strategy and possible future analyses were reviewed as well as special requirement listed in the guide related to the implementation of Guide YVL B.6 in relation to the containment isolation function.

The state of the instructions, failures, test results and possible needs for changes and spare parts were analysed with regard to the systems.

In STUK's opinion, the situation of the inspected area was appropriate and no requirements were presented in the context of the inspection. The most significant observation pertained to the nomenclature of the spare parts for the heat shield lowering mechanism not being entirely up to date. This issue will be revisited in next year's inspection.

Annual outage, 22 August–28 September 2021

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. Offices 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. Among other areas, STUK focused on machine technology, electrical and I&C technology, construction technology, radiation protection and operational safety. STUK inspectors also paid particular attention to the management of foreign material when moving around the plant.

Special targets of the annual outage inspection included locating the LO₂ fuel leak and determining its impacts and replacing LO₁'s neutron absorbers, which was related to the additional noises detected by means of the reactor pressure vessel's (RPS) foreign material monitoring system in 2020–2021. Other targets included the general management of foreign materials, the new presentation format of the control room process computers in the context of outages and practical functionality of the format, heavy lifting work in reactor halls, the radiation protection measures of work, decontamination activities and, as modifications, the partial update of the plant units' protection system and an I&C update on one of LO₁'s emergency diesel generator.

STUK was involved in overseeing the arrangements related to locating the LO₂ fuel leak. The arrangements appeared exemplary in all respects, and effective methods to minimise errors in sample handling were in place. The sampling took into account the operating experiences from the previous fuel leak (2013).

In the regulatory control 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 and carried out a joint inspection with Fortum employees responsible for foreign materials. Based on STUK's observations the management of foreign materials is in a good state and has improved further. STUK still considers it important that any observations made in foreign material management are treated with due seriousness and that operations are systematically developed also in future.

STUK carried out its regulatory control targeting the radiation protection activities by carrying out plant tour and by having discussing with the representatives of Fortum and contractors. Based on STUK's inspection, deficiencies were found in the decontamination activities: Water currently floods out of the LO₁ decontamination centre. In addition to this, there were deficiencies in the discharge measurement of goods and transports, which may lead to the spreading of radioactivity to the plant's yard area. Radioactive particles have been found in the yard area this year, too, and Fortum is conducting a comprehensive investigation on the root causes behind their occurrence and the necessary corrective measures. Due to aforementioned observations and in addition to the basic report provided by Fortum, STUK required Fortum to prepare a plan on corrective measures to prevent water flooding, identify development targets related to the restraint of goods and transports, and present to STUK an action plan aimed at improving the situation.

STUK oversaw the heavy lifting conducted in the reactor halls of both plant units by viewing the pertinent camera recordings. Based on its observations, STUK required Fortum to provide a clarification on the possible optimisation of heavy lifting tasks.

The updates to the protection system and emergency diesel generator I&C were successfully completed, and the deviations found were addressed. The individual deviation related to the fire protection of cables, which was found in the context of the protection system update, was addressed separately during the I&C technology inspection carried out later in the year.

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.

Disposal facilities, 13–14 October 2021

By means of an inspection, STUK assessed whether or not the disposal facilities for power plant waste at the Loviisa plants (VLJ repository) and their use met the general safety principles and official requirements applicable to nuclear waste management. The inspection also covered the rock surrounding the VLJ repository and the monitoring of the groundwater properties over time, and the management of the VLJ repository's structures with an emphasis on rock and concrete structures. In terms of organisational oversight, human resources, competence management and the currency of the instructions were inspected.

STUK did not present any requirements based on the inspection. In the corresponding inspection of 2019, STUK required the number of employees to be increased. Fortum has recruited a new professional who is currently in orientation training. The impact of the additional resources was immediately evident as a clear improvement on operational assessment, planning and development related to the VLJ repository. In the future, STUK will also oversee the development of resourcing and competence related to concrete structures, as there appears to be a lack of it in the group. The concrete structures are the most important technical barriers of the VLJ repository, which is why in-house expertise in this area is important.

The instructions related to the VLJ repository are current and they have been observed.

Fortum provides STUK with annual reports on the monitoring of the VLJ repository bedrock and the groundwater contained by it in the form of reports covering rock mechanics, hydrology and groundwater chemistry. The last reports were submitted in 2019 and 2020. A significant portion of the VLJ repository's measurement devices and sensors for rock mechanics did not function as planned. STUK did not present a requirement in the context of this inspection because the matter had been addressed and taken into account in the periodic safety assessment of the Loviisa VLJ repository, which was under way at the same time.

Fortum has updated its external resources related to the analysis of the VLJ repository's groundwater chemistry. As a possible development target, STUK highlighted the monitoring of groundwater chemistry, i.e. the functionality of interfaces between various operators. According to Fortum, the considerations on the necessity of monitoring measurements in the VLJ repository and the utilisation of the information gained have been initiated. Measures have also been initiated to ensure the utilisation of external resources.

Fortum has progressed analyses related to the damaging of the metal barrels in maintenance waste spaces 1 and 2 containing absorption and solidification waste, and has determined the probable causes and development of the damage that began inside the barrels. Fortum presented plans on the maintenance of the damaged waste containers and

the development of the absorption and solidification method to prevent the damage from recurring.

For a few years now, Fortum's annual reports have indicated changes in the sprayed concrete surface of the loading area ceiling. The matter has been investigated further. The samples taken from the vault and walls of the loading area's sprayed concrete surfaces indicated corrosion caused by groundwater chloride and sulphate. Fortum is planning an expansion to the sampling in order to determine the condition of the sprayed concrete surfaces of the VLJ repository premises located inside bedrock.

Fortum indicated having initiated preparations to change the final disposal concept of maintenance waste spaces 1 and 2. The aim of the project that is under development is to ensure that the activity in the barrels does not contaminate any leaking water or spread otherwise. If the final disposal concept is changed, there will still be enough room for maintenance waste in the VLJ repository during the plant's operation and half of maintenance space 3 will be available for decommissioning waste.

The training and equipment related to fire prevention in the VLJ repository were in order.

Management system, 13–14 October 2021

The inspection covered plans to develop the management system in the coming years, the impacts of the KELPO project (development of the licensing and qualification of serially manufactured standard devices) on the management system, and the independent assessment activities conducted by the nuclear safety unit.

In the context of operational planning, the goals set by the division and power plant management have been used to derive unit- and group-level measures, the implementation of which is overseen and reported on regularly. The power plant's most important strategic goals in the coming years will be a possible extension to the operating licence and related development measures, KELPO development work and measures through which the plant aims to reach the highest category in external WANO review.

Process descriptions will continue, and a new tool has been selected for them. Fortum has instructed the KELPO activities to be incorporated into Loviisa's management system, trained related personnel and established the position of a qualification manager for the activities. New methods are currently being introduced.

The independent assessment activities of the power plant's nuclear safety unit are being developed. The description of the assessment process as part of the procedures is under way. In STUK's opinion, Fortum has methods and plans for developing its management system in the coming years. No requirements were presented based on the inspection.

I&C technology, 19–20 October 2021

The inspection focused on Fortum's I&C technology systems, organisations and instructions. The inspection especially focused on the ageing of the circuit breakers of the I&C systems' equipment platforms and the cabling of reactor-internal measurements and the fire protection deviation observed during the 2021 annual outage as well as related procedures and instructions on installation methods. I&C maintenance was examined on the organisational level.

In proportion to the number of devices in operation, there have been very few faults in circuit breakers, and spare parts have been readily available. However, the operating parameters of the circuit breakers are not systematically tested on site, which is why STUK requested an account of how the correct operating parameters of the I&C circuit breakers are maintained.

As regards the reactor-internal measurements, the cables are covered by the ageing monitoring arrangements and there are no condition-related qualification requirements on them. However, the condition-related qualification of the cable measurement housing may require reassessment in the long term. Fortum has taken this into account in its plans.

In terms of the inspected fire protection measures for cables, STUK required Fortum to clarify its operating processes and instructions in relation to the redundancy isolations and fire protection of the I&C cables. One of the positive observations was related to Fortum's new documentation for installation methods and principles approved for the plant and to be used in connection I&C. The documents include a collection of installation instructions and related documentation to support operations.

No comments or requirements were needed with regard to the number of I&C maintenance employees and the management of their competence. As a positive observation, fitters were included in the process of updating the instructions, for example. The reviewed instructions were up to date.

Electrical technology, 19–20 October 2021

The inspection focused on the electrical maintenance organisation, the failures and ageing of safety-classified circuit breakers, monitoring of voltage quality, licensee installation inspections of electrical devices and cables, and the condition of safety-significant direct current systems.

Based on the inspection, the electrical maintenance team has a sufficient number of competent people to handle the tasks assigned to the maintenance area, and future recruitment needs have been identified and taken into account. During annual outages, temporary needs for additional resources are covered by contractor labour, in which case Fortum's fitters take lead of the installation groups. The instructions were sufficiently up to date.

As regards installation inspections, the electrical installations to be inspected were determined and the timing and methods of documenting the work were specified. Instructions, resources and orientation training were also covered. Fortum has one in-house inspector for electrical technology (QC engineer) who performs all necessary inspections of electrical technology during power operation. For annual outages, Fortum typically finds between four and six external installation inspectors, all of whom have been experienced and proficient. Based on the inspection, the installation inspection activities and resources are appropriate. A possible development need is preparing more detailed instructions and specifications on the initial orientation of installation inspectors.

As regards circuit breakers, their applications in the Loviisa power plant's electrical systems were initially covered. The inspection also involved addressing the failure mechanisms found in the Loviisa plant's circuit breakers and the measures taken as a result. In addition to this, the testing and spare parts situation of the circuit breakers were examined.

In terms of monitoring voltage quality, Fortum has considered and analysed factors impacting the voltage quality of the Loviisa power plant's internal consumption grid extensively and utilised international operating experiences. Voltage quality is taken into account in planning and maintenance work. Based on operating experiences, voltage quality has been sufficiently good at the Loviisa power plant. However, as a development target Fortum should consider voltage quality measurements related to voltage distortion.

The inspection did not necessitate any requirements regarding the condition of the direct current systems. The systems have exhibited some inoperability and device faults, but they have been insignificant in terms of nuclear safety. All issues found have been repaired appropriately. Fortum is also replacing battery sets preventively at regular intervals and based on their conditions.

In STUK's opinion, the status of the inspected areas related to electrical technology was appropriate. No requirements were issued in the inspection.

Structures and buildings, 26–27 October 2021

The inspection concerned the use, condition monitoring, maintenance and ageing control of structures, buildings and sea water ducts and tunnels. 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.

Based on the inspection, STUK required the instructions included in the updatable organisation manual to be updated to match the organisational changes in 2021 and the impact of damage caused by ageing in certain circulating water pump building structures on the functionality of the structures to be assessed.

Furthermore, STUK recorded two observations which will be monitored. The observations concerned the incomplete competence requirements of the target organisation and positive actions taken to appoint substitute for the persons with system responsibility. The construction technical periodic inspections, repairs and modifications of the Loviisa power plant have mainly been conducted as planned.

According to STUK's view, the use, condition monitoring, maintenance and ageing management of structures and buildings are at an adequate level.

Interim storages of spent nuclear fuel, 28 October 2021

The inspection focused on the operation of the interim storage of spent fuel (KPA storage), the modification of systems and the ageing management of systems and structures. The inspection assessed the state of modifications of the KPA storage as well as future modification work. The inspection also covered the responsibilities and authorities of various Fortum organisations involved in the use of the KPA storage.

Based on the inspection, it was STUK's impression that the KPA storage works more systematically than before, and work organisation and monitoring have improved. There has been a positive change following the organisational change at Fortum. The changes made to the space-specific responsibilities regarding the KPA storage have also had a positive impact on the situation.

The inspection covered operational events that have occurred at the KPA storage in recent years and the resulting measures. Fortum has actively prepared observation notifications and operational event reports, and carried out corrective measures based on the events.

Fortum has procedures in place for managing and monitoring ageing. The inspection involved checking a sample of the spare parts for various KPA storage systems. Based on the inspection, the electrical systems and components of the KPA storage's lifting and transfer equipment are quite old, and the availability of spare parts is poor. The analysis of the ageing of the cranes' electrical systems and the efforts to determine whether or not replacement is necessary did not progress as expected. For this reason, STUK required Fortum to provide an account of the ageing of the electrical systems of the KPA storage cranes and fuel transfer machine.

No comments or requirements were necessary with regard to the fuel usage team's resources or competence management. The periodic updates of instructions related to the operation of the KPA storages have been completed on time.

Emergency response arrangements, 9–10 November 2021

The matters covered in the 2021 inspection included the emergency response organisation, emergency response training and emergency response exercises, including relevant experiences and feedback. The inspection covered operating experience activities with regard to emergency response arrangements, including how Loviisa has reacted to the plant emergency that took place at OL2 in December 2020. In terms of the equipment covered in the 2021 inspection, the main focus was on the weather monitoring system and radiation measurements related to emergency response operations.

Based on the inspection, the emergency response arrangements at the Loviisa power plant were at the required level. Training and development efforts have been active, and the efforts have been monitored as planned.

Only minor changes have been made to the emergency response plan during the inspection period. The Loviisa plant has monitored operating experiences extensively, which has been useful for the development of emergency response operations. Fortum initiated an analysis from the perspective of emergency response arrangements sufficiently quickly and extensively based on the OL2 plant emergency. Representatives of the unit handling emergency response arrangements have also taken part in the operations of the group conducting the analysis. The possible impacts on emergency response arrangements will be determined once the final report is completed in early 2022.

The Loviisa power plant's external radiation monitoring network and weather monitoring system have been operable for the entire duration of the inspection period. The radiation measurement devices used for emergency response operations are in order, there is a sufficient number of them, and they have been positioned in appropriate locations at the plant.

No requirements were presented based on the inspection.

Utilisation of the PRA, 16 November 2021

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 LO1, LO2 and the KPA storage, the extensions and updates under preparation and their schedules were reviewed. In addition, the instructions and the operation of the organisation relating to the preparation and application of the PRA were assessed in the inspection.

No requirements were issued in the inspection. Based on the inspection, it can be stated that the instructions concerning the PRA are up to date, the PRA has been developed in accordance with the plans and it is used in a versatile manner as a support for safety management. Despite changes in personnel, the PRA resources have increased and no comments were necessary with regard to the competence of the personnel in question.

Plant maintenance, 16–17 November 2021

The objective of the inspection was to verify that the licensee takes care of the operability of the structures and equipment in the short and long term. Among other things, the inspection covered the spare parts management required by Guide YVL A.8, certain systems that are important to safety and were assigned a low condition category in the annual assessment, as well as Fortum's relevant measures. In addition to this, the inspection assessed condition monitoring at the Loviisa plant units and the sufficiency of maintenance-related resources, functions and tasks.

The measures related to the organisation of the mechanical maintenance and service life management groups and employee competence have progressed as planned. Both groups are late in providing instruction updates. Operational challenges have been presented by the necessity to work in alternating weeks due to the COVID-19 pandemic and providing the opportunity for remote meetings to those in various installation tasks, but the situation has become easier.

Fortum has updated the spare parts management (2018–2021). According to the related criticality classification of spare parts (2019–2020), the critical spare parts necessitated by Requirement 724 of Guide YVL A.8 are classified in higher categories. Fortum has also integrated a database describing the technical ageing of the items into the spare parts management system. The number of such critical spare parts at o balance has also been reduced significantly in 2021 from the previous 30% – the current percentage is only about 5% of all items. Generally speaking, an increasing portion of the spare parts items are technically obsolete and require constant and systematic maintenance.

The condition category analysis focused particularly on the situation of the primary circuit's pressure equalisation system (pressurise, etc.), since the pressuriser is one of the most critical devices of the plant in terms of ageing over the long term. The relatively low value was primarily due to the inoperability of the heating resistor group, which has now been resolved and repaired. Another cause was the technical ageing of certain valves, for which measures were yet to be determined at this point but which are monitored. The potential

ageing mechanisms of the pressure equalisation systems were determined, and Fortum has the necessary long-term plans in place.

Based on the inspection, STUK required Fortum to submit for information Fortum's own more detailed report on the ageing of the pressuriser's heating resistors and, in the event of a possible continuation of the operating licence, an update plan for the monitoring system of primary circuit pipes, the thermal loads of the connections and thermal stratification.

Nuclear safeguards 2–3 December 2021

The inspection targeted the nuclear safeguards system of Fortum's Loviisa nuclear power plant. The inspection established how the Loviisa plant is managing its nuclear safeguards obligations. Fortum's procedures to comply with the requirements set in legislation, the YVL Guides and EU regulations were assessed in the inspection. The following aspects were covered by the inspection:

- export control of nuclear materials,
- reporting and processing of small nuclear material batches as waste,
- other nuclear materials and related records, and
- nuclear material inspections and preparations for them.

In STUK's opinion, nuclear safeguards have been handled appropriately at the plant. There is enough proficient personnel and the state of the instructions is good. In terms of special inspection targets, some small deficiencies were found in the plant's operation, with regard to which STUK required a clarification to the instructions concerning the licence procedures for dual-use goods, a small specification in the nuclear material records, and a review of the annual reporting coverage. Among other measures, STUK identified personnel orientation to nuclear material inspection activities as a good practice.

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

Human resources and competence, 21–23 May 2021

The inspection assessed the quality monitoring and development of supervisory work, recruitment procedures and orientation. Shift managers and project managers were examined as examples. In addition to this, the inspection covered the licensee's procedures related to the utilisation of research activities on human and organisational factors (HOF) and the impacts of the COVID-19 pandemic on staff performance and the arrangement of training.

According to TVO, the COVID-19 pandemic has not hindered the employee's opportunities to perform their basic duties. Staff training events have been largely carried out successfully as webinars and other online arrangements. That said, on-site mock up training have not succeeded as normal due to the coronavirus crisis.

TVO has invested in the development of supervisory activities through the new Nuclear Professional Leader (NPL) programme, for example. The success of the supervisory activities is primarily monitored through personnel surveys. Based on the personnel survey results,

the quality of the supervisory work is at an adequate level. Other metrics include monitoring related to maintaining work capacity and the results of the safety culture survey. A situational picture on supervisory activities is also maintained through weekly meetings with HR partners, for example. TVO stated that the opportunities of supervisors to observe decreased functional capacity among personnel has improved in recent years. In recent years, good experiences have been gained on the occupational health negotiation procedure.

Suitability assessments are an integral part of the recruitment process at TVO. There is a separate assessment arrangement for the managerial and supervisory level. The practices for assessing the suitability and orienting of shift managers were found to be good. Abilities related to leadership are a particular focus in the suitability assessment of project managers. STUK stated as an observation that the assessment could focus more on the special characteristics of projects in the nuclear sector, which impose special requirements on project manager duties.

TVO has utilised the results of Finnish HOF research in its operations to a degree. At TVO, the field of HOF research is monitored and the utilisation potential of the results is primarily assessed by one person. In STUK's view, distributing the monitoring among multiple people could enable wider usage and competence development both at TVO and in research circles.

As a conclusion of the inspection, STUK deemed the requirements for the area to be met. No requirements were presented based on the inspection.

Management and safety culture, 2–3 November 2021

The inspection on management safety culture covered the licensee's situational picture on its own safety culture and the development measures to improve it. The inspection also examined the use of key figures and metrics for management purposes. The inspection also addressed TVO's preparations for a replacement of the safety manager.

The inspection found that TVO's way of implementing the self-assessment of the management system and safety culture is good in many respects. The report serves TVO's management in that it specifies the current state of the safety culture in relation to the targeted level and crystallises essential substantive needs to make operational changes. The development measures decided upon based on the recommendations have been initiated. The self-assessments covered by the inspection highlight TVO's long-standing challenges with plant modification and spare parts processes, but they do not clearly analyse the causes for recurrence and prolongation. Based on the inspection, TVO should consider how to get at the root causes in a situation of this kind, and how to identify and highlight root causes and any broader changes that may be required. This is important to ensure that the rectification of deficiencies impacting safety is not unduly delayed. STUK presented a requirement on this issue.

Monitoring operational quality by means of key figures seemed comprehensive and diverse overall. Managers monitor metrics from various data sources and the methodologies may vary between units, but the monitoring of key figures based on inspection data is used as part of management practices. In terms of presenting metrics, development efforts are being taken that will facilitate the management in gaining a situational picture. The inspection also found that TVO has initiated practical measures, such as planned an extensive orientation programme to prepare for the replacement of the manager of the Safety function.

Management system, 9–10 December 2021

The management system inspection examined the impacts of the organisational changes to TVO's Technology function, Human Factors Engineering (HFE) resources and competence, and the usage of HU methods for managing human risks.

The impacts of the organisational changes to the Technology function were processed in light of personnel indicators. TVO's Technology function served as a technical and project specialist organisation regarding usage and planning, and it plays a key role in the planning and support of projects and modifications. In 2019, TVO dismantled the organisation's service model established in 2015 and increased the number of supervisors in the organisation. The change implemented in 2021, updated the operating processes based on experiences gained within the Technology function, and clarified the interfaces of the Electricity Production and Technology functions and decision-making. The inspection examined the personnel survey of this autumn, employee turnover, absences due to illness and the competence survey conducted in 2020. Based on employee turnover and the personnel survey, the changes made in recent years have been largely positive. In the competence survey, there were still deficiencies in relation to the target level with regard to several parties responsible for systems. However, TVO indicated that the situation has improved in recent years in terms of these aspects.

The inspection verified that the resource situation of TVO's HFE experts is currently good, but attention will need to be paid on long-term competence management and resource sufficiency. The plant knowledge and expertise of the HFE experts must be sufficiently good so that they can form an independent view of the importance of plant changes. During the inspection, STUK presented a requirement necessitating TVO to prepare a plan to ensure the development of the professional expertise of the HFE experts.

TVO has resourced an HU expert for Operations Support functions and a development expert for Maintenance functions, whose core duties involve developing the use of HU methods in relation to maintenance activities. In STUK's view, the human resource situation of HU methods has seen positive development. However, the responsible persons are relatively new in their tasks, which means that competence development and the organisation's support are still required.

Operating experience activities, 14–16 September 2021

The inspection of the operating experience activities focused on internal operating experience activities, i.e. TVO's learning from its own experiences.

TVO has still observed the recurrence of similar events and causes. Recurrences happen despite the personnel actively developing the process of internal operating experience process. TVO's management assumed management responsibility of development measures initiated based on deficiencies that explained two recurrences, and the operations have improved with regard to them. TVO's observation means that, even now, the internal operating experience process does not always produce the desired result. Deficiencies in technology, operations and culture are not always identified or repaired through operating experience activities. This is an essential safety-related observation from TVO. The aim of the inspection was to determine TVO's own view on the severity of the situation and its improvement. In STUK's opinion, TVO has the willingness and capability to improve its operations and promote related

measures. On the other hand, STUK noticed that the views on the improvement needs of the operating experience activities' process varies across the different levels and sections of TVO's organisation. Based on the inspection, STUK presented two requirements aimed at improving the process under the leadership of TVO's management and at TVO's event investigations producing more unambiguous information on causes of possible recurrences and the occurrence of the causes that generate events.

STUK also examined the human resourcing of operating experience activities and assurance of competence development. In STUK's view, TVO has optimised the total human resources of the organisational unit that handles internal operating experience activities tightly. In addition to internal operating experience activities, three other main tasks important to safety have been assigned to the organisational unit, and the unit's employees serve as each other's substitutes in various tasks. TVO itself has stated that the numerous personnel changes over the past two years have temporarily weakened the handling and development of internal operation experience activities. Based on the information gained through the inspection, TVO has reacted to the observation through internal arrangements and recruitment.

Operation (OL1/2), 22–23 September 2021

The inspection on the operation of OL1 and OL2 analysed and verified the situation of the development of operational occurrence and emergency instructions, the management of failures resulting from immediate OLCs limitations, the condition monitoring conducted by operation, the competence management of operators, and the verification and validation methods of operational occurrence and emergency instructions.

The plan prepared by TVO for 2020–2022 for the development of the procedures for abnormal conditions and emergency procedures has been implemented as planned so far. The resource situation of the instruction development efforts, which had been deemed challenging, was found to have improved. In recent years, TVO has developed methods that pay more attention to a systematic and independent approach in the verification and validation of operational occurrence and emergency instructions.

STUK deemed TVO to have the appropriate procedures for the management of immediate OLCs limitations. TVO has been able to implement the requisite measures and fault repairs within the time limits set by the OLCs requirements. TVO has developed a separate report for the reporting of immediate operational limitations, with which it can more systematically learn about OLCs limitation events and identify possible recurrences of these events.

STUK found the procedures of TVO's Operations unit to be appropriate with regard to condition monitoring. The operators felt mostly satisfied with the orientation training received but, with regard to refresher training, they indicated that the training does not fully serve their competence requirements. The amount of the training was found sufficient, but the competence development measures could be better focused based on the operators' needs.

As a conclusion of the inspection, STUK deemed the plant operation to be compliant with the applicable regulations. No requirements were presented based on the inspection. STUK will oversee the progress of the recorded inspection observations as part of its normal operations monitoring.

Operation (OL3), 9–10 November 2021

The aim of the inspection on OL3's operation was to determine and verify the readiness of the plant state management for the first criticality and the commencement of power operation. In addition to this, the inspection covered the operations and resources of the Operations Support unit, the activities of the on-call safety engineers and the procedures related to changing the vacancies of the shift controllers. A plant visit to OL3's main control room was conducted in connection to the inspection.

As regards plant status management, STUK stated that the process has become more systematic thanks to the new operating model deployed in the summer 2021. Furthermore, improved procedures had been introduced to lighten the heavy work load, which had been identified as challenge for shift personnel. That said, it was not possible to fully verify the efficacy of the measures in connection to the inspection, due to which TVO was required to provide an account of the readiness of the plant status management as part of the criticality licence application.

Based on the inspection, the operations of the on-call safety engineers were found to be appropriate. As a shortcoming, however, it was observed that procedures for verifying their competence were not described in the instructions. A requirement was presented on a matter.

The inspection also addressed TVO's procedures that OL3 control room operators can change tasks (from turbine operator to reactor operator, for example) and the preconditions for maintaining approval for two separate operator tasks at the same time. The procedure presented by TVO for maintaining approval for two operator tasks did not fully meet the requirements of Guide YVL A.4. During the inspection, TVO indicated that it will change the process to comply with Guide YVL. STUK did not present a separate requirement on the matter and will instead assess the development of TVO's practices and, in the context of its control efforts and operator approval procedures, ensure that the YVL Guide requirements are met.

Based on the inspection, the Operations Support unit's resources are sufficient. STUK is monitoring the development of the resource situation and needs as part of its normal control activities.

Plant maintenance, 13–14 April 2021

The sufficiency of the resources, functions and tasks relating to the condition monitoring and maintenance of the plant units to ensure safe operation was assessed in the inspection. Among other things, the inspection covered spare parts for prolonged operational occurrences and accidents (so-called critical spare parts), update situation of the maintenance manual and instructions, and assessment and monitoring of the operating condition on systems and devices. The inspection was implemented otherwise remotely but the spare parts review was conducted on site.

The main focus of the inspection was on going through the critical spare parts specified by Guide YVL A.8. The inspection covered the procurement situation of missing spare parts and verified spare parts quantities at TVO's central warehouse. There have been no changes in the procurement situation of missing spare parts from the situation at the end of 2020. As previously approved, TVO must acquire the missing spare parts by 30 April 2022. No shortcomings were found in the central warehouse review, and the inventory balance matched the reports received by STUK. Obsolete spare parts were also not found.

At the time of the inspection, all instructions in the maintenance manual were up to date. OL3 currently has separate maintenance instructions, which will be used until the start of commercial operation. The OL3 plant's maintenance instructions will be integrated into TVO's maintenance manual, and TVO has prepared a separate plan for this purpose.

The inspection found that the system operating condition assessment used in the ageing monitoring report necessitated by Guide YVL A.8 is heavily focused on factors related to loss of electricity production. As regards safety systems, for example, the operating condition assessment provides an excessively positive view of the operating condition. STUK finds it important for TVO to assess the weighting of the operating condition assessment's various factors and development assessment in such a way that the system's unplanned instances of inoperability receive enough focus. In assessing inoperability, it is important to also consider inoperability due to hidden defects.

No significant deficiencies were found in the inspection and STUK did not present any requirements.

Hot functional tests for OL3's commissioning (HFT II)

The inspection assessed and verified the commissioning tests conducted during the hot functional tests (HFT II) for commissioning and the operations of the licensee and plant supplier during the tests. Furthermore, STUK oversaw the way in which safety is prioritised in the licensee's decision-making process.

During the HFT II phase, STUK monitored multiple tests, examples of which were control rod drop tests in a cold and hot space, functional tests of the main steam blowdown line, tests related to the pressuriser's safety valve, connecting line vibration measurements, a change-over test and a test regarding the loss of off-site power. Based on the indications, the tests were mainly successful and the activities were systematic. The approval criteria were not reached the first time for some tests, after which TVO conducted the requisite analyses, repairs or modifications and the acceptability was verified through new tests. The tests indicated that the plant operates as planned and the dampers added to the pressuriser connecting line have brought the line vibrations to an acceptable level.

The maturity of the plant status management was monitored as part of the HFT II phase monitoring. Based on the inspections, STUK deemed OL3's operation to be safe during the HFT II phase. The cooperation between OL3 shifts and the commissioning personnel was efficient during the commissioning tests. The OLCs requirements were primarily observed well and interpreted conservatively. TVO developed the plant status management and work planning processes during the HFT II phase, and STUK found the activities to have developed in a positive direction.

The conclusion of the inspection was that the plant operations during the HFT II were controlled and safe. STUK did not present any requirements based on the inspection.

OL3's operating experience activities, 1 June 2021

The inspection focused on the resources and processes of the OL3 unit's internal operating experience activities. The inspection covered the human resources from the viewpoints of sufficiency and competence and assessed the compliance of OL3's internal operating experience processes on a basic level.

The inspection revealed that there is sometimes a shortage of human resources in OL3's operating experience activities, which is evident in delays in event investigations and result reports. The shortage of human resources is due to the plant's life cycle phase, which intrinsically entails a large quantity of matters to resolve. Based on experiences (e.g. Taishan, HFT1, HFT2) it is likely that the number of events will remain at least at the current level. At the moment, handling the requisite duties requires flexibility from the personnel, which is not tenable. Furthermore, TVO has been forced to prioritise tasks in such a way that the resolution of internal matters prioritised lower.

The OL3 unit has a process to mainly resolve events referred to in Guide YVL A.10 and identify their causes so that corrective measures can be specified. The implementation of corrective measures is also monitored. TVO has initiated process improvements related to identified development targets. The process of the internal operating experience activities is compliant with the applicable regulations, from the perspective of the depth achieved in the inspection.

One requirement was presented based on the inspection, according to which TVO must in the context of OL3's internal operating experience activities prepare for temporary increases in workloads by defining procedures that can be leveraged as needed to gain additional resources for investigating events, identifying corrective measures and utilising lessons learned in a timely manner.

Fire protection, 19–20 October 2021

The inspection covered the organisation and HR planning of fire protection and fire technology, human resources, instructions related to fire protection, training and exercises of the fire brigade, inspections conducted by the licensee and other organisations, alarms and annual outages, periodic inspections of fire protection systems, modifications, IRS reports and an interview of the plant fire brigade. A plant walkdown of OL1 and OL2 was conducted as part of the inspection.

Based on the inspection, the fire protection arrangements of the plants are at an acceptable level. TVO is currently conducting measures to improve the resources of the plant fire brigade, and to define the training requirements of the fire protection personnel and monitor their fulfilment. The monitoring of open penetrations has been developed in recent years, but the practical implementation of the instruction still requires measures. The plant walkdown revealed some deficiencies related to markings, fastenings and work permit practices. At the end of the walkdown TVO entered the appropriate records of the observations in the deviation management systems for corrective measures.

Radiation protection, 24–25 March 2021

The inspection concerning radiation protection focuses on radiation protection, radiation measurements and release and environmental monitoring at the nuclear power plant. This year's inspection focused on radiation measurement. The inspection was carried out remotely, in addition to which a resident inspector visited the site to ensure that the instructions in the plant units' control rooms are up to date.

Among other things, the inspection covered deviation processing and failure statistics with regard to radiation measurements. The radiation measurement systems have functioned in accordance with the goals set for them. The inspection found the spare parts situation to have improved significantly with the modernisation of the equipment. The modernisation projects of radiation measurement equipment will continue in the coming years.

STUK presented three requirements based on the inspection. One requirement pertained to recording target values for emissions in the plant's documents. In addition to this, TVO must prepare instructions that describe using a radiation measurement expert, considering the requirements set by the legislation. TVO must also have instructions for failures of the work dosimetry system.

Nuclear security, 3–10 May 2021

The nuclear security inspection focused on the OL1/OL2/OL3 nuclear power plant units. The inspection covered human resources, competence and training, development projects, safety arrangement events and deviations, map exercise scenarios, information security development projects and access rights management. In addition to this, procedures related to security arrangements during the annual outage were also inspected.

In the context of the inspection, STUK conducted a plant visit which involved monitoring access control and security checks at the plant gates, security control centre activities and access control in essential premises as well as interviewing security personnel. The inspection procedures included reviewing recordings and documents, making observations and conducting interviews.

Based on the inspection, STUK finds that TVO maintains and develops security arrangements in accordance with the principle of continuous improvement. On the basis of the inspection, STUK presented two requirements concerning security arrangements.

Nuclear security, 17–19 August 2021

The inspection was carried out as an unannounced surprise inspection. The inspection covered OL1/OL2/OL3 plant gate activities, surveillance system updates and training materials for the security organisation.

STUK presented one requirement based on the inspection. In connection to the inspection, a site visit was conducted to supervise an exercise of the security organisation, which carried out successfully.

Safety planning, 22–23 September 2021

The inspection concerned TVO's plant modification process. A special focus was on the identification and prioritisation of modification needs that are important to safety, and the processing of modification proposals and their development into modification projects. In addition to this, the development of TVO's plant modification process was examined from the perspective of the planning function.

The inspected area is currently under significant development at TVO. The new procedures have just been partially adopted, but some of them are still under development. As part of its development efforts, TVO has analysed deficiencies prior procedures. For this reason, the

inspection focused on development work and its results instead of examining the functionality of the existing procedures.

Inputs for plant modification proposals are gained from the long-term plan, plant and system responsibility analyses and a few other sources individually. The majority of the proposals come from the first two sources (i.e. systematic operations). TVO is in the process of developing the processing of proposals and especially their prioritisation. As a new element, the prioritisation involves scoring for the proposals, based on which a priority list is maintained on OL1 and OL2 modifications.

TVO is also conducting an extensive development project on the plant modification process, the starting points and measures of which were presented during the inspection.

STUK did not issue any requirements based on the inspection, because the work is so clearly incomplete. STUK will monitor the results of the development work through KTO inspections covering different fields and possible separate targeted control measures.

Safety functions (OL1/2): Fuel cooling and residual heat removal, 27–28 September 2021

The inspected area encompassed fuel cooling and residual heat removal. The inspection was originally scheduled for 2020 but it was postponed to 2021. The inspection covered ventilation and air conditioning systems, with a special focus on the containment cooling system, reactor building ventilation system, and the air condition system for the electrical rooms of the control room, switch plant and auxiliary building. On a general level, the inspection also covered the situation of all ventilation and air conditioning systems, but with weighting based on the safety significance.

The systems verified during the inspection are primarily in good conditions, but the I&C used in many of the ventilation and air conditioning systems is nearing the end of its life span. The repeats are already under way and they are progressing in phases. In accordance with the inspected periodic test results, the systems are still in working order. When inspecting system-related failure reports, it was found that the distribution of responsibility related to maintenance instructions regarding ventilation and air conditioning systems on building exteriors was lacking, as a result of which some of the devices are in poor condition. Based on this, TVO was required to review the conditioning monitoring and maintenance measures in question to rectify the situation.

Safety functions (OL1/2): Containment and severe accident management, 21–22 October 2021

The inspected area entailed the containment and severe accident management. The inspection assessed TVO's procedures that the licensee uses to ensure that the systems implementing safety functions are in a state required for safety and that their basis is correct. The inspection covered the following systems: the containment's overpressure protection system, the containment's pressure reduction system, the containment's flooding system and the battery backed-up 380 V network.

As regards the aforementioned system, the review covered the results of system-related periodic tests required by OLCs from previous years, the currency of the testing instructions and the system responsibility reports.

With regard to periodic tests, an ambiguity was observed related to the calibration of one OLI pressure differential transmitter in 2016. In relation to this test, it remained unclear what happened after two rejected tests; in other words, whether the device had been recalibrated and approved or replaced. The next test in 2017 was completed successfully and approved. Based on the inspection, it was not possible to verify if the device, and thereby the plant, had been in state compliant with the OLCs after the rejected test. Deficiencies were not found in the periodic tests of other systems. STUK did not find it purposeful to have TVO initiate an event investigation to resolve an individual deviation due to long period of time that had passed since then. TVO's habit of conducting battery tests far more often than required by the OLCs was identified as a good practice. The test instructions were up to date. Based on the system responsibility reports, the systems in the inspection area are in good condition and there are no particularly significant short-term modification projects under way in relation to them. In relation to electrical systems, it will be necessary to update the severe accident management system assemblies that were excluded due to the scope of the current update project.

The systems processed based on the inspection were in a condition required by the design bases. STUK did not issue any requirements based on the inspection.

Emergency response arrangements, 13–14 April 2021

The inspection comprehensively covers the nuclear power plant's emergency response arrangements. The topics covered in the 2021 inspection included emergency response instructions, facilities and equipment, the emergency response organisation and related training. In addition to this, the development of emergency response activities were covered and the reports and observations related to the OL2 plant emergency that occurred in December 2020 and the OLKI-20 emergency response exercise were reviewed. In terms of the equipment and supplies related to emergency response activities, the focus was on public announcement systems, the telephone system, data transfer within the plant and dosimetry arrangements. The inspection was carried out remotely.

Based on the inspection, TVO's emergency response arrangements were at the required level. The inspected area included on-going development measures and ones that had not yet been initiated. TVO was deemed to complete these measures as planned. Based on the inspection, STUK presented two requirements. The emergency response training report must be submitted to STUK for information, and TVO must examine the audibility of announcements in OL3's outdoor area and around the barracks in the area, and make any necessary changes to the operations or equipment.

Spare parts management, 26–27 October 2021

The main focus of the inspection was on assessing the steps to develop and further spare parts management. In previous years, the challenges of spare parts management have manifested

themselves as an increase in postponed modifications and repairs, for example. TVO has indicated this in the report results it has provided to STUK.

TVO developed a new operating model for spare parts management and deployed it in the autumn of 2020. A particular aim of the new operating model has been to clarify ownership in the context of the spare parts process. TVO has begun using the prioritisation procedure included in the operating model in the monitoring of plant modifications and is considering expanding the procedure to cover spare parts modifications.

For the purposes of the inspection, STUK interviewed nine people from TVO's organisation, who represented technology, maintenance and procurement. As a summary of the interviews, it can be stated that the cooperation and spare parts management process has improved in recent years, and that strengthening orientation and expertise requires enough time and resources.

For managing the ageing of spare parts in the inventory, TVO has instructions aimed OL3. However, instructions for OL1 and OL2 are not available at this time. The review of the spare parts inventory, which was conducted in connection to the inspection, covered the status of ten items, without significant observations. The primary spare parts management programs were found to be functional and appropriate for the purpose.

STUK did not present new requirements on the spare parts management process, which is currently under development. STUK will monitor the progress through various KTO inspections and possible separate targeted control measures.

Power plant waste, 6–7 October 2021

The inspection covered the procedures of power plant waste management, storage and accounting with regard to all Olkiluoto power plant units. Particular topics included the situation of OL3's commissioning, the status of the waste management development projects, the sufficiency and competence of waste management personnel, the currency of the instructions, the functionality of nuclear waste management's main process, and risk assessment. A plant walkdown was conducted in connection with the inspection, which covered the condition of the waste processing and storage facilities, and the radiation levels, classifications and markings of the facilities.

The functionality of the main process of nuclear waste management has been developed. The resource situation is good at the moment, and preparations for recruitment needs in the near future have been made in the personnel plan. The instructions had been reviewed in a timely manner, but the inspection indicated that the review process does not work effectively across the board. The instructions were found to have deficiencies or to describe procedures that could not be verified in an operational context.

The situation of the commissioning of OL3's waste systems was good, with the exception of the processing system for radioactive waste. Problems were found with regard to equipment operation and the quality of the dried end product. TVO is not intending to use this system as a primary processing system for liquid waste. Instead, the intention is to solidify liquid waste in cement. The planning efforts related to cement solidification are under way, and the aim is to deploy cement solidification at OL3 in 2024.

Spare parts have been procured for the waste processing systems of OL1 and OL2 (bituminisation and evaporators), and the systems have mainly functioned well. The plant walkdown revealed that some of the barrels absorbed and solidified in 1998, which are in the OL1 barrel storage, are in poor condition, which may hamper their safe storage and final disposal.

Two requirements were presented in the inspection, which pertained to the repackaging of the damaged barrels and the addition of storage procedures for very low level waste in the work instructions before the commencement of operations.

Annual outage, 25 April–15 June 2021

The inspection concerning annual outages covered and verified TVO's OL1 and OL2 plant units' annual outage actions used to ensure safety as well as the actions used to manage and control operations during an annual outage. Furthermore, STUK oversaw the way in which safety is prioritised in the licensee's decision-making during annual outages.

The currency of the control room documentation, the installation of electrical penetrations, the management of foreign materials, and the implementation of the primary circuit's pressure test at OL1 were selected as particular focuses of the inspection. Other inspection targets included outage risks, radiation protection, electrical and I&C technology, reactor and safety systems, construction technology and fire protection. In addition to this, the inspection examined human resources, competence maintenance and the currency of the instructions.

During the annual outage, TVO updated the containment's electrical penetration modules at both plant units. STUK's representatives monitored the mechanical, electrical and I&C work related to the electrical penetration modules. Based on the inspection, the work went well and no deficiencies were found.

The documents that are essential to operational safety were ensured to be up to date and appropriate by means of spot checks in the context of verifying the start-up readiness of OL1 and OL2. The inspections indicated that the documents are up to date and there were no deficiencies.

The pressure test of OL1's primary circuit was carried out and approved. STUK's representatives monitored the performance of the pressure test in the control room and by taking part in the inspection walkdowns conducted at the plant during the pressure test. Based on STUK's inspections, the pressure test was completed in a controlled manner and the requisite test criteria were met.

As regards foreign material exclusion (FME), STUK verified TVO's annual outage procedures in the OL1 and OL2 control areas by means of spot-check visits and monitored recorded FME observations based on TVO's reports. Based on the inspection, TVO's investment in the development of FME is reflected in work areas and the operations of the plant. TVO's FME coordinator has been able to further the development targets highlighted in 2020, and the plant treats foreign materials with due seriousness. The plant has conducted extensive measures to prevent fuel leaks, and FME is a natural part of these efforts. The observations made by STUK in the field were mostly positive.

STUK conducted annual outage monitoring related to radiation protection arrangements on site, through document reviews and by interviewing people. The cleanliness of the plants was at a good level during STUK's site visits. The shoe boundaries were clear, and the areas of dose rates had been marked appropriately. However, the dose estimates of the annual outages of both plant units were exceeded. This was due to several factors, including an increase in the number of work phases after the estimates were prepared and the conditions in certain locations being more challenging than expected in terms of radiation protection. However, the annual outage doses were relatively small. Based on the site visits, the radiation protection measures were implemented appropriately.

As regards the organisation and management systems, it was found that many practices had seen positive development during the annual outage. For example, TVO's management had a visible role in promoting safety culture and TVO's decision-making was conservative in many respects. Based on the observations made during the plant walkdowns, the performance of project tasks at the plants seemed appropriate.

The construction technology inspection revealed that a lot of varying structural installation were carried out during annual outages, and these were based on a new version of the retrofitting instructions that had not yet been approved and sent to STUK. The retrofitting instructions have been under preparation for quite some time, and STUK has required changes to it with regard to the practices for obtaining approval for construction plans, for example.

According to STUK's general observation, TVO's COVID-19 safety measures did not hinder the safe execution of the annual outage work. The COVID-19 measures were taken seriously and TVO reviewed the effects of the measures throughout the annual outage. All work necessary in terms of safety was carried out in accordance with the original plan.

Based on the inspection, STUK presented one requirement regarding the delivery of the retrofitting instructions to STUK.

Chemistry, additional inspection, 29 November–2 December 2021

The chemistry inspection, which was included in the 2021 inspection programme as an additional inspection, covered TVO's validation practices for radiochemical procedures as well as instructions and documentation related to the validations. Among other things, the inspection covered the resource situation and work load of the radiochemistry experts as well as future plans. The inspection also addressed errors observed in the emission reports submitted to STUK.

On the basis of the inspection, STUK presented six requirements and 17 observations. Four of the requirements pertained to the validation procedures for radiation measurement devices and updates to the validation instructions. One requirement concerned monitoring the decrease of emission reporting errors. One requirement pertained to ambiguities found at OL3 in relation to indicating the usability of measurement devices. STUK required TVO to determine how the usability of the devices has been verified in a traceable manner.

Nuclear security, 2nd additional inspection, 22–26 November 2021

The second additional nuclear arrangement inspection of 2021 covered all three of the Olkiluoto nuclear power plant units. The topics were activities at the plant unit gates, OLG's security control centre activities, and the processing of security deviations and events. The inspection involved observing the operations and conducting interviews.

Over the course of the inspection, STUK verified that TVO had conducted the requisite measures related to the three open STUK requirements regarding security arrangements. Based on the inspection, STUK closed all three of the requirements and did not present new ones. Security arrangements at Olkiluoto are developed in accordance with the principle of continuous improvement.

APPENDIX 4

The start-up readiness inspections of Olkiluoto 3 in 2021

The Olkiluoto 3 plant unit was dealt with both in the readiness inspections and inspections specified in the periodic inspection programme (KTO) because many functions inspected are shared by all plant units of Olkiluoto. The periodic inspection programme inspections are described in further detail in Appendix 3 and this appendix contains only the inspections related to the verification of readiness.

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 plant unit 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. The final readiness inspection was conducted before the provision of the fuel loading licence, and the inspections under the inspection programme concluded at this point. In the future, all OL3 inspections will be conducted as part of the KTO inspection programme, which is shared by the OL1–3 units.

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	12–15 January 2021 22–26 February 2021 1–5 March 2021 16–18 March 2021
Commissioning of the controlled area	23–24 February 2021
Verifying operational readiness	8–10 March 2021

STUK conducted four nuclear security inspections at Olkiluoto. The on-site inspections covered the status of the security control and surveillance systems commissioning, the operations of the security organisation, security control centre, the exercise activities of the security organisation and topics related to information security. They also involved checking the OL3 plant unit's commissioning-related arrangements with regard to the fence and gates. Based on the inspection results, the security arrangements were found sufficient to warrant a fuel loading permission.

STUK conducted a commissioning inspection of the controlled area, which confirmed the readiness of the controlled area. Requirements were presented based on the inspection, but the requirement essential in terms of fuelling readiness was closed during the following week's inspection on personnel and goods monitors.

In March, STUK conducted an operational readiness verification inspection. The inspection confirmed fuel loading readiness in its entirety, including issues that had been left open in other inspections, such as the readiness of the control room and management system. Based on the inspection, readiness across all areas could not be verified, which is why TVO was required to provide clarifications of all open technical issues and a summary of the completion of remaining tasks related to fuel loading readiness. The delivery of the summary and clarifications were requirements for the granting of the fuel loading permission.

APPENDIX 5

Inspections pertaining to the processing of Fennovoima's construction licence application 2021

STUK inspects and assesses 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 inspections are planned every six months, and in 2021, STUK carried out six inspections according to its inspection programme. The operation inspection was postponed from spring to autumn, because the inspection could not be conducted in early 2021.

There was no need to postpone or cancel the processing of matters due to the COVID-19 pandemic, as all 2021 inspections were largely carried out remotely. With regard to the transition to remote inspections and based on the experiences from the first remote inspections, STUK made some changes to the detailed implementation and running of the inspections. The results of the inspections will be used by STUK when preparing a safety assessment and statement on the construction licence.

Summaries of the inspections performed in 2021 are presented below. The final inspection of 2021 will be reported during the first third of 2022.

Fennovoima Oy, RAOS Project Oy, JSC Atomproekt, JSC OKB Hidropress: Inspection procedures

The inspection covered the inspection procedures of organisations participating in the design as well as relevant open RKT requirements. The inspection also checked and verified the quality planning of the preliminary safety report batches that had been or would be supplied to STUK, the processing of the licence materials in the inspection chain, and requirement and configuration management.

Fennovoima and RAOS Project Oy arranged remote connections for all organisations as well as access to all necessary databases in order to enable verification. The inspection indicated progress in many areas, but the majority of STUK's prior requirements remained open. For example, the inspection found that the main designer's process for managing STUK's inspection observations was under development but not yet complete. In relation to the

delivery of the preliminary safety report, STUK urged the parties to determine and present any deviations from STUK's YVL guides, as well as relevant justifications, to achieve a matching level of safety. STUK also issued a comment on the presentation of design and production standards and norms in the preliminary safety report – the matter has been discussed since the beginning of the project. At the time of the inspection, new procedures were about to be adopted for managing the configuration, i.e. the plant complex. However, descriptions or instructions on the procedures had not yet been provided.

In the inspection, STUK also found that the quality plans regarding design remain unfinished but design activities are under way regardless. STUK closed its previous quality planning requirement and presented a specified requirement, according to which quality plans for systems must be prepared before the beginning of the design and planning process so that they can be deployed to guide it.

Fennovoima: Competence and resource management

The inspection focused on competence and resource management related to the FH1 project. The inspection covered the competence and resources of Fennovoima's main suppliers and the procedures for managing these aspects. Responsibility tasks necessitated by the Nuclear Energy Act, the development of Fennovoima's organisation in Pyhäjoki and the plans related to the operating organisation were also addressed. Based on the inspection, STUK presented a requirement stating that the responsible manager's role description and methods of referring issues for processing must be specified by 31 October 2021 to ensure the responsible manager's sufficient authority and ability to receive information to make safety-significant decisions.

Fennovoima: I&C

The inspection focused on Fennovoima's procedures regarding the oversight and assessment of the Hanhikivi 1 facility's I&C design and implementation. The inspection covered the I&C resources, the situation of the plant's I&C design and construction licence materials and the I&C-related or general procedures required in the design and construction phase. The inspection was partially organised as a video conference due to the coronavirus restrictions.

Fennovoima had prepared well for the inspection and all necessary persons were available for its entire duration. Over the course of the inspection, Fennovoima presented its activities openly, and the discussions during the inspection were useful.

STUK did not issue any requirements based on the inspection, as some of the organisations' responsibilities are yet to be defined and some essential documents in the inspected area are still in the draft phase. Instead, STUK presented some observations for Fennovoima to take into account in the development of its operations. The observations were related to conducting design phases in parallel and the challenges this may pose to configuration management, the consideration of the long-lasting qualification of some I&C devices in the project, and the consistency of the design and licensing materials and ensuring this consistency at Fennovoima. As a positive observation, the inspection team noted that Fennovoima is in the process of developing the management of open issues.

The inspection also entailed discussion on the requirements set for I&C system descriptions in STUK's YVL guides in the construction licence phase. STUK reminded that I&C system descriptions are subject to the same YVL guide requirements as process and electrical system descriptions, for example.

Fennovoima: Operation and commissioning

The inspection conducted in October focused on processing Fennovoima's Operation Unit and operation-related matters that are significant in terms of nuclear and radiation safety. The inspection involved assessing how Fennovoima and, more specifically, its Operation Unit as the end user of the plant has ensured that the plant design process has accounted for the operational requirements and expectations that are essential with regard to nuclear and radiation safety. This also involved assessing the amount and sufficiency of the Operation Unit's human resources as well as related plans and the Operation Unit's competence.

Additionally, the inspection evaluated Fennovoima's plans to develop operations, and particularly the control room arrangement and its various areas, at present and in the facility's construction phase in order to achieve sufficient operational readiness in a timely manner in later phases of the project. In this context, development plans regarding the operation phase management system were also assessed alongside the lessons learned by Fennovoima's Operations Unit from recent nuclear power plant projects and their operational preparations.

The inspection included two advance exercises the responses to which Fennovoima submitted to STUK before the inspection. The responses to the advance exercises were covered during the inspection. The inspection was primarily conducted on site at Salmisaari.

Based on inspection, STUK required Fennovoima to assess and justify the Operation Unit's tasks and responsibilities in the construction licence phase. Furthermore, Fennovoima must assess and justify the suitability and sufficiency of the experience and competence of the Operation Unit's personnel in relation to their duties and responsibilities. Fennovoima must also identify and assess the risks related to the Operation Unit's duties, competence and experience.

Fennovoima must also determine the documents that require systematic review by the Operation Unit and develop specific instructions and criteria for the Unit on reviewing these documents. This applies to both plant design and licensing materials. Fennovoima must adopt the instructions that guide the Operation Unit's inspection and provide them to STUK for information.

In addition to this, Fennovoima's Operation Unit must prepare plans on how it will participate in the development of the plant's operating instructions and TechSpecs to ensure that these documents are complete in a timely manner in later phases of the project and meet Fennovoima's expectations. Correspondingly, Fennovoima must plan the development of an in-service management system. STUK will assess the plans within the framework of its inspection programme.

Fennovoima: Management and safety culture

The inspection focused on Fennovoima's management activities and management system. The inspection addressed Fennovoima's safety culture and readiness for nuclear construction and Fennovoima's view on the safety culture of the supply chain and its capacity for nuclear construction. The inspection also covered STUK's open requirements related to the pertinent topics.

Through the inspection, Fennovoima presented its safety culture programme and principles. Fennovoima indicated that it has prepared the latest version of the safety culture programme with an aim to increase employee understanding on the principles and expectations related to safety culture. This inspection addressed the safety culture self-assessment of 2021, which was in the reporting phase at the time of the inspection. Based on Fennovoima's safety culture self-assessment, the company's safety culture has been developed but there are still needs for improvement. STUK stated that it is important for Fennovoima to take the observations of the safety culture self-assessment carefully into account in the implementation of organisational changes. The inspection also covered the measures taken based on the recommendations related to Fennovoima's 2019 safety culture self-assessment. The recommendations are extensive and some of the measures are still under way. The action plan to be prepared based on the 2021 assessment was still being drafted. According to STUK's view, Fennovoima's procedure for the self-assessment of safety culture is comprehensive.

Safety culture of the suppliers

Fennovoima divides operators into different categories and visualises the supply chain to determine the types of comments each supplier receives in relation to Fennovoima's operations and safety culture work. STUK considers these to be good practices.

In the context of the inspection, Fennovoima emphasised that it is important for the supply chain's own safety culture monitoring to include assessing the impacts of the development work and procedures (e.g. assessments of behavioural changes). A partial challenge has been that the assessment has focused on verifying performances that cannot always be used to conclude the impacts directly. According to Fennovoima, the capability of the supply chain to assess its own safety culture is improving gradually.

The view Fennovoima presented on the suppliers' safety culture during the inspection is based on continuous observation and monitoring by means of various methods, including supplier assessment procedures, observation processing and safety culture audits. Among other things, the inspection covered deviations recorded in safety culture audits and their status. Fennovoima also presented general conclusions related to the safety culture of the supply chain and the main suppliers.

More specifically, the inspection focused on the organisation of the main contractor Titan2 and its safety culture. Fennovoima's recent assessments of Titan2's capability show improvement, but there are still development needs. As such, Fennovoima sees development as a process involving many steps and requiring continuous measures.

The inspection also addressed the safety culture of the worksite. Fennovoima's assessment of the worksite safety culture is based on continuous observation, which includes analysing observations recorded on site. The strengths identified by Fennovoima included the interest of the management of the main organisations towards developing safety culture and the employees' good attitude towards safety. The weaknesses included ambiguities relating to who can interrupt work and to information flow within the supply chain.

Fennovoima is actively guiding its suppliers in developing their safety culture and a sufficient understanding of it using a variety of methods (e.g. meetings, working groups, safety culture day).

A worksite safety questionnaire and a more systematic assessment of the key suppliers' safety culture are scheduled for the first half of 2022. STUK finds that these assessments are important sources of information with regard to Fennovoima's construction readiness assessment and safety assessment as well as STUK's safety assessment.



APPENDIX 6

Construction inspection programme for the encapsulation plant and the disposal facility 2021

In 2021, licensing and construction oversight project PORA regarding Posiva's spent fuel disposal project systematically continued the inspections included in the construction inspection programme (RTO). 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's construction work and for taking the safety requirements into account in the project.

The 2021 programme included six inspections on current activities important to the safety of the construction phase. The number of inspections remained at the level of the previous year. Posiva is about to transition to the commissioning phase, which is why STUK decided to focus one of the 2021 inspections on commissioning. 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.

In the context of the 2021 RTO inspections, STUK has provided the licensee with advance exercises related to the themes of the inspection. The advance exercises have involved self-assessment or other matters that need to be analysed against the safety requirements before the actual inspection. The purpose of the advance exercises is to achieve the strategic goals related to emphasising the licensee's responsibility, coaching-oriented monitoring and focusing the inspection area on aspects and overall arrangements that are significant (in terms of risk).

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. The inspections have assessed quality assurance and requirement management at Posiva's nuclear waste facilities, the safety-critical functions of the final disposal facility, the suitability criteria and monitoring of the rock, the security arrangements, the construction of technical barriers and its monitoring, commissioning and management.

Quality assurance requirement management

The inspection focused on Posiva Oy's quality management measures, which Posiva uses to ensure the fulfilment of the necessary quality requirements. The purpose of the inspection was to verify compliance with the quality requirements set for products and services. A special focus was to verify the measures to which product and service experiences have led and ensure

that the relevant procedures are aligned with Posiva's management system. Specifically, the inspection focused on the systems PK.152 Handling cell and PK.411 Receipt area bridge crane.

Based on the inspection, it can be concluded that the organisation of and instructions on quality are mostly appropriate. As a deficiency, STUK noticed that Posiva had not prepared a production monitoring plan on all systems under construction, and that deviation management with regard to work under the SPJU agreement is systematic, even though not all aspects of the procedures comply with Posiva's management system. SPJU (applied project management contract) refers to the project management model Posiva uses in the construction of the encapsulation plant. In its requirements, STUK stated that the operations must meet the specifications of the management system.

Based on the inspection, it appears that Posiva is effectively ensuring the sufficiency of its own inspection resources during construction and is aware of the inspection organisations used by the delivery chain during construction. The deviation management procedures applied support the procedures used to ensure compliance with regard to systems manufactured and constructed within Posiva's supply chain.

Safety-critical functions of the final disposal plant, RSC and monitoring

The inspection focused on the safety-critical functions of the final disposal facility, the Rock Suitability Classification (RSC) criteria and monitoring. The inspection covered the coordinating the processes within the inspection area and defining the interfaces between them. As another topic, the consideration of various views in the context of decision-making was analysed through examples.

The inspection found that the processes are mostly in order and the interfaces have been defined. The inspection presented one requirement related to the interfaces. The inspection also addressed decision-making, with regard to which it could be concluded that the procedures were sufficient and the examples took safety perspectives into account to a sufficient degree.

Security arrangements

The inspection focused on the physical security and information security arrangements implemented by the licensee. Based on the inspection, Posiva was found to have developed the security arrangements according to the requirements as construction progressed. However, the documents indicate that the strength of the security organisation and the durability of the engineered barrier systems are under examination. The development of system descriptions for the processing of the operating licence application has been presented as an observation. As regards NNSA cooperation, the inspection involved piloting an information security inspection by means of a remote and hybrid arrangement. The experiences gained were positive.

The production of EBS components and production oversight

The inspection focused on the production of engineered barrier systems (EBS) and the oversight of the production activities. The inspection involved reviewing the instructions for the production of EBS components and the oversight of the production. Other aspects covered included how the tests already completed have impacted the current instructions and what

kinds of lessons have been learned from previous work. The inspection indicated that Posiva had learned from its own production tests and international cooperation projects, and that the procedures were sufficient. In terms of manufacturing, the project is in an intermediate phase. The production tests were conducted in accordance with prior procedures, and activities compliant with the new procedures have not yet been commenced. The production instructions specified small development needs, which Posiva assured it would take into account in the next update. No requirements were issued based on the inspection.

Commissioning

The inspection focused on the commissioning of Posiva's nuclear waste facilities. It covered the organisation, resources, training and instructions related to commissioning as well as pertinent procedures. The inspection reviewed Posiva's plans for commissioning and the ways in which it will prepare for operation during the commissioning phase.

Posiva has drawn up procedures preparing and obtain approval for equipment, system and plant level test programmes and instructions as well as result reports. Based on the inspection, the procedures in the instructions have been described sufficiently. In addition to this, the authorities and responsibilities related to commissioning have been specified clearly and sufficiently within Posiva's organisation.

The licensee does not yet have full access to the operating organisation's personnel. The licensee has determined the commissioning organisations in sufficient detail, and the licensee has a clear plan to rectify resource deficiencies in the commissioning organisation. Based on the inspection, the training and employee orientation arrangements do not fully meet the specifications of the commissioning plan.

Based on the inspection and Posiva's commissioning plan, STUK will comment on the commencement of the commissioning of the Posiva nuclear power plants, pursuant to Section 110 of the Nuclear Energy Decree. The inspection found that Posiva's commissioning procedures are not fully sufficient for the transition to commissioning. Among other things, the inspection indicated that the commissioning plan does not sufficiently describe commissioning training and orientation or the validation procedure for operating instructions. Human resources and the commissioning schedules presented were also touched upon, and they must be better described in the commissioning plan.

STUK has prepared a request for clarification based on the inspection and Posiva's commissioning plan. Posiva must update the commissioning plan and present responses to the requirements in the request for clarification before it can proceed to commission the nuclear systems of the encapsulation plant and final disposal facility.

Management

The management inspection addressed the procedures that Posiva's management uses to form an overview of the safety situation and the ways in which it takes the relevant matters into account in its communications and measures. The inspection covered Posiva's measures related to learning from operating experiences, and the situation of the measures specified based on the recommendations provided in the final report of the 2020 self-assessment on the management system and safety culture.

Based on the inspection, it was concluded that Posiva has assessed, monitored and developed its safety culture appropriately in accordance with its own procedures. Posiva's aim to view the development of safety culture through the lens of strategic management and operational planning was found to be an asset. However, Posiva's management is currently heavily focused on projects, concrete progress and occupational safety aspects. In order to maintain a healthy safety culture, the management must focus more visibly on the various areas of safety and safety culture.

In relation to operating experience activities, STUK stated that the case studies could be more ambitious. However, the results achieved by Posiva indicate that operating experience activities are taken into account.

APPENDIX 7

Licences granted by STUK in accordance with the Nuclear Energy Act in 2021

Teollisuuden Voima Oy

- STUK 11/C42214/2020, 10 February 2021: OL1, OL2 – Import licence for fission chambers. Last date of validity 31 December 2038.
- STUK 1/G42214/2021, 1 June 2021: OL3 – Import licence for a model of the fuel top end piece. Last date of validity 31 December 2021.
- STUK 3/G42214/2021, 22 June 2021: OL3 – Disclosure licence for nuclear information concerning fuel. Last date of validity 31 December 2025.
- STUK 4/G42214/2021, 20 August 2021: OL3 – Import licence for a control rod actuator. Last date of validity 31 December 2025.
- STUK 1/C42214/2021, 30 September 2021: OL1 e 44 "T" – Import licence. Last date of validity 31 December 2022.
- STUK 1/D42214/2021, 30 September 2021: OL2 e 42 "C" – Import licence. Last date of validity 31 December 2022.
- STUK 2/D42214/2021, 30 September 2021: OL2 e 42 "P" – Import licence. Last date of validity 31 December 2022.
- STUK 5/G42214/2021, 22 December 2021: OL3 – Import licence for fuel transfer machine grippers. Last date of validity 31 December 2022.
- STUK 6/G42214/2021, 29 December 2021: OL3 – Import licence for a dummy assembly. Last date of validity 31 December 2023.

Fennovoima Oy

- STUK 1/J42214/2021, 23 July 2021: Disclosure of nuclear information under particular safeguards obligation. Last date of validity 31 December 2023.

RAOS Project Oy

- STUK 9/Y42214/2020, 20 January 2021: Import, possession and disclosure licence for nuclear information under particular safeguards obligation and expansion of licence 6/Y42214/2020. Last date of validity 31 December 2023.

Others

- STUK 5/Y42214/2021, 8 July 2021: Elomatic Oy, Possession and processing licence for nuclear information under particular safeguards obligation and related to Fennovoima Oy's Hanhikivi 1 project. Last date of validity 31 December 2023.
- STUK 6/Y42214/2021, 28 October 2021: Joint Stock Company Rusatom Automated Control Systems, Finnish branch, Import, possession and disclosure licence for nuclear information under particular safeguards obligation. Last date of validity 31 December 2029.
- STUK 9/Y42214/2021, 13 December 2021: Umicore Finland Oy, Import, transport, possession, storage and processing licence for nuclear materials. Last date of validity 31 December 2024.

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