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INTEGRATED REVIEW SERVICE FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT, DECOMMISSIONING AND REMEDIATION (ARTEMIS)

MISSION

TO

FINLAND

Helsinki, Finland

27 November – 8 December 2022

DEPARTMENT OF NUCLEAR SAFETY AND SECURITY
DEPARTMENT OF NUCLEAR ENERGY

IAEA

Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation

ARTEMIS

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REPORT OF THE INTEGRATED REVIEW SERVICE FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT, DECOMMISSIONING AND REMEDIATION (ARTEMIS) MISSION TO FINLAND

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INTEGRATED REVIEW SERVICE FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT, DECOMMISSIONING AND REMEDIATION (ARTEMIS) MISSION

TO

FINLAND

Mission dates: *27 November – 8 December 2022*
Location: *Helsinki, Finland*
Organized by: *IAEA*

ARTEMIS REVIEW TEAM	
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IAEA-2022

The number of recommendations, suggestions and good practices is in no way a measure of the status of the national infrastructure for nuclear and radiation safety. Comparisons of such numbers between ARTEMIS reports from different countries should not be attempted.

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EXECUTIVE SUMMARY

At the request of the Government of Finland, the International Atomic Energy Agency (IAEA) organized an Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation (ARTEMIS) peer review mission.

The objective of the ARTEMIS Peer Review Service is to provide independent expert opinion and advice on radioactive waste and spent fuel management, decommissioning, and remediation, based upon the IAEA safety standards and technical guidance, as well as good international practice. Finland requested this ARTEMIS review to fulfil its obligations under Article 14.3 of the Council Directive 2011/70/Euratom of 19 July 2011, establishing a *Community Framework for the Responsible and Safe Management of Spent Fuel and Radioactive Waste.*

The review was performed by a team of eight senior international experts in the field of decommissioning and radioactive waste and spent fuel management, from multiple IAEA Member States, with IAEA staff providing coordination and administrative support. The ARTEMIS review team evaluated the Finnish national programme and the national framework for executing the country's obligations for safe and sustainable management of radioactive waste and spent fuel as well as decommissioning of facilities.

The ARTEMIS review was organized 'back-to-back' with an earlier Integrated Regulatory Review Service (IRRS) review mission, conducted during 3 to 14 October 2022. The ARTEMIS review took account of the results of the IRRS review of the legal and regulatory oversight of activities, facilities and exposure situations in the field of radioactive waste and spent fuel management.

The ARTEMIS review team considered that Finland is managing radioactive waste and spent fuel in a safe and responsible manner. The Finnish programme is effectively supporting the achievement of climate change goals.

The ARTEMIS review team identified the following good practice:

— The Government, the regulatory body, the operating organization, and interested parties, have effectively implemented the national strategy to develop a geological disposal facility for spent fuel, which would be the first in operation in the world.

To maintain and further improve the safe management of radioactive waste and spent fuel in Finland, the ARTEMIS review team made several recommendations and suggestions to the Government as follows:

— The Government should consider improving consistency of the legislation to reduce the complexity of regulation and management of all radioactive waste.

— The Government should require early preparation of initial decommissioning plans for all facilities that generate radioactive waste and maintain them throughout the lifetime of the facilities consistent with the graded approach.

— The Government should make arrangements for a licensed solution for the safe disposal of the few waste streams without a licensed disposal option.

— The Government should consider making arrangements to ensure that sufficient licensed storage or disposal capacity is available for the anticipated future inventory of disused sealed radioactive sources.

— The Government should consider continuously evaluating the suitability of the current policy and strategy for radioactive waste and spent fuel management against the anticipated future demands of the Finnish Climate and Energy Strategy.

— The Government should consider assessing resources to govern the national programme on radioactive waste and spent fuel management in Finland and considering the need for redundancy in competence.

The ARTEMIS review team also identified further suggestions as follows:

— The regulatory body should consider strengthening the national inventory so that it covers all radioactive waste and includes additional information on radionuclides and toxic substances. Additionally, the regulatory body should consider the establishment of common principles for estimating the future inventory.

— The regulatory body should consider ensuring its competencies and capacity planning against the demands and challenges that are expected.

The ARTEMIS review team commended the Finnish counterparts for the professionalism displayed by all staff and the commitment to safety.

Finland is encouraged to make the review public and to take the findings of the review into account.

I. INTRODUCTION

On 25 April 2019, Finland requested the IAEA to organize an Integrated Review Service for Radioactive Waste and Spent Nuclear Fuel Management, Decommissioning and Remediation Programmes (ARTEMIS). On 2nd March 2021, the Ministry of Economic Affairs and Employment of Finland (MEAE) further requested the IAEA to organize back-to-back Integrated Regulatory Review Service (IRRS) and ARTEMIS missions in 2022.

Finland's request for the ARTEMIS review is to satisfy its obligations under Article 14(3) of the European Council Directive 2011/70/Euratom of 19 July 2011 establishing a Community Framework for the Responsible and Safe Management of Spent Fuel and Radioactive Waste (hereinafter the EU Waste Directive).

The review was performed by a team of eight senior international experts in the field of decommissioning and radioactive waste and spent fuel management, from multiple IAEA Member States, with IAEA staff providing coordination and administrative support. Subsequent to a virtual preparatory meeting in June 2022, and the receipt and review of Advanced Reference Material in September 2022, in November 2022 the ARTEMIS review team evaluated the Finnish national programme and the national framework for executing the country's obligations for safe and sustainable management of radioactive waste and spent fuel as well as decommissioning of facilities.

The ARTEMIS review was organized 'back-to-back' with an earlier IRRS review mission, conducted during 3 to 14 October 2022. The ARTEMIS review took account of the results of the IRRS review of the legal and regulatory oversight of activities, facilities and exposure situations in the field of radioactive waste and spent fuel management.

II. OBJECTIVE AND SCOPE

The ARTEMIS review provided an independent international evaluation of Finland's programme for the management of radioactive waste and spent fuel together with the decommissioning of facilities.

The ARTEMIS review, jointly organized by the Department of Nuclear Safety and Security and the Department of Nuclear Energy of the IAEA, was performed on the basis of the relevant IAEA Safety Standards and proven international practice and experiences, with the combined expertise of the international peer review team selected by the IAEA.

III. BASIS FOR THE REVIEW

A) PREPARATORY WORK AND IAEA REVIEW TEAM

At the request of the Government of Finland, a virtual preparatory meeting for the ARTEMIS Review mission, was conducted on the 13th June 2022. The preparatory meeting was carried out by the appointed Team Leader Mr John Tappert, the IAEA coordinator coordinator Mr David Bennett, and the team of National Counterparts led by Ms Linda Kumpula from the Ministry of Economic Affairs and Employment (Ministry), with participation of representatives of Radiation and Nuclear Safety Authority (STUK) and Posiva Oy (Posiva).

The ARTEMIS mission preparatory team had discussions regarding:

- the Terms of Reference for the ARTEMIS review of the Finnish strategy to fulfil obligations from article 14(3) of the EU Waste Directive;
- the specific characteristics and organization of the ARTEMIS mission in Finland, as IRRS and ARTEMIS back-to-back missions; and
- the relevant detailed aspects for organization and conduct of the review.

IAEA staff presented the ARTEMIS principles, process and methodology. This was followed by a discussion on the work plan for the implementation of the ARTEMIS review in Finland in November-December 2022. Ms Linda Kumpula from the Ministry and Ms Päivi Mäenalanen from STUK were appointed as the national liaison officers for the ARTEMIS mission and designated IAEA points of contact.

Finland provided IAEA with the Advance Reference Material (ARM) for the review in September 2022.

B) REFERENCES FOR THE REVIEW

The review was made in accordance with Version 2.0 of the guidelines for the ARTEMIS review service and the draft Supplementary Guidelines on the Preparation and Conduct of IRRS-ARTEMIS back-to-back Missions. The Finnish responses to the ARTEMIS self-assessment questionnaire were used as a key basis for the review, together with the rest of the ARM and materials presented during the review mission and the associated discussions. In accordance with the Statute of the IAEA, the ARTEMIS review was made against the IAEA Safety Standards. Other IAEA publications were considered where relevant. The complete list of IAEA publications for this review is provided in Appendix E.

C) CONDUCT OF THE REVIEW

The initial Review Team meeting took place on Sunday, 27 November 2022 in Helsinki, Finland, directed by the ARTEMIS Team Leader Mr John Tappert, the ARTEMIS Team Coordinator Mr David Bennett and the Deputy Team Coordinator, Mr Gerald Nieder-Westermann.

The ARTEMIS entrance meeting was held on Monday, 28 November 2022, with the participation of representatives from the Ministry, the Ministry of Social Affairs and Health, STUK, Fortum Power and Heat Oy (Fortum), Teollisuuden Voima Oyj (TVO), VTT, University of Helsinki, and Posiva.

Opening remarks were made by Ms Liisa Heikinheimo, Deputy Director General, Energy Department of the Ministry of Economic Affairs and Employment, by Mr Mikko Paunio, Senior Ministerial Adviser, Medical Affairs Ministry of Social Affairs and Health, by Mr Jaakko Leino, Director of the Nuclear Waste and Materials Safeguards Regulation, STUK, by Mr John Tappert, ARTEMIS Team Leader, and by Mr David Bennett IAEA ARTEMIS Coordinator.

Ms Liisa Heikinheimo gave an overview of the role of nuclear energy in the national climate and energy strategy in Finland.

During the ARTEMIS mission, a review was conducted for all review topics within the agreed scope, aiming to provide Finnish authorities with recommendations and suggestions for improvement and, where appropriate, identifying good practices.

The ARTEMIS review team performed its review according to the mission programme given in Appendix B.

The ARTEMIS Exit Meeting was held on Thursday, 8 December 2022. Opening remarks were made by Ms Liisa Heikinheimo. A presentation of the results of the Review Mission was given by the ARTEMIS Team Leader Mr John Tappert. Remarks by the Ministries and STUK in response to the mission findings were made by Mr Liisa Heikinheimo, Mr Mikko Paunio, and Mr Jaakko Leino. Closing remarks were made by Ms Anna Clark, Section Head, Waste and Environmental Safety Section, Division of Radiation, Transport and Waste Safety, Department of Nuclear Safety and Security, IAEA.

1. NATIONAL POLICY AND FRAMEWORK FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT

1.1. NATIONAL POLICY

Finnish position

In Finland, spent fuel is generated as a result of the operation of nuclear power plants (NPPs). Radioactive waste is generated by the operation of nuclear power plants and other nuclear facilities. Smaller quantities of radioactive waste arise from the use of radiation sources in industry, health care and research facilities.

According to the leading principle of waste management, the amount of spent fuel and radioactive waste shall be kept as small as reasonably possible. Nuclear waste generated in connection with or as a result of use of nuclear energy in Finland shall be handled, stored and permanently disposed of in Finland. The above provisions shall not, in cases to be laid down by a Government decree, apply to:

1. small amounts of nuclear waste which will be, or have been, delivered abroad for research purposes;

   1a) nuclear waste containing minor quantities of radioactive material and which is delivered to another country for treatment in the appropriate manner;

2. nuclear waste that has been generated in connection with or as a result of the operation of a research reactor in Finland.

No spent fuel or radioactive waste may be imported to Finland for treatment, storage, or disposal. However, a disused radiation source may be exported from Finland (for example, to return a sealed source to a supplier), but a radiation source manufactured outside Finland may not be imported to Finland as radioactive waste.

The ultimate objective of spent fuel and radioactive waste management is to protect the general public and the environment from the dangers of ionising radiation.

Isolation of spent fuel and radioactive waste from the living environment is carried out by means of disposal. Prior to disposal, spent fuel and radioactive waste are treated and stored on the site of the NPP where they are generated. Radioactive waste is disposed of as soon as possible. Disposal is planned and implemented in such a way that the safety of the spent fuel and radioactive waste after the disposal is achieved without active measures, that is, passively.

The operator is responsible for all measures of spent fuel and radioactive waste management and their appropriate preparation. In addition, the operator is responsible for the disposal of radioactive waste from the use of nuclear energy until the closure of the disposal facility. After the closure of the disposal facility, responsibility for the disposed spent fuel and radioactive waste will be transferred to the State.

An operator generating spent fuel and radioactive waste in connection with its operations is fully responsible for the costs of waste management measures. The State has to ensure that the licensee provides adequate funding for the management of spent fuel and radioactive waste. If the licensee cannot provide adequate funding, the responsibility falls to the State.

ARTEMIS observation

Spent Fuel Management Policy

The ARTEMIS review team considers that the Finnish nuclear waste management policy is based on the ethical principle of avoiding transferring undue burdens to future generations. The Finnish policy does not require a national disposal facility. Each operator has to develop plans for the management of its spent fuel from the early stage of NPP projects. The Posiva geological disposal facility is designed to accommodate all spent fuel from the currently operating NPPs. In the future, other geological disposal facilities for spent fuel could be developed for the spent fuel from new NPPs.

Finland only has spent fuel from commercial reactors, as spent fuel from the research reactor has been returned to the US as the country of origin.

Finland has adopted the strategy of direct disposal for spent nuclear fuel management. There is no reprocessing facility, and it is not permitted to send spent fuel for reprocessing to another country. Therefore, according to the Finnish waste management policy, spent fuel is regarded as waste and shall be permanently disposed of in Finland.

Spent fuel is currently stored at the NPPs' wet storage facilities until the availability of the disposal facility that is under construction.

The way in which the Finnish national programme is organized has resulted in the development of disposal facilities for low and intermediate level waste at each NPP site and the development of a single geological disposal facility for the spent fuel from the existing NPPs.

Finland's Climate and Energy Strategy 2022 includes a goal of carbon neutrality by 2035 and a significant proportion of nuclear power. Potential new NPPs will benefit from the existing infrastructure in the country and the knowledge generated in the Posiva project. The strategy for disposal of spent fuel has been succesful for current operators. The policy and strategy for radioactive waste and spent fuel management may require review if the nuclear programme in Finland develops further (e.g. to include further NPPs or small modular reactors (SMRs) and operating organizations).

From the knowledge preservation point of view, Finland's activities to archive experiences from the geological disposal programme, such as the development of the current disposal concept, would be beneficial to a future disposal programme.

Radioactive Waste Management Policy

STUK has a duty to operate and maintain oversight of the storage room for State-owned radioactive waste, situated inside TVO's Olkiluoto disposal facility for LLW and ILW. Operation and oversight functions are performed by two different departments within STUK. The ARTEMIS review agrees with the IRRS recommendation from the 2022 mission that the Government should separate responsibilities for operation and oversight of the storage facility.

Disposal facilities for LLW and ILW are operational at both existing NPP sites and are planned to also host decommissioning waste. At Olkiluoto, preparations for licensing VLLW disposal in a near-surface facility were started at the end of 2018.

The predisposal management of LLW and ILW currently takes place at the NPPs under their operating licences and additional provisions. The waste is segregated, treated, conditioned, packaged, monitored and stored, as appropriate, before they are transferred to the site specific disposal facilities. This practice will be also applicable to the disposal of the decommissioning waste of the NPPs.

The licensee possessing a sealed radioactive source should make arrangements for the return of the disused source to a supplier or manufacturer. Where this is not possible, the sealed radioactive source is currently stored in the storage room at Olkiluoto. Disused sealed sources will be kept in storage until a suitable licensed disposal solution is available. The first campaign to dispose of disused sealed sources was conducted in 2016. Currently there is no licensed disposal pathway for some of the remaining stored sources. Three possible disposal routes are under consideration. These are the two existing low and intermediate level waste disposal facilities and the geological disposal facility under construction. In 2018, the Radiation Act was updated to include the provision to retire sources greater than 40 years of age. There was a five-year transition period to implement this requirement which expires in December 2023. To accommodate the potential increase in sources under State control, it is unclear if enough licensed storage capacity is available.

The mining company Terrafame Oy was granted a licence to produce U_3O_8 (yellow cake) as a byproduct of nickel cobalt mining, by a Government decision in February 2020. The decision was enforced with a Supreme Administrative Court decision in June 2021. Uranium recovery will produce small amounts of operational waste. Arrangements for management of these wastes and regulatory oversight will be defined during 2023, with the recovery starting by June 2024 otherwise the licence would expire.

In Finland safety licence holders currently operate 10 cyclotrons, mainly on radioisotope production. Preliminary estimation on the amount of decommissioning waste exists, but the estimations contain significant uncertainties on the amount and activity of the waste. Part of the waste can be released from regulatory control. No initial decommissioning plan is required or exists. The disposal of the decommissioning waste could be done in existing repositories but would require direct contracts between licence holders.

1.2. LEGAL, REGULATORY AND ORGANIZATIONAL FRAMEWORK

Finnish position

In Finland, the policies and strategies for radiation and nuclear safety are mainly expressed through legislation, namely through the Nuclear Energy Act for nuclear safety and through Radiation Act for radiation safety. The Nuclear Energy Act (990/1987) and Radiation Act (859/2018), as well as the Nuclear Energy Decree (161/1988), Government Decree on Ionizing Radiation (1034/2018), and Ministry of Social Affairs and Health Decree on Ionising radiation (1044/2018) are considered to be part of the national framework. In addition, the Waste Act (646/2011) is considered to belong to the framework. The decrees specify the requirements set by the acts.

The requirements for the management of spent fuel and radioactive waste resulting from the use of nuclear energy are included in the Nuclear Energy Act and the requirements for the management of radioactive waste resulting from the use of radiation are included in the Radiation Act. The requirements of the EU Waste Directive (2011/70/Euratom) have been implemented by the Nuclear Energy Act and the Radiation Act. In addition, the Radiation Act has transposed requirements of the EU Directive on Basic Safety Standards for Protection Against the Dangers Arising from Exposure to Ionising Radiation (BSS Directive, 2013/59/Euratom). The requirements of the Radiation Act also apply to activities conducted under authorizations under the Nuclear Energy Act, for example with regard to radiation work.

More detailed requirements for the management of spent fuel and radioactive waste are laid down in STUK's regulations and guides. Thus, the national framework also includes STUK's regulations on the safety of a nuclear power plant (Y/1/2018), the emergency arrangements of

a nuclear power plant (Y/2/2018), security in the use of nuclear energy (Y/3/2020), the safety of disposal of nuclear waste (Y/4/2018) and the safety of mining and milling operations aimed at producing uranium or thorium (Y/5/2016) under the Nuclear Energy Act as well as the regulation on exemption levels and clearance levels (SY/1/2018) under the Radiation Act and the Nuclear Energy Act.

In addition, there is a policy paper on the national programme on waste management (Management of spent nuclear fuel and radioactive waste in Finland, 2022), and the Government has prepared a national climate and energy strategy.

ARTEMIS observation

The ARTEMIS review team notes that the Finnish legislation includes clear assignment of roles and responsibilities to the relevant Ministries, licensees, and regulators to ensure the safe use of nuclear energy and use of radiation including emergency preparedness and response and existing exposure situations.

Finland has ratified all relevant international treaties and actively participates in conventions and other relevant international arrangements considering nuclear and radiation safety.

The Fundamental Safety Objective and Principles 1, 3 to 10 of the IAEA have been addressed in the provisions of the legislation. In accordance with Principle 2 (Role of the Government), the legislation (adopted by Parliament) establishes a comprehensive legal and regulatory framework for the regulation of facilities and activities, including the establishment of STUK as an independent regulatory body.

The Finnish radioactive waste classification system includes two main categories: nuclear waste and non-nuclear radioactive waste.

The management of nuclear waste is governed by the Nuclear Energy Act while the management of non-nuclear radioactive waste is governed by the Radiation Act. Radioactive waste not originating from the use of nuclear energy or the associated nuclear fuel cycle is considered non-nuclear radioactive waste and is governed by the Radiation Act. The management of radioactive waste resulting from radiation practices under the Radiation Act, but which is then further managed in nuclear facilities, is treated there according to the Nuclear Energy Act.

The interface between the two acts causes some difficulties, such as, the transfer of information and responsibilities between actors under different acts. This may lead to similar waste being treated differently depending on its origin. Additionally, the ARTEMIS review team was informed that there are challenges in managing the different requirements for nuclear waste, non-nuclear radioactive waste, and other waste.

This issue is acknowledged by the Government and will be taken into account in the next planned update of the nuclear energy legislation. Parallel classification has long history and may be difficult to remove completely. In that case the interface will be clarified to minimize the drawbacks.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *The laws governing radioactive waste management, the Nuclear Energy Act and the Radiation Act, do not define or treat radioactive waste with different origins consistently. This situation leads to complexities in the regulation and management of radioactive waste.*	
(1)	**BASIS: GSR Part 1 (Rev. 1) Requirement 22 para 4.28 states that:** *"There shall be consistency in the decision-making process of the regulatory body and in the regulatory requirements themselves, to build confidence among interested parties."*
S1	**Suggestion: The Government should consider improving consistency of the legislation to reduce the complexity of regulation and management of all radioactive waste.**

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *Under the Radiation Act, Finland is operating facilities with the potential to generate radioactive waste (e.g. cyclotrons). While the Radiation Act provides for arrangements for managing waste generated during operations and when discontinuing the practice, it does not require preparation of initial decommissioning plans as part of the operational licence.*	
(1)	**BASIS: GSR Part 1 (Rev. 1) Requirement 10 states that:** *"The government shall make provision for the safe decommissioning of facilities, the safe management and disposal of radioactive waste arising from facilities and activities, and the safe management of spent fuel."*
(2)	**BASIS: GSR Part 6 Requirement 5 states that:** *"The regulatory body shall regulate all aspects of decommissioning throughout all stages of the facility's lifetime, from initial planning for decommissioning during the siting and design of the facility, to the completion of decommissioning actions and the termination of authorization for decommissioning."*
(3)	**BASIS: GSR Part 6 Requirement 10 states that:** *"The licensee shall prepare a decommissioning plan and shall maintain it throughout the lifetime of the facility, in accordance with the requirements of the regulatory body, in order to show that decommissioning can be accomplished safely to meet the defined end state."*
(4)	**BASIS: GSR Part 6 para 7.4. states that:** *"The licensee shall prepare and submit to the regulatory body an initial decommissioning plan together with the application for authorization to operate the facility."*
R1	**Recommendation: The Government should require early preparation of initial decommissioning plans for all facilities that generate radioactive waste and maintain them throughout the lifetime of the facilities consistent with the graded approach.**

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *Finland has no identified licensed disposal route for a few waste streams such as a limited sub-set of the high activity sealed sources. Three possible disposal routes are under consideration. These are the two existing low and intermediate level waste disposal facilities and the geological disposal facility under construction.*	
(1)	**BASIS: GSR Part 5 para 3.5 states that:** *"The national policy on radioactive waste management has to set out the preferred options for radioactive waste management. It has to reflect national priorities and available resources and has to be based on knowledge of the waste to be managed (e.g. knowledge of the inventory and of waste streams) now and in the future…."*
(2)	**BASIS: GSR Part 1 (Rev. 1), Requirement 10 states that:** *"The government shall make provision for the safe decommissioning of facilities, the safe management and disposal of radioactive waste arising from facilities and activities, and the safe management of spent fuel."*
R2	**Recommendation: The Government should make arrangements for a licensed solution for the safe disposal of the few waste streams without a licensed disposal option.**

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *The way in which the Finnish national programme is organized has resulted in the development of disposal facilities for low and intermediate level waste at each nuclear power plant (NPP) site and the development of a single geological disposal facility for the spent fuel from the existing NPPs. Finland's Climate and Energy Strategy 2022 includes carbon neutrality by 2035 and a significant proportion of nuclear power. The policy and strategy for radioactive waste and spent fuel management may require review if the nuclear programme in Finland develops further (e.g. to include further NPPs or small modular reactors (SMRs) and operating organizations).*	
(1)	**BASIS: GSR Part 1 (Rev. 1) Requirement 10 states that:** *"The government shall make provision for the safe decommissioning of facilities, the safe management and disposal of radioactive waste arising from facilities and activities, and the safe management of spent fuel."*
(2)	**BASIS: GSR Part 5 para 3.5 states that:** *"The national policy on radioactive waste management has to set out the preferred options for radioactive waste management. It has to reflect national priorities and available resources and has to be based on knowledge of the waste to be managed (e.g. knowledge of the inventory and of waste streams) now and in the future. It has to assign responsibilities for various aspects of radioactive waste management, including regulatory overview."*
S2	**Suggestion: The Government should consider continuously evaluating the suitability of the current policy and strategy for radioactive waste and spent fuel management against the anticipated future demands of the Finnish Climate and Energy Strategy.**

2. NATIONAL STRATEGY FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT

2.1. SCOPE

Finnish position

The second national programme describes the national strategy of Finland regarding the management of radioactive waste and spent fuel. This programme was made pursuant to Article 12 of Directive 2011/70/Euratom of the Council of the European Union.

The strategy is guided by the principle that any operator generating spent fuel or radioactive waste has to take all the measures needed for the safe management of this waste (including bearing of the costs).

For radioactive waste and spent fuel produced by facilities under the Nuclear Energy Act, the Government specifies the time frame and implementation to be followed at the key waste management stages and specifies when the measures regarding the management of the radioactive waste and spent fuel are to be carried out at the latest. The operator must plan and implement the waste management accordingly and in line with the principles of the national policy.

For the waste generated from practices that fall under the Radiation Act, operators must submit plans for their management to STUK for approval, as part of the application for a safety licence, or the application for a change in this licence during its period of validity.

The national programme covers mainly the following:

- The operational low and intermediate level waste generated by the nuclear power plant Loviisa (units 1 and 2), operated by Fortum, and the nuclear power plant Olkiluoto (units 1, 2 and 3), operated by TVO.
- The spent fuel from the Loviisa and Olkiluoto nuclear power plants.
- The waste that will be generated by the decommissioning of the Loviisa and Olkiluoto nuclear power plants and the facilities for treatment and storage of LLW and ILW and storage of spent fuel.
- Small amounts of low and intermediate level waste arising from the operation of the encapsulation plant for spent fuel.
- The waste that will be generated by the decommissioning of the encapsulation plant for spent fuel.
- The waste generated by the decommissioning of the VTT Technical Research Centre of Finland Ltd's (VTT's) FiR 1 research reactor and waste from VTT's radioactive research facilities.
- Disused sealed radioactive sources, including some high activity sealed sources (HASS).
- Waste from the radiochemistry laboratories of the University of Helsinki.
- Waste arising from the use of radiation whose activities, especially after ceasing operations, may result in significant amounts of waste, such as particle accelerators and cyclotrons from universities or hospitals.
- NORM waste, in particular waste generated by the mining and subsequent refining of nickel-cobalt ore, which contains small amounts of uranium.

Finland implements the following principles for treatment, storage and disposal of radioactive waste and spent fuel, produced from facilities licensed under the Nuclear Energy Act:

— The waste production is kept as small as reasonably achievable. This means in practice that at the design and during operation, priority is given to solutions minimizing the amount of waste at the different stages in the life of the facility. Waste is also minimized by avoiding as much as possible the introduction of materials into the controlled areas.
— Radioactive waste produced is sorted and waste eligible for release from regulatory control is separated from other radioactive waste. Procedures are in place at the facilities to release the waste from regulatory control.
— Waste treatment and packaging operations further reduce the volume of radioactive waste produced. These measures, together with efforts to minimize the waste at the source, have led to a reduction in the amount of waste produced in recent years.
— The waste produced from the use of nuclear energy must be permanently disposed of in Finland. Low and intermediate level waste is disposed of in disposal facilities located in the Finnish bedrock. Two disposal facilities exist for LLW and ILW, one at Loviisa and one at Olkiluoto.
— Spent fuel is to be disposed of in a disposal facility to be built in bedrock in Finland. The spent fuel will be encapsulated before disposal. In order to achieve this, TVO and Fortum are cooperating (via the joint venture Posiva) to develop a joint geological disposal facility for spent fuel. The encapsulation plant and geological disposal facility ONKALO are located at the Olkiluoto site. In 2021, Posiva submitted a licence application for the operation of the encapsulation plant and geological disposal facility.
— The Nuclear Energy Act allows for the disposal of very low level waste in a near-surface disposal facility. TVO is planning to build such a facility in Olkiluoto.
— The operator's responsibility for spent fuel and radioactive waste management will continue until the waste management for each waste stream has been completed and a decision on the termination of the operator's responsibility has been taken by the State. In practice, this means for most of the operators that the responsibility includes the decommissioning and dismantling of the facilities, the disposal of all radioactive waste and spent fuel and the closure of the disposal facilities. After the closure of a disposal facility, the ownership and responsibility for the disposed spent fuel and radioactive waste is transferred to the State.
— For the FiR 1 research reactor, the principle for the management of radioactive waste and spent fuel relies on returning the spent fuel to the US, which has been accomplished recently, and on disposing the radioactive waste in the LLW and ILW disposal facilities of the power companies. In practice, this waste is planned for disposal at the Loviisa LLW and ILW disposal facility. In order to do so, direct arrangements are being made between the producer of the waste and the operator of the disposal facility, Fortum, which will require licences in accordance with the Nuclear Energy Act.

Finland implements the following principles for the treatment, storage and disposal of radioactive waste arising from radiation practices:

— The waste production is kept as small as reasonably achievable.
— Disused sealed radioactive sources (DSRS) are preferred to be returned to the manufacturer. If this is not possible, DSRS, including high activity sealed sources, and other radioactive waste arising from the use of ionizing radiation, are handed over to a safety licence holder who has a safety licence for the reception, treatment, and storage of radioactive waste. Suomen Nukliditekniikka Oy is currently the only operator licensed to receive, condition and transfer radioactive waste to the storage room operated by STUK, attached to the disposal facility at Olkiluoto for LLW and

ILW. The responsibility for the stored radioactive waste and DSRS lies with the State. The option for their management is disposal in the facilities at Olkiluoto or at Loviisa for LLW and ILW. In order to do so, contractual arrangements are made between the producer of the waste or the State, and the operator of the disposal facility. There are, however, small amounts of radioactive waste and sealed radioactive sources for which the disposal in the present disposal facilities is not possible.

— The Radiation Act defines a maximum service life of 40 years for sealed sources. Beyond this timeframe, they must be decommissioned. Due to this provision, an increase in the amount of disused sealed radioactive sources in the storage room is expected in the future.

For NORM waste, in case the waste may not be released from regulatory control, the radiation exposure must be investigated and taken into account. Methods for treatment and disposal are chosen primarily on the basis of conventional waste and environmental legislation. When possible, such waste is disposed of in a hazardous landfill. If potential exposures generated by such a facility are above predefined thresholds, then a licence in accordance with the Radiation Act needs to be obtained.

ARTEMIS observation

The ARTEMIS review team notes that the national programme covers all radioactive waste and spent fuel generated in Finland. It details in a comprehensive way the strategies for the safe management of this radioactive waste and spent fuel, up to and including its disposal.

The ARTEMIS review team specifically learned that following the issue of the first operating licences for nuclear power plants in the late 1970s, the Government imposed conditions in 1978 on the planning of radioactive waste management. The requirements of the Government Policy Decision of 1983 on the objectives and timeframes of the research and development of spent fuel and radioactive waste management were also included in the operating licences for nuclear power plants issued in the same year. The Government decision in 1983 included disposal facilities for (i) LLW and ILW, and (ii) spent fuel. Since then, a consistent and step-wise strategy, aiming at designing, constructing and operating disposal facilities for LLW and ILW and a geological disposal facility for spent fuel has been implemented. This has led to submission of the licence application by Posiva, in 2021 to operate a geological disposal facility for spent fuel. The implementation of the disposal strategy included the establishment of the necessary requirements by the regulatory body, as well as successful interactions with all interested parties. Posiva aims at starting operations of the disposal facility around 2025, which would imply that it would be the first geological disposal facility for spent fuel in operation in the world.

2.2. MILESTONES AND TIMEFRAMES

Finnish position

The second national programme describes the timeframes and milestones for the management of spent fuel and radioactive waste in Finland.

Figure 1 gives an overview of the timeframes for the management of spent fuel and nuclear waste generated in nuclear facilities.

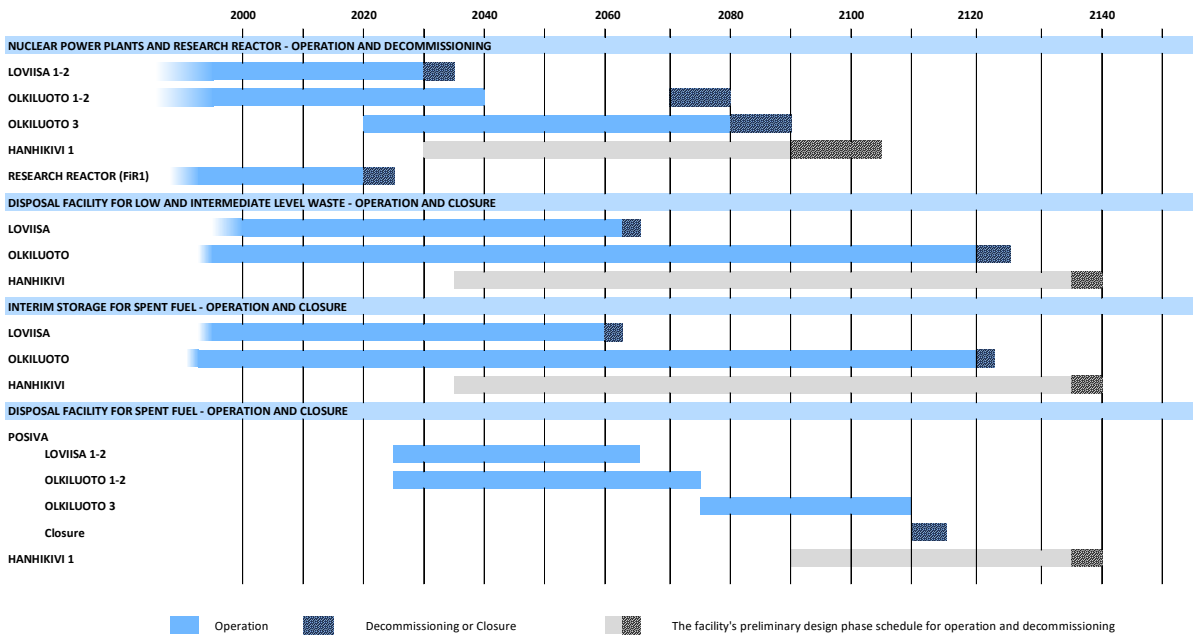

Figure 1: Overall timeframe for the management of spent fuel and radioactive waste from nuclear facilities (from the second national programme)

(Note: the development of the Hanhikivi NPP has been discontinued due to the withdrawal of the licence application from the handling of the Government by the company in May 2022.)

Disposal facilities for LLW and ILW were commissioned for Loviisa and Olkiluoto in the 1990s. The facilities receive the LLW and ILW generated by the operation, as well as future waste from the decommissioning of the NPPs, storage facilities, and treatment facilities. Closure of the disposal facilities for LLW and ILW is foreseen for Loviisa in the 2060s and for Olkiluoto in the 2130s, in line with the current decommissioning schedule of the nuclear power plants.

In the spring of 2020, VTT and Fortum agreed to store the LLW and ILW generated by the decommissioning of the FiR 1 research reactor and laboratory facilities at the Loviisa plant and dispose them in the LLW and ILW disposal facility of Loviisa. These plans are dependent on regulatory review and Government approval. According to the current plans, the dismantling of the research reactor will take place in the early 2020s and will be completed around the mid 2020s.

TVO is planning to construct and operate a VLLW disposal facility at Olkiluoto. It expects to be operational in the early 2020s up to the 2090s.

Regarding the spent fuel, an environmental impact assessment of the construction and operation of Posiva's encapsulation plant and geological disposal facility was for the first time assessed in 1999. The decision in principle for the encapsulation plant and the geological disposal facility was taken in 2000. Posiva applied for a construction licence in 2012, which was granted in 2015. In 2021, a licence application was submitted to operate the encapsulation plant and geological disposal facility. Posiva is expecting to start disposal operations-around 2025 and to end operations in the 2120s. The closure of the facility is foreseen to be completed by the end of the 2130s at the latest.

Uncertainties in the timeframes are managed through the three-yearly waste management plans, which the operators need to provide, and in which the operator has to report on the planned measures for the management of spent fuel and radioactive waste for a period up to six years. Certain uncertainties regarding the impact of longer operations of certain nuclear power plants are also assessed in the national programme.

For the disused sealed sources, the licensing conditions of the LLW and ILW disposal facility at Olkiluoto were updated in 2012 allowing for the disposal of the majority of the sealed sources in storage at that time. Disposal of the sources started in 2016.

ARTEMIS observation

The ARTEMIS review team finds that the national programme contains comprehensive and clear timeframes and milestones regarding the management of radioactive waste and spent nuclear fuel generated in nuclear facilities, as well as information regarding some milestones regarding the storage and disposal of DSRS.

The ARTEMIS review team especially acknowledges that the initial timeframe set out in the early eighties for the disposal of the spent fuel, has been respected up to this day with little deviation, which is truly remarkable. This also supports good practice GP1.

2.3. PROGRESS INDICATORS

Finnish position

In Finland, the responsibility for the management of spent fuel and radioactive waste lies with those who generate the spent fuel and radioactive waste, in connection with or as a result of their activities. The implementation of the waste management by the operators is monitored by STUK, through its control measures. Operators also make cost estimates of the implementation of the radioactive waste and the spent fuel management. Five "key figures" are identified, which are considered as performance indicators:

- The implementation of technical solutions and timeframes for the management of spent fuel and radioactive waste, and adequacy and timelines of planned measures;
- Functioning of the financial provisions for the management of spent fuel and radioactive waste;
- Implementation of the principle of continuous improvement in the management of spent fuel and radioactive waste;
- Amount of radioactive waste generated, and amount of radioactive waste disposed of and waste released from regulatory control with respect to the amount of waste generated;
- Expertise development and maintenance.

ARTEMIS observation

The ARTEMIS review team recognizes the importance of the "key figures" identified as performance indicators, while understanding that the process of using them as performance indicators has only recently been initiated. The ARTEMIS review team would encourage the Government to further develop these "key figures" into measurable key performance indicators for the implementation of the radioactive waste and spent fuel management programme in Finland.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *A geological disposal facility for spent fuel is being constructed in Finland. During 2021, an operational licence application was submitted by Posiva to the Ministry of Economic Affairs and Employment along with supporting documentation to STUK.*	
(1)	**BASIS: SF-1 Principle 7 para 3.29 states that:** "*Radioactive waste must be managed in such a way as to avoid imposing an undue burden on future generations; that is, the generations that produce the waste have to seek and apply safe, practicable and environmentally acceptable solutions for its long term management….*"
GP1	**Good Practice: The Government, the regulatory body, the operating organization and interested parties, have effectively implemented the national strategy to develop a geological disposal facility for spent fuel, which would be the first in operation in the world.**

3. INVENTORY OF SPENT FUEL AND RADIOACTIVE WASTE

Finnish position

The radioactive waste classification system in Finland includes two main categories: nuclear waste, and radioactive waste not originating from the use of nuclear energy and the associated nuclear fuel cycle (non-nuclear radioactive waste).

According to the Nuclear Energy Act and the Regulation STUK Y/4/2018, nuclear waste is classified as:

- VLLW refers to radioactive waste whose average activity concentration of significant radionuclides does not exceed 100 kBq/kg and whose total activity per licensed disposal facility does not exceed 1 TBq and α activity does not exceed 10 GBq.
- LLW refers to radioactive waste whose activity is so low that it can be treated without any special radiation protection arrangements. The activity concentration of the waste is normally not more than 1 MBq/kg.
- ILW refers to radioactive waste whose activity is so high that effective radiation protection arrangements are needed when handling it. The activity concentration of the waste is usually between 1 MBq/kg and 10 GBq/kg.
- HLW refers to radioactive waste whose activity is so high that very effective radiation protection arrangements and, in most cases, cooling are needed when handling it. The activity concentration of the waste is normally over 10 GBq/kg. Spent fuel is classified as high-level waste.

The Regulation STUK Y/4/2018 also provides the following classification according to the routes of disposal, that is:

- Short-lived waste refers to nuclear waste of which the activity concentration after 500 years will be below the level of 100 MBq per kilogram in each disposed waste package, and below an average value of 10 MBq per kilogram of waste in one emplacement room;
- Long-lived waste refers to nuclear waste, of which the activity concentration after 500 years will be above the level of 100 MBq per kilogram in a disposed waste package, or above an average value of 10 MBq per kilogram of waste in one emplacement room.

Regulation STUK Y/4/2018 shall also apply to radioactive waste referred to in Section 4 of the Radiation Act (859/2018) if it is handled or stored at a nuclear facility or disposed of in a disposal facility for nuclear waste. DSRS and other solid radioactive waste are preferred to be returned to the supplier or manufacturer, or handed over to a licensee having a safety licence for the reception, treatment, and storage of radioactive waste. Suomen Nukliditekniikka Oy is currently the only private operator licensed to receive, condition and transfer radioactive waste to the storage room currently operated by STUK and attached to the disposal facility at Olkiluoto for LLW and ILW.

Release of waste is also permitted if it complies with clearance levels set in STUK Regulation SY/1/2018.

Waste released from regulatory control can be treated in accordance with the Waste Act (646/2011) as conventional municipal or industrial waste. This enables the reuse and recycling of waste and minimizes the waste volume, which needs to be stored and disposed.

The classification system for radioactive waste from nuclear operations is not precisely the same as presented in IAEA GSG-1, but is based on the same principles. Numerical values are defined among the different classes.

Figure 2 shows the Finnish radioactive classification system for disposal purposes.

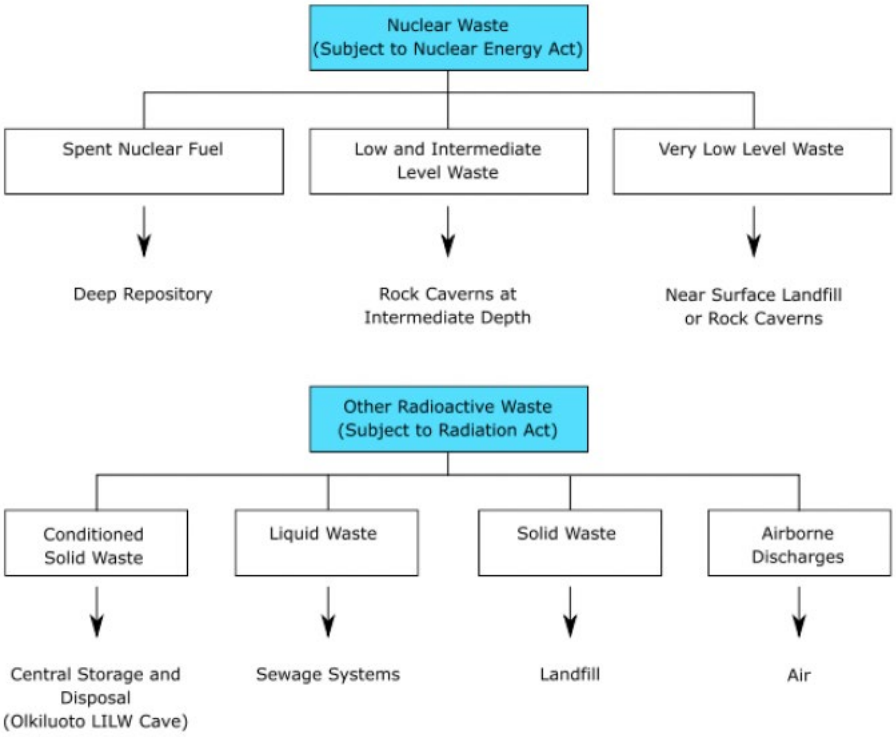

Figure 2 – The Finnish classification of radioactive waste for disposal purposes

The licensees under the Nuclear Energy Act maintain databases, where information on produced radioactive waste and spent fuel is stored. YVL Guide D.4 contains detailed requirements about the information which should be stored. Additional requirements for the record keeping of disposed waste are presented in the Regulation STUK Y/4/2018.

For unconditioned waste, the regulation YVL Guide D.4 req. 419 provides for which information has to be recorded by the licensee.

According to STUK Y/4/2018 Section 29, the licensee shall maintain a record of the disposed waste that includes waste package specific data on the waste type, radioactive substances, location within the emplacement rooms and other information deemed necessary by the authority. The waste records shall be submitted to STUK in a format approved by it.

The national inventory is gathered based on the above mentioned information. The data is stored in STUK's own database, which is still very simple and contains only information on waste amounts in storage and disposal, and also the information on the waste amount released from regulatory control. In addition to this, the IAEA's Spent Fuel and Radioactive Waste Information System (SRIS) database has been used since 2020 as a national inventory. The data is input to SRIS annually and also includes the estimates, made by the licensee, for future waste arisings.

In radiation practices, safety licence holders are required to maintain the information on the radioactive wastes they have, but there are no routine reporting obligations to STUK. The waste inventory shall be kept up-to-date and it should be available to STUK, if required. Information on radioactive waste from radiation practices is collected in the national inventory only when

the waste comes under the State's control and the waste is either sent to STUK or is stored in the State's storage room operated by STUK at Olkiluoto.

In the national programme, the need to develop and establish the accounting procedures of radioactive waste and spent fuel inventory in Finland is recognized. The information to be stored in the national inventory should be defined clearly and communicated to the licensees.

Operators subject to the Nuclear Energy Act are obliged to keep their own waste accounting up to date and to submit the data annually to STUK.

Less precise data is available on the quantities of radioactive waste held by operators subject to the Radiation Act.

In the future, efforts will be made to improve the preparation and reliability of forecasts of the quantities of radioactive waste by agreeing on common principles for the calculation of forecast data.

ARTEMIS observation

The ARTEMIS review team notes that, as discussed in Section 1, the provisions for radioactive waste are divided under two Acts. Depending on the practices where the radioactive waste is generated, there are differences that produce some challenges, starting from the definition of radioactive waste.

The ARTEMIS review team recognizes that possible improvements in the classification system could be introduced in the reorganization of the nuclear legislation.

With regards to the national inventory, both Nuclear Energy Act and Radiation Act require the licensee to have up-to-date radioactive waste and spent fuel inventories in their databases. Input data to the IAEA SRIS system is provided directly by the licensee from the nuclear sector. Consistency of provided data is verified by STUK.

The ARTEMIS review team noted that STUK collects data in its own database, which is still very simple and contains only information on amounts of stored and disposed waste. STUK's database also includes information on the amount of materials released from regulatory control.

The ARTEMIS review team recognizes the need for an integrated national inventory of the radioactive waste and spent fuel in Finland that includes more detailed information, for instance, including radionuclides and toxic substance contents.

The ARTEMIS review team also noted the need for improved guidance to the licensees, which establishes a common approach for the estimation of the future waste.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *All licensees have the obligation to maintain records of radioactive waste, both in storage and disposal facilities. Information on spent fuel and radioactive waste from the nuclear sector, as well as radioactive waste and disused sources coming from practices authorized under the Radiation Act, is collected by STUK. Integrating additional data and further developing common principles for estimating the future inventory would improve radioactive waste management.*	
(1)	**BASIS: GSR Part 1 (Rev.1) Requirement 35 para 4.63 states that:** *"The regulatory body shall make provision for establishing and maintaining the following main registers and inventories:* *— Inventories of radioactive waste and of spent fuel."*
(2)	**BASIS: GSR Part 5 Requirement 9 para 4.10 states that:** *"Radioactive waste has to be characterized in terms of its physical, mechanical, chemical, radiological and biological properties."*
(3)	**BASIS: GSR Part 5 Requirement 9 para. 4.11 states that:** *"…The relevant characteristics of the waste have to be recorded to facilitate its further management."*
S3	**Suggestion: The regulatory body should consider strengthening the national inventory so that it covers all radioactive waste and includes additional information on radionuclides and toxic substances. Additionally, the regulatory body should consider the establishment of common principles for estimating the future inventory.**

4. CONCEPTS, PLANS AND TECHNICAL SOLUTIONS FOR SPENT FUEL AND RADIOACTIVE WASTE MANAGEMENT

Finnish position

The requirements for the management of radioactive waste and spent fuel resulting from the use of nuclear energy in Finland are established in the Nuclear Energy Act, with requirements for management of radioactive wastes arising from other sources being established in the Radiation Act. The Radiation Act includes those industries involved in the management of NORM. These acts cover the expectations across all phases of the design, operations and closure phases of waste management according to the classification and nature of the waste.

Currently, Finland has two organizations responsible for the operation of NPPs for energy generation; TVO and Fortum. As generators of nuclear waste TVO and Fortum are responsible for implementing nuclear waste management and disposal arrangements for the NPPs under their ownership (TVO at Olkiluoto, Fortum at Loviisa).

Waste disposal facilities for LLW and ILW have been constructed and are in operation at both the Olkiluoto and Loviisa facilities. They contain an inventory of waste packaged in a final disposable form. The Loviisa disposal facility extends to a depth of approximately 110 m in granite bedrock and consists of three halls for solid LLW and a cavern for ILW. The Olkiluoto disposal facility for LLW and ILW consists of two silos extending to depths of 60 and 95 m in tonalite bedrock, one for solid LLW and the other for bituminized ILW. The silo for solid LLW is shotcreted rock, while the silo for bituminized waste consists of a thick walled concrete silo where the concrete boxes containing the bituminized waste are emplaced.

Development of the geological disposal facility for the management of the spent fuel is the responsibility of Posiva an organization which was jointly established by TVO and Fortum in 1995. The Finnish approach for management of spent fuel is for wet storage and cooling prior to disposal.

An encapsulation plant will be used to encapsulate cooled and dried spent fuel assemblies ready for disposal within a cast iron insert inside a copper canister. The encapsulated spent fuel will be disposed of in the disposal facility at a depth of 420-450m in bedrock. The geological disposal facility is at an advanced stage of development with the expectation that the facilities will be licensed to commence operations in 2024.

The licensing of the geological disposal facility is specific to the target bedrock and the inventory expected to be managed from the operation of the NPPs currently in operation in Finland (the fuel from the test reactor having previously been returned to its country of origin). Under the requirements of the Nuclear Energy Act, any new organization wishing to implement a NPP in Finland would have to prepare a waste management and decommissioning plan, which should include proposals for implementation of LLW and ILW disposal capability and management of spent fuel arising from its operation. This does not necessarily mean disposal in the existing licensed facilities implemented within the national programme.

The waste acceptance criteria for the disposal facilities for LLW and ILW are based on the operational and post closure safety assessments for the facilities and included within the licensing requirements for the NPPs. The Nuclear Energy Act (Section 7g) requires that the operators provide updated decommissioning plans (every six years) and waste management plans including predictions of wastes arisings (every three years) for review by STUK. The current decommissioning plan for the Loviisa NPP is based on immediate dismantling within ten years from shutdown, while for the Olkiluoto NPP a safe storage period of about 30 years prior to dismantling is envisaged. The justification for postponed dismantling of OL1 and OL2

is based on the decrease in radioactivity and the availability of nuclear site infrastructure, since the OL3 unit will be operational while the OL1 and OL2 units are being dismantled. The decommissioning strategy for OL3 is immediate dismantling. The disposal plans for waste arising from the decommissioning of the NPPs are based on the enlargement of the existing disposal facilities for LLW and ILW.

The plans and associated timeline for the operational durations and closure plans for all facilities managed under the Nuclear Energy Act including the waste disposal facilities are endorsed by the Ministry, these are presented in Figure 1.

As identified above in Section 2 and 3, the waste inventory includes an amount of non-nuclear radioactive waste including DSRS.

ARTEMIS observation

The ARTEMIS review team observes that the strategy for the management of radioactive waste and spent fuel arising from the operation and decommissioning of nuclear facilities in Finland is at an advanced stage of maturity and implementation. The Finnish approach for the management of LLW and ILW (including waste from decommissioning) is for their disposal at the NPP site of its generation. The disposal facility for LLW and ILW at Olkiluoto has been in operation since 1992, with the equivalent facility at Loviisa operational since 1998.

The ARTEMIS review team observes that the geological disposal facility being developed by Posiva is at an advanced stage, with a large proportion of the disposal infrastructure having been constructed. The facility has a clearly established basis of safety, clearly established requirements and there is a mature understanding of the performance objectives of the multiple barriers. The licence application for the operation of this facility is currently with STUK for review in support of an operating licence.

The ARTEMIS review team observes that the Finnish national programme includes a number of organizations and facilities outside the nuclear power programme who generate radioactive waste. The management of wastes generated from these facilities is covered by the Radiation Act. As discussed in Section 1, the fact that the provisions for radioactive waste are managed under two Acts introduces a risk that a licensed facility for the disposal of wastes from the operation and decommissioning of these non-nuclear facilities may not be available when needed.

The ARTEMIS review team notes a requirement established in the 2018 update of the Radiation Act which established a maximum service life of 40 years for sealed radioactive sources. The law established a five-year transitional period until December 2023 during which the inventory of sealed radioactive sources meeting this criterion must be sent to an appropriately licensed facility (Radiation Act section 83, subsection 2). At this time, it is unclear how much of this inventory will require management by the State and whether existing licensed facilities are suitable for the storage or disposal of these materials.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *A storage room for the management of disused sealed radioactive sources and radioactive waste is operated by STUK at Olkiluoto. Some of these are stored without a licensed disposal route. A substantial increase in the number of disused sealed radioactive sources to be stored is expected by December 2023.*	
(1)	**BASIS: GSR Part 1 (Rev. 1) Requirement 10 states that:** *"The government shall make provision for the safe decommissioning of facilities, the safe management and disposal of radioactive waste arising from facilities and activities, and the safe management of spent fuel."*
(2)	**BASIS: GSR Part 5 para 4.22 states that:** *"The adequacy of the storage capacity has to be periodically reviewed, with account taken of the predicted waste arisings, both from normal operation and from possible incidents, of the expected lifetime of the storage facility and of the availability of disposal options."*
S4	**Suggestion: The Government should consider making arrangements to ensure that sufficient licensed storage or disposal capacity is available for the anticipated future inventory of disused sealed radioactive sources.**

5. SAFETY CASE AND SAFETY ASSESSMENT OF RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT ACTIVITIES AND FACILITIES

Finnish position

The safety of radioactive waste or spent fuel management activities and facilities in Finland is regulated at different levels of the Finnish legal and regulatory framework (acts, decrees, STUK's regulations and guides). According to this framework, a safety case is part of all licensing phases for a nuclear facility as defined in the Nuclear Energy Act (decision-in-principle, construction, operation, decommissioning or closure). A Preliminary Safety Analysis Report (PSAR), i.e. a safety case[1], is required when a construction licence is applied for and a Final Safety Analysis Report (FSAR) is required when the operating licence is applied for. Safety cases are developed and updated by the operators and submitted to the regulatory body for approval. Periodic safety assessment for the predisposal management of nuclear waste is carried out in connection with the periodic safety assessment of the NPPs at least once every 10 years, while periodic safety assessment for disposal facilities is required at least once every 15 years. Safety cases are maintained and, if necessary, revised taking into account operating experiences (including incidents/accidents), plant modifications and research results.

The Nuclear Energy Act prescribes high level safety principles, which are further elaborated in STUK's regulations and guides in terms of safety requirements. The primary goal is to prevent accidents, the secondary goal is to manage accidents, in which case the necessary practical measures must be taken to mitigate the consequences. The safety case describes the quantities of radioactive substances and the components of the facilities (e.g. the waste packages, buffer and backfill materials, seals, the host rock and the natural environment at the disposal site) as well as their safety functions and relevant performance targets, and demonstrates how safety requirements are met. The safety case also defines the organization's management system, including the operating procedures. Further, the safety case documents the justification for the choices made in terms of technical solutions (optimization at the facility level) and the significance of the identified uncertainties based on deterministic and probabilistic sensitivity analyses as well as the research plan to reduce uncertainties. Radiological consequences for expected evolutions and postulated unlikely accidents or disruptive events impairing part of the multi-barrier system are then analysed.

For a disposal facility, both operational safety and post-closure safety (passive) are assessed. The post-closure safety assessment period covers a period of approximately one hundred thousand years for LLW and ILW, and one million years for spent fuel, depending on the characteristics of the waste. The facility-specific waste acceptance criteria are derived from the safety case. A graded approach is adopted, i.e. the requirements and measures for ensuring safety and the level of details in the safety case are commensurate with the hazard potential of the radioactive waste or spent fuel.

STUK reviews the safety cases, according to the above-mentioned regulatory framework and STUK's internal review guides. When preparing its review, depending on its safety significance and in addition to its own review capacities, STUK may request the opinion of expert organizations. Additionally, STUK requests a statement from the Advisory Committee on Nuclear Safety for periodic safety reviews and licence applications. STUK maintains a "Case

[1] In Finnish legislation, the term "safety case" is used for post-closure safety assessment for disposal facilities; "safety analysis" is used instead of "safety case" for operational safety assessment. In this report, the meaning of "safety case" is that of the IAEA glossary, which applies to both operational safety and post-closure safety of a disposal facility.

Management System" for tracking open requirements. Besides regular oversight reviews, STUK also interacts with waste producers and operators of disposal facilities in meetings where e.g. the licence holder clarifies its intentions to meet the regulatory requirements, or concerns are heard. Further, STUK also reviews compliance with safeguards requirements, thus making sure that potential conflicts when considering both safety and safeguards have been addressed by the licensee or applicant.

At both the Olkiluoto and Loviisa sites, spent fuel storage and predisposal management of LLW and ILW are covered by the operating licences of the nuclear power plants. With regard to the disposal facilities for LLW and ILW operated at Olkiluoto and Loviisa since 1992 and 1998, respectively, the most recent FSAR updates were delivered by TVO and Fortum in 2020 and in 2022. In 2021, Posiva submitted an operating licence application (including FSARs) for spent fuel encapsulation and geological disposal at Olkiluoto. STUK is in the process of reviewing these safety cases and the application.

The storage room attached to the disposal facility for LLW and ILW in Olkiluoto is operated by STUK according to the operating safety assessment of the disposal facility.

The use of radiation (e.g. activities related to radiation sources or to radioactive waste produced outside the nuclear field) and NORM and mining activities are regulated under the Radiation Act. The Radiation Act requires a safety licence to be granted by STUK and the requirements for safety assessments are defined in the Act and STUK's regulations and guides. According to the graded approach, the safety provisions, safety assessment and STUK's review process are adapted to the potential radiation exposure from these waste and materials.

ARTEMIS observation

The ARTEMIS review team acknowledges that, for management of radioactive waste and spent fuel produced as a result of the use of nuclear energy, the regulatory requirements ensure that the safety cases developed by the licensees or prospective licensees are documented at a level of detail and to a quality sufficient to demonstrate the safety of the activities and facilities. These safety cases rely on step-by-step, regular, mature safety assessments and independent regulatory reviews, accounting for changes in facilities and experience feedback.

Some specific issues were discussed between the ARTEMIS review team and the Finnish counterparts, such as site selection, management of uncertainties, monitoring, operating processes for facilities under the Radiation Act, the selection of scenarios for assessing post-closure safety of disposal facilities, and regulatory review processes. The ARM together with the provided additional information show overall compliance with IAEA standards and guides. The ARTEMIS review team particularly recognizes the high-level of safety expertise of the Finnish counterparts, the benefits of the constructive interactions between the regulatory body and the operators throughout and beyond the review process, and the treatment of safety, security, and safeguards (3Ss) and the interfaces between them. It is important to ensure an appropriate balance and consistency between the graded approach and strong requirements.

6. COST ESTIMATES AND FINANCING OF RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT

Finnish position

Financing of radioactive waste and spent fuel management in Finland is the responsibility of producers generating spent fuel and radioactive waste. If the waste producer is unable to bear the costs, the State is responsible. Consistent with international practice and the requirements of the Joint Convention on the Safety of Radioactive Waste Management and on the Safety of Spent Fuel Management, the Government has ultimate financial responsibility.

The financial mechanism is set in two laws:

- For the waste generated in connection with or as a result of the use of nuclear energy (nuclear waste) in Nuclear Energy Act;
- For the radioactive waste generated as a result of radiation practices (non-nuclear radioactive waste) in Radiation Act.

Nuclear Waste:

The cost estimation is prepared by operators of facilities and updated every three years. Updates can be performed earlier if some large changes are expected. The estimation is prepared on the basis of experience from NPP operations in the country and follows the guidance from the IAEA and other international bodies (e.g. OECD Nuclear Energy Agency). The assessed costs are benchmarked by comparison with experience from cost estimations of radioactive waste management at other operators and submitted for evaluation to the Ministry. The Ministry ensures the accuracy and reliability of the calculation by an independent review of experts, and/or organizations specialized in assessing techno-economic calculations. In addition, the Ministry seeks STUK's statement on cost estimation.

The estimates include all the activities associated with waste management:

- Costs of storage, treatment, transport, and disposal of all radioactive waste and spent fuel generated at NPPs;
- Costs of treatment and disposal of the waste from decommissioning;
- Costs of NPP decommissioning
- Costs of research and development
- Other costs (e.g. regulatory costs and taxes).

The estimations are based on the assumption that NPPs end their operation at the end of the year when estimations are made. They are made based on real labour costs, subcontractors' costs and experience gained in upgrading existing facilities. Most of the facilities needed for radioactive waste management are already constructed or are under construction, so uncertainties in the cost estimations are smaller than in less advanced programmes. To cover remaining uncertainties in estimating future costs, 10-20 % of the estimated value is added.

Whenever a significant change in a nuclear programme is made, the assumptions underlying the cost estimates are revised and the fund target is increased in a stepwise manner. The updated cost estimates are reported to the Ministry annually or every three years, according to a schedule agreed with the Ministry.

Financial resources for the management of radioactive waste and spent fuel, including disposal, from nuclear energy production are collected in a dedicated fund. The National Nuclear Waste Management Fund (Fund) is managed under the supervision of the Ministry. The Fund is not part of the State budget. It was established in 1988.

The governance of the Fund is outlined below:

- The Director of the Fund is appointed by the Government and represents and guides the Fund's management;
- The Fund is led by the Management Board, appointed by the Government.

The Fund is organized in such a way that the collected assets serve as a guarantee in the event, that any of the licence holders could not, for any reason, carry out the planned appropriate action of radioactive waste management foreseen in national programme.

The Ministry informs the Fund annually of the estimated costs planned for each licensee with a nuclear waste management obligation, including the risk protection component. The Fund calculates the difference of the planned costs and the assets that the licensee already has. If the planned costs exceed the provision made, the Fund confirms the difference as the new waste management fee. If the planned costs are lower than the assets collected in the Fund, the amount to be returned to the licensee with a nuclear waste management obligation is confirmed.

The investment plan of the Fund is updated at least once per year and approved by the Management Board.

Non-Nuclear Radioactive Waste:

In the Radiation Act, it is stated that the licensee is responsible for the costs of radioactive waste management under their licensed activities. The licensee bears the costs of the management of radioactive waste resulting from the use of the sealed radioactive sources and other radiation practices. The costs needed to return the radiation sources to the manufacturer are the responsibility of the operator, unless otherwise agreed at the time of purchase. The cost of the treatment, packaging for disposal and disposal of radioactive waste is the responsibility of each licensee when they hand over the waste to another operator that handles the delivery of the waste for disposal. The licensee that delivers radioactive waste for disposal or storage pays for the disposal. The disposal fee for radioactive waste is based on the volume and the activity of the package to be disposed.

The licensee needs to provide a financial security (lodge) for costs arising from activities needed for the disposal of radioactive sources or for any necessary activities related to the decontamination of premises or the environment due to the performance of radiation practice. A financial security is required if the licensee has HASS or if the total activity per nuclide of the radioactive material or radioactive sources held by the licensee at any time exceeds the activity of HASS of the same nuclide. In the case of radioactive waste resulting from the radiation practices, the operator has to provide a security if the costs of rendering the radioactive waste harmless, of managing the waste generated or of carrying out the necessary clean-up measures are estimated to exceed EUR 100,000. The operator that performs radiation practices is obliged to prepare the radioactive waste management cost assessment and present it to STUK. STUK makes the decision on the furnishing of a financial security, based on a cost assessment.

The State has the secondary responsibility in case the producer of radioactive waste is not capable to fulfil its management obligation.

The collection and processing of non-nuclear radioactive waste is currently managed by Suomen Nukliditekniikka Oy. The agreement between the owners of radioactive waste and Suomen Nukliditekniikka Oy is made on the basis of a commercial agreement and the price is set according to the Government contract. The responsibility for the radioactive waste is transferred to Suomen Nukliditekniikka Oy. Once the waste is prepared for storage/disposal, the company needs to conclude a contract with STUK. STUK then concludes a contract with the operators of a disposal facility.

ARTEMIS observation

The ARTEMIS review team notes that Finland places a high level of importance on ensuring there is sufficient financial provision for the safe management of its radioactive waste and spent fuel, through to the closure of all disposal facilities. The principle of "the polluter pays" is applied and there are clear and well-defined processes for funding the activities needed for the safe management of radioactive waste and spent fuel.

Cost estimates have been developed for the safe management of radioactive waste and spent fuel. These estimates have been developed using the methods recommended in international studies. The review team noted the high level of effort that is devoted to ensuring that the costs are as accurate as possible, through benchmarking with similar projects, sensitivity studies and regular updates.

Funds collected serve as a guarantee in the event that any of the licence holders could not, for any reason, carry out the planned actions of radioactive waste management foreseen in the national programme. They are closely managed with the aim of protecting their value and there are rules in place to ensure that they can only be used for the purposes for which they were collected. Thus, there is confidence that sufficient budget will be available when required.

However, the formal process for decision making related to cost estimation for disposal of non-nuclear radioactive waste, to ensure that the costs cover the disposal costs is not clear because it is based on commercial agreements. A potential risk, recognized by the review team, is that because there is no final decision for the disposal of certain non-nuclear radioactive waste and clear determination and decision of their storage and disposal costs, there may be significant uncertainties in the cost estimation for the disposal of this waste. In this case, the Government will need to assume the costs. The review team observes that clarification and more detailed definition of this process in the future would be beneficial.

7. CAPACITY BUILDING FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT – EXPERTISE, TRAINING AND SKILLS

Finnish position

Legal provisions

The provisions of different organizations having responsibilities in the safe management of radioactive waste and spent fuel are established in legislation.

The Nuclear Energy Act states in Chapter 7a that availability of expertise needs to be ensured. Relevant parties shall participate in the financing of research activities and training, ensuring that the authorities have at their disposal such adequate and comprehensive nuclear engineering expertise and other facilities as are needed to assess the various practices and methods of nuclear waste management.

The Nuclear Energy Act was amended in 2003 to ensure funding for long-term nuclear safety and nuclear waste management research in Finland. The amendment of the Nuclear Energy Act in 2021 emphasizes that the development of national capabilities should not only target the authorities but also the licence holders and those responsible for nuclear waste management.

The Nuclear Energy Decree - Section 119 states that "The Radiation and Nuclear Safety Authority sees to it that the organization of the licence holder is adequate and serves its purpose, that the persons participating in the use of nuclear energy meet the qualification requirements set, and that proper training has been arranged for them."

The Radiation Act - Section 33 to 35 stipulate the requirements on training and induction of workers and states that all workers engaged in radiation practices or whose tasks otherwise require special expertise in radiation protection are in possession of the qualifications, radiation protection education and training and induction to their duties required by the practices and the tasks.

Competence, organization, and staffing

National surveys of competence in the Nuclear Energy Sector are conducted at the request of the Ministry. The latest version, conducted in August 2022 is currently being finalized and initial results are available (status as of November 2022). It is assumed that it represents the opinion of all main actors. Age and gender seem well balanced in the sector. The survey shows no major deficiencies in terms of competences. However, in certain areas such as radionuclide transport and biosphere modelling, experts have a predominantly more senior age profile. Furthermore, the number of people in these areas is somewhat limited.

The regulators and operators for the management of radioactive waste and spent fuel that require competences are STUK, Fortum, TVO, VTT, and Posiva. The Ministry governs the radioactive waste and spent fuel management programme. Currently there is only one dedicated person in the Ministry to govern the radioactive waste and spent fuel management programme on a day-to-day basis.

Capacity building at STUK is addressed in the 2022 IRRS report. It states that STUK has a detailed process in place for long term staffing and competence training. It also recommends that STUK makes greater efforts towards centralized documentation of information. Focusing on the domain of radioactive waste and spent fuel management, STUK systematically tries to ensure redundancy (duplication) of competences within the organization. Where this is not the case, external expertise is sought. Annual personnel turnover rate at STUK is low and recruitment is reasonably straightforward. As STUK is currently reviewing multiple licences it

indicates its resources are stretched, also because the headcount has been somewhat in decline over the past years. However, it is confirmed that the quality of the work is not affected. Future loss of competences would be perceived as detrimental. After granting the operating licence for the geological disposal facility, updates on the safety case will be needed at a minimum of once every 15 years. STUK has not yet evaluated in detail the impact of this on its competence and capacity management.

The personnel training process in Fortum is based on the IAEA systematic approach for training model. Capacity building and training is particularly relevant in the domain of safety assessment as Fortum is also contracted to conduct the safety assessment for the TVO owned LLW and ILW disposal facility.

Posiva and TVO organize their competence management and training in a similar manner. Posiva ensures at least duplication of competences in all key domains. Where needed, expertise from other companies (e.g. Fortum) is brought in. Competence management in the long term is especially relevant for Posiva, being responsible for the geological disposal facility. As the start of operation of the geological disposal facility draws closer, Posiva is now identifying the needs for the operating phase in order to reach the competence and organizational preparedness required. Special requirements for competence come from the facilities' technology, uniqueness of the final disposal process, and practices of the nuclear facilities. Transitioning from the facilities' construction and commissioning phases to the nuclear facilities' operating phase has been taken into account in the personnel management at Posiva and career paths and additional training are being planned. A major driver for this is to avoid competence loss and ensuring staff motivation throughout the transition. Annual staff turnover rate at Posiva is low. Total turnover has been around 10% over the period from 2020 to 2022. Recruitment of new staff is currently not seen as problematic.

VTT applies state-of-the-art approaches for training and competence management in all disciplines. It acts as an important interface between the academic world and the operators and STUK.

The provision and content of the radiation protection training is assessed in the 2022 IRRS report.

R&D to support capacity building

The National Nuclear Safety and Waste Management Research Programme – SAFER 2028 - is the current research programme of the Fund to ensure that the authorities and operators have the necessary nuclear safety competences and other prerequisites for nuclear waste management in Finland. The plan is developed by a group appointed by the Ministry.

SAFER 2028 integrates the national research on nuclear safety and nuclear waste management into one research programme. The SAFIR 2022 programme, and its sister programme KYT 2022, had access to a total budget of 30 million Euro for research and infrastructure development for the period of 2019 and 2020. The various nuclear actors in Finland, such as various Ministries, STUK, the operators of NPPs and Posiva have been able to use the competences created in research programmes of similar nature over the past 20 years. In an external review, requested by the Ministry, it was concluded that the primary perceived value is that the programme provides a pipeline for new talent and expertise for the successful regulation of radioactive waste management. This can be extended to the competence management conducted at the operators.

The operators manage their own independent RD&D programmes. The focus of the current Posiva RD&D programme is mainly on reducing remaining uncertainties in the safety case and optimization of the current concepts and plans in anticipation of the further construction of the

geological disposal facility and its subsequent operation. Maintaining competence can bring additional benefit from the RD&D conducted. However, it is not seen as one of the main drivers. International RD&D collaboration in key areas is also being pursued. In the operational phase, as a further means of maintaining competence, national and international projects will be conducted through the commercial subsidiary Posiva Solutions Oy with a target of having 20% of Posiva staff time accounted for by external contracts.

STUK does not currently have an independent R&D programme but does have ability to commission technical studies, as needed. Similar to Posiva, STUK has a small commercial arm serving mainly regulatory authorities outside Finland.

ARTEMIS observation

The ARTEMIS review team notes that the Finnish situation meets the IAEA requirements for capacity building.

The Ministry has the responsibility for the national programme on radioactive waste and spent fuel management. The Climate and Energy Strategy in Finland towards net zero carbon is ambitious and most likely this will increase demands in the nuclear energy domain, especially if newcomers show an interest in operating in Finland. A revision of the Nuclear Energy Act will take place in the next years and several licences or extensions of licences are in preparation. With currently only one dedicated person in the Ministry to govern the radioactive waste and spent fuel management programme on a day-to-day basis the system is stressed. This stress is expected to increase in the future. An assessment of the human resources, taking into account the elements listed above, should be considered.

STUK is currently stretched with the review of multiple licence applications. Although redundancy (duplication) of staff with key competences is ensured and long-term staffing and competence training is in place. The regulation of Posiva is expected to change significantly now that Posiva is planning to go into operations in the next years. After the review of the operational licence for the geological disposal facility, future safety case updates can be foreseen at a minimum of once every 15 years. This period is similar for the LLW and ILW safety cases. Safety case review requires specific competencies, and it is currently unclear how STUK will ensure that no loss of knowledge will occur.

Additionally, new or existing operators might consider the construction of new NPPs, e.g. SMRs. Regulating new NPPs and especially SMRs will require significant additional competencies and capacities. This suggests that demands on the competencies and capacities of STUK are expected to evolve over the next several years. This has been identified by STUK. However, STUK has not yet developed in detail how it plans to proceed. Taking further steps to ensure its competencies and capacity planning against the future demands and challenges would bring more clarity.

With the geological disposal facility planned to go into operations in the next few years, a significant change in the Posiva company structure and how it operates will take place. Posiva is preparing this through the implementation of a dedicated project portfolio. It will be restructuring whereby the share of the staff in RD&D will diminish, while the share of the staff for operations will increase. Certain core competences are planned to be taken in house. Individual career plans are being offered to all staff to meet the future skills and competencies. The extensive licensing and internal supporting documentation, whereby the safety case is regularly updated, will further prevent loss of knowledge.

The national research programmes SAFIR and KYT, now merged into SAFER2028, are high quality instruments that provide a basis for capacity building and ensuring new generations are

entering the field of waste management and disposal. The programme is sustainably funded and of high scientific quality, acting as a competence pipeline for all actors.

Finland, being a relatively small country, does not have a large waste management community. As a consequence, it is not practically feasible to have different institutes for capacity building for the government and STUK on the one hand, and operators on the other. VTT is the main research institute, providing services for STUK while also acting as a research provider for Posiva, Fortum and TVO. VTT avoids potential conflicts of interest in a pragmatic manner in that individuals are either assigned to the regulator or to the operators. Where there is doubt about independence, the issue is resolved on a case-by-case basis.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *The Ministry of Economic Affairs and Employment has responsibility for the national programme on radioactive waste and spent fuel management and currently only has one dedicated person to govern the programme on a day-to-day basis.*	
(1)	**BASIS: GSR Part 1 (Rev. 1) para 2.3 states that:** *"…In the national policy and strategy, account shall be taken of the following:* *(d) The need and provision for human and financial resources;"*
(2)	**BASIS: GSR Part 2 Requirement 9 para 4.27 states that:** *"The knowledge and the information of the organization shall be managed as a resource."*
S5	**Suggestion: The Government should consider assessing resources to govern the national programme on radioactive waste and spent fuel management in Finland and considering the need for redundancy in competence.**

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *Demands on the competencies and capacities of the regulatory body are expected to evolve over the next several years (e.g. operation of geological disposal facility, potential for SMRs). There seems to be uncertainty how competence can be maintained during the period between the safety case updates for the geological disposal facility and the low and intermediate level waste disposal facilities, which could be up to 15 years.*	
(1)	**BASIS: GSR Part 2 Requirement 9 states that:** *"Senior management shall determine the competences and resources necessary to carry out the activities of the organization safely and shall provide them."*
(2)	**BASIS: GSR Part 1 (Rev. 1) Requirement 3 states that:** *"The government, through the legal system, shall establish and maintain a regulatory body, and shall confer on it the legal authority and provide it with the competence and the resources necessary to fulfil its statutory obligation for the regulatory control of facilities and activities."*
S6	**Suggestion: The regulatory body should consider ensuring its competencies and capacity planning against the demands and challenges that are expected.**

APPENDIX A: TERMS OF REFERENCE

ARTEMIS Review of Finland's National Programme on Radioactive Waste and Spent Fuel Management

Terms of Reference

1. Introduction

On 25 April 2019, Finland requested the IAEA to organize an Integrated Review Service for Radioactive Waste and Spent Nuclear Fuel Management, Decommissioning and Remediation Programmes (ARTEMIS). On 2nd March 2021, the Ministry of Economic Affairs and Employment of Finland further requested the IAEA to organize back-to-back Integrated Regulatory Review Service (IRRS) and ARTEMIS missions in 2022, with the IRRS mission in October 2022 and the ARTEMIS mission in December 2022.

Finland's request for the ARTEMIS review is to satisfy its obligations under Article 14(3) of the European Council Directive 2011/70/EURATOM of 19 July 2011 establishing a Community Framework for the Responsible and Safe Management of Spent Fuel and Radioactive Waste (hereinafter the EU Waste Directive).

In line with the requests, the ARTEMIS review will be carried out in late November and early December 2022 in a coordinated manner with the IRRS mission, scheduled in October 2022. The ARTEMIS review will be led by the IAEA by the Department of Nuclear Safety and Security who will be supported by the Department of Nuclear Energy.

2. Objective

The ARTEMIS review will provide an independent international evaluation of Finland's radioactive waste and spent fuel management programme.

The review will be conducted by an international team of experts selected by the IAEA and will be based on the relevant IAEA Safety Standards and proven international practices.

3. Scope

The ARTEMIS review will evaluate the Finnish national programme and the national framework for executing country's obligations for safe and sustainable radioactive waste and spent fuel management. Taking into consideration that the review of the national programme is only focusing on existing and operating or realistically anticipated future operating facilities, the nuclear installation project by company Fennovoima shall be out of scope due to the withdrawal of the licence application from the handling of the Government by the company in May 2022.

The outcomes from the 2022 IRRS mission to Finland will be taken into account as appropriate to avoid unnecessary duplication in line with the Supplementary Guidelines on the Preparation and Conduct of IRRS-ARTEMIS back-to-back Missions, applicable for situations when an IRRS mission is conducted before an ARTEMIS mission. These Supplementary Guidelines are not a substitute for the ARTEMIS Guidelines but supplement them with the specific provisions that need to be taken into account while conducting IRRS-ARTEMIS back-to-back missions.

4. Reference material

The ARTEMIS review will cover all documentation submitted by National Counterpart for the scope of the review, including the results of a national self-assessment, which should be based on the ARTEMIS self assessment questionnaire provided by the IAEA.

For IRRS-ARTEMIS back-to-back missions, the National Counterpart will include in the reference material the sections of the IRRS Reference material relevant to the ARTEMIS review (e.g. parts of the IRRS self-assessment report dealing with radioactive waste and spent fuel management) as soon as they are available as well as the IRRS final draft mission report.

For IRRS-ARTEMIS back-to-back missions, identified areas of possible overlap will be addressed only by one mission, either IRRS or ARTEMIS, depending on the scope and nature of the reviews. The National Counterpart will be able to bypass in each self-assessment certain questions to avoid addressing twice the same issues. Namely, questions dealing with the General Safety Requirements (GSR) Part 1 Requirement 10 in Module 1 of eSARIS Self-assessment will be covered in the ARTEMIS mission and certain questions of topics 1, 3, 5 and 7 of ARTEMIS self-assessment questionnaire dealing with legal and regulatory framework will be covered by IRRS mission.

The provisional list of reference material is provided in **Annex 1** (this list is subject to updates and should be finalized by submission of the advance reference material).

All documents for the purpose of the ARTEMIS review will have to be submitted in English.

Reference material for the purpose of the ARTEMIS review shall be submitted to the ARTEMIS mission webpage on the Global Nuclear Safety and Security Network (GNSSN) of the IAEA.

5. Modus operandi

The working language of the review, including the review mission, will be English.

The National Counterpart is the Ministry of Economic Affairs and Employment of Finland, Energy Department. The National Counterpart Liaison Officers for the review are Ms Linda Kumpula (Ministry of Economic Affairs and Employment) and Ms Päivi Mäenalanen (Radiation and Nuclear Safety Authority, STUK).

The timeline for the key steps of the review process is provided below:

- Self-assessment: questionnaire was made available to Finland as of **27 Apr 2021**.
- Preparatory Meeting: **13 June 2022 (WebEx meeting)**.
- The reference material and the results of the self-assessment questionnaire will be provided to the IAEA as soon as they are available and not later than **27 September 2022**.
- Questions based on a preliminary analysis of the reference material and the self-assessment results will be provided to the National Counterpart from the review team by **11 November 2022**.
- The review mission will be held during **27 November - 8 December 2022 (12 days) in Helsinki, Finland**:
    - Sunday 27 November: arrival of experts and their initial team meeting.
    - Monday 28 and Tuesday 29 November: interviews/exchange/discussion with Counterparts on the basis of preliminary analysis and drafting of recommendations and suggestions.
    - Wednesday 30 November: Site visit to Olkiluoto.

- Thursday 1 December: interviews/exchange/discussion with Counterparts on the basis of preliminary analysis and drafting of recommendations and suggestions.
- Friday 2 December: finalization of identified recommendations, suggestions and good practices – presentation of recommendations, suggestions and good practices to the Counterparts.
- Saturday 3 and Sunday 4 December: drafting of the Review Report. Delivery of the draft Review Report to the Counterparts. Drafting of the executive summary and press release.
- Monday 5 December: fact checking of draft Review Report by Counterparts - internal reflection by Review Team - discussions with the Counterparts.
- Tuesday 6 December: Finnish National Holiday (Independence Day).
- Wednesday: 7 December: discussions of the draft Review Report with the Counterparts, finalization of draft Review Report by the Review Team.
- Thursday 8 December: delivery of final draft Review Report and Exit Meeting.

It is suggested that the interviews/exchange/discussion sessions for each review topic should begin with a brief and highly focused presentation from the National Counterparts that addresses any initial review questions provided by the review team in the period before the review mission.

Locations: the Counterpart will identify and arrange suitable locations for the Review Mission and for transport and accomodation of the Review Team within Finland. The Review Mission will be held at the premises of Ministry of Justice (Eteläesplanadi 10, Helsinki).

6. International peer review team

The IAEA will convene an international team of experts to perform the ARTEMIS review according to the agreed Terms of Reference. The team will comprise:

- Eight qualified and recognized international experts from government authorities, regulatory bodies, waste management organizations and technical support organizations, with experience in the safe management of radioactive waste and spent fuel. Among the experts, the IAEA will identify one expert with enough knowledge and experience in the regulatory field as well as in the radioactive waste and spent nuclear fuel management, decommissioning and remediation field to participate in both the IRRS and ARTEMIS missions. This Expert will cover IRRS Modules 5 to 9 on aspects for waste and spent fuel management facilities and will ensure that the ARTEMIS mission is informed on the IRRS review findings and mission.
- Two IAEA staff to coordinate the mission. The coordinator of the ARTEMIS review is Mr David Bennett from the Waste and Environmental Safety Section of the Department of Nuclear Safety and Security. The deputy coordinator is Mr Stefan Mayer from the Waste Technology Section of the Department of Nuclear Energy.
- One IAEA staff for administrative support who will assist the Review Team to assemble the Review Report. The administrative staff member for the review mission is Ms Irene Bollozos-Semana from the Waste and Environmental Safety Section of the Department of Nuclear Safety and Security.
- A senior member of IAEA staff from the Department of Nuclear Safety and Security will oversee the closure of the review mission.

The peer review team will be led by a Team Leader, assisted by a Deputy Team Leader. The Team Leader will be Mr John Tappert, USNRC, US. The Deputy Team Leader will be Mr Mario Dionisi, ISIN, Italy.

The review mission may include the presence of up to two observers, including the possibility of an observer from the EC. The National Counterparts will be notified of any proposed observers; the presence of any observers will be agreed between the IAEA and the National Counterpart in advance of the mission.

7. Reporting

The findings of the ARTEMIS review will be documented in a final ARTEMIS Review Report that will summarize the work of the review and contain any recommendations, suggestions and good practices. The report will reflect the collective views of the review team members and not necessarily those of their respective organizations or Member States, or of the IAEA.

Prior to its finalization, the ARTEMIS Review Report will be delivered to the National Counterpart for fact-checking.

8. Funding of the peer review

The ARTEMIS review will be funded by Finland. The costs for the services will be limited to the travel costs and per diem of the peer review team (external experts and IAEA staff) in line with IAEA Financial Regulations and Rules.

The cost of the ARTEMIS review is estimated to the amount of 56 000 EUR, to be paid to the IAEA as voluntary contribution before the start of the mission. Finland is aware that the review cost includes 7% programme support costs.

If the actual cost of the ARTEMIS review exceeds the estimated voluntary contribution, Finland agrees to cover such additional cost to the IAEA. Similarly, if the actual cost is less than the estimated voluntary contribution, any excess will be refunded to Finland through the Counterpart.

These Terms of Reference have been agreed between the IAEA and the Ministry of Economic Affairs and Employment of Finland during the preparatory meeting held on-line on 13 June 2022.

Annex 1: List of reference material

- Responses to the ARTEMIS Self-assessment Questionnaire
- National policy, strategy and programme for spent fuel and radioactive waste management
- 3rd Member State Report of Finland as required under Article 14.1 of Council Directive 2011/70/Euratom
- Final Report of the National Cooperation Group on Nuclear Waste Management
- Operating licence application – Spent Nuclear Fuel Encapsulation Plant and Disposal Facility
- Operating licence application summary of Loviisa Nuclear Power Plant
- Operating licence application summary of Loviisa Final Disposal Facility for LILW
- Environmental impact assessment report of Loviisa Nuclear Power Plant
- YJH-2021 Programme – Nuclear waste management programme for the Olkiluoto and Loviisa power plants for 2022- 2024
- The development of investment activities by the National Nuclear Waste Management Fund – final report
- A short summary of the investment plan for the National Nuclear Waste Management Fund
- SAFIR2022 Program, KYT2022 Program and SAFER2028 Draft Framework External Evaluation Report
- National Nuclear Safety and Waste Management Research Programme – SAFER2028 Framework Plan 2023-2028
- Report of the Committee for Nuclear Energy Competence in Finland
- Survey of Competence in the Nuclear Energy Sector 2017-2018 in Finland
- 7th Joint Convention National Report
- The report on Finland from the Coordinator of the relevant Country Group at the 7th Joint Convention Review Meeting
- Finland IRRS ARM Summary Report
- The IRRS self-assessment report including parts dealing with radioactive waste and spent fuel management
- The IRRS Review Report
- Legislation
    - Nuclear Energy Act (990/1987)
    - Radiation Act (859/2018)
    - Nuclear Energy Decree (161/1988)
    - Government Decree on Ionizing Radiation (1034/2018)
    - Decree of the Ministry of Social Affairs and Health on the Ionizing Radiation (1044/2018)
    - Government Decree on Nuclear Waste Management Fund (161/2004)
    - Government Decree concerning the Providing for Nuclear Waste Management Costs (991/2017)
- STUK regulations under the Nuclear Energy Act
    - On the safety of a nuclear power plant (Y/1/2018)
    - The safety of disposal of nuclear waste (Y/4/2018)
    - The safety of mining and milling operations aimed at producing uranium or thorium (Y/5/2016) under the Nuclear Energy Act

    - Regulation on exemption values and clearance levels (SY/1/2018) (under the Radiation Act and the Nuclear Energy Act).
- STUK regulations under the Radiation Act
    - Radiation Act on the investigation, assessment and monitoring of occupational exposure (S/1/2018)
    - A plan for radiation safety deviations and actions during and after radiation safety deviation (S/2/2018)
    - Radioactive waste and discharge of radioactive substances in the use of unsealed sources (S/2/2019)
    - Practices causing exposure to natural radiation (S/6/2022)
    - The in-service radiation safety of radiation sources (S/5/2019)
    - Radiation practices subject to a safety licence (S/6/2019)
    - Measurements of ionizing radiation (S/7/2021)
    - The security arrangements of radiation sources subject to a safety licence (S/9/2021)
- Regulatory Guides on nuclear safety dealing with waste management (YVL)

APPENDIX B: MISSION PROGRAMME

<table>
<tr><th>Time</th><th>Sun
27 Nov</th><th>Mon
28 Nov</th><th>Tue
29 Nov</th><th>Wed
30 Nov</th><th>Thurs
1 Dec</th><th>Fri
2 Dec</th><th>Sat
3 Dec</th><th>Sun
4 Dec</th></tr>
<tr><td>09 :00</td><td rowspan="4">Arrival of Team Members</td><td>Entrance meeting –
General Presentation</td><td rowspan="3">Waste and Spent Fuel Inventory</td><td rowspan="2">Concepts, Plans and technical solutions (With Posiva and TVO)</td><td>Team meeting</td><td rowspan="3">Review Team finalize draft Suggestions & Recommendations</td><td rowspan="8">Report drafting. Draft Executive Summary & Press Release</td><td rowspan="3">Report drafting &
delivery of draft report to Counterparts</td></tr>
<tr><td>10 :00</td><td rowspan="3">National Policy and Framework</td><td rowspan="3">Cost and Financing</td></tr>
<tr><td>11 :00</td><td rowspan="2">Safety Demonstration (With Posiva and TVO)</td></tr>
<tr><td>12 :00</td><td>Concepts, Plans and technical solutions (with VTT, Fortum…)</td></tr>
<tr><td>13 :00</td><td>Lunch</td><td>Lunch</td><td>Lunch</td><td>Lunch</td><td>Lunch</td></tr>
<tr><td>14 :00</td><td rowspan="4">National Strategy</td><td>Concepts, Plans and technical solutions (with VTT, Fortum…)</td><td rowspan="5">Site visit to Olkiluoto by review team</td><td rowspan="2">Capacity building</td><td rowspan="2">Review Team finalize draft Suggestions & Recommendations</td><td rowspan="5">Social event for the team
Review of draft report by Finnish counterparts</td></tr>
<tr><td>15 :00</td><td>Safety Demonstration (with VTT, Fortum…)</td></tr>
<tr><td>16 :00</td><td rowspan="3">Team meeting at the hotel</td><td rowspan="3">Team meeting and reort drafting at the hotel</td><td>Presentation of draft Suggestions & Recommendations to Counterparts</td></tr>
<tr><td>17 :00</td><td rowspan="3">Initial team meeting
(at the hotel)</td><td rowspan="3">Team meeting and report drafting at hotel</td><td rowspan="3">Team meeting and Report drafting at hotel</td></tr>
<tr><td>18 :00</td><td rowspan="2">Travel to Olkiluoto</td></tr>
<tr><td>19 :00</td><td>Return to Helsinki</td><td>Report drafting at hotel</td></tr>
</table>

Time	Mon 5 Dec	Tue 6 Dec	Wed 7 Dec	Thurs 8 Dec
09 :00	Review of draft report by Finnish counterparts	Report drafting & **Finnish National Holiday**	**Discussion of draft report with Counterparts**	**Exit Meeting-** see separate detailed agenda
10 :00				
11 :00				
12 :00				
13 :00	Lunch		Lunch	
14 :00	**Discussion of draft report with Counterparts**		Finalising Report at hotel	
15 :00				
16 :00				
17 :00	Review drafting at the hotel			
18 :00				
19 :00			Official diner	

APPENDIX C: RECOMMENDATIONS AND SUGGESTIONS

Area		R:Recommendations S: Suggestions G: Good Practices	Recommendations, Suggestions or Good Practices
1.	NATIONAL POLICY AND FRAMEWORK FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT	S1	**Suggestion:** The Government should consider improving consistency of the legislation to reduce the complexity of regulation and management of all radioactive waste.
		R1	**Recommendation:** The Government should require early preparation of initial decommissioning plans for all facilities that generate radioactive waste and maintain them throughout the lifetime of the facilities consistent with the graded approach.
		R2	**Recommendation:** The Government should make arrangements for a licensed solution for the safe disposal of the few waste streams without a licensed disposal option.
		S2	**Suggestion:** The Government should consider continuously evaluating the suitability of the current policy and strategy for radioactive waste and spent fuel management against the anticipated future demands of the Finnish Climate and Energy Strategy.
2.	NATIONAL STRATEGY FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT	GP1	**Good Practice**: The Government, the regulatory body, the operating organization and interested parties, have effectively implemented the national strategy to develop a geological disposal facility for spent fuel, which would be the first in operation in the world.

Area		R:Recommendations S: Suggestions G: Good Practices	Recommendations, Suggestions or Good Practices
3.	INVENTORY OF SPENT FUEL AND RADIOACTIVE WASTE	S3	**Suggestion:** The regulatory body should consider strengthening the national inventory so that it covers all radioactive waste and includes additional information on radionuclides and toxic substances. Additionally, the regulatory body should consider the establishment of common principles for estimating the future inventory.
4.	CONCEPTS, PLANS AND TECHNICAL SOLUTIONS FOR SPENT FUEL AND RADIOACTIVE WASTE MANAGEMENT	S4	**Suggestion:** The Government should consider making arrangements to ensure that sufficient licensed storage or disposal capacity is available for the anticipated future inventory of disused sealed radioactive sources.
7.	CAPACITY BUILDING FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT – EXPERTISE, TRAINING AND SKILLS	S5	**Suggestion:** The Government should consider assessing resources to govern the national programme on radioactive waste and spent fuel management in Finland and considering the need for redundancy in competence.
		S6	**Suggestion:** The regulatory body should consider ensuring its competencies and capacity planning against the demands and challenges that are expected.

APPENDIX D: LIST OF ACRONYMS USED IN THE TEXT

ARM – Advanced Reference Material

EU – European Union

DSRS – Disused Sealed Radioactive Sources

FSAR – Final Safety Analysis Report

HASS – High Activity Sealed Sources

HLW – High Level Waste

IAEA – International Atomic Energy Agency

ILW – Intermediate Level Waste

IRRS – Integrated Regulatory Review Service

LLW – Low Level Waste

MEAE – Ministry of Economic Affairs and Employment

NORM – Naturally Occurring Radioactive Material

NPP – Nuclear Power Plant

PSAR – Preliminary Safety Analysis Report

R&D – Research and Development

RD&D – Research, Development, and Demonstration

SRIS – IAEA's Spent Fuel and Radioactive Waste Information System

STUK - Radiation and Nuclear Safety Authority

TVO – Teollisuuden Voima Oyj

VLLW – Very Low Level Waste

APPENDIX E: IAEA REFERENCE MATERIAL USED FOR THE REVIEW

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Fundamental Safety Principles, Safety Fundamentals No. SF-1, Vienna (2006).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Governmental, Legal and Regulatory Framework for Safety, General Safety Requirements No. GSR Part 1 (Rev. 1), Vienna (2016).

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Leadership and Management for Safety, General Safety Requirements No. GSR Part 2, IAEA, Vienna (2016).

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, IAEA Safety Standards Series No. GSR Part 3, IAEA, Vienna (2014).

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Assessment for Facilities and Activities, IAEA Safety Standards Series No. GSR Part 4, IAEA, Vienna (2009).

[6] INTERNATIONAL ATOMIC ENERGY AGENCY, Predisposal Management of Radioactive Waste, IAEA Safety Standards Series No. GSR Part 5, IAEA, Vienna (2009).

[7] INTERNATIONAL ATOMIC ENERGY AGENCY, Decommissioning of Facilities, IAEA Safety Standards Series No. GSR Part 6, IAEA, Vienna (2014).

[8] INTERNATIONAL ATOMIC ENERGY AGENCY, Disposal of Radioactive Waste, IAEA Safety Standards Series No. SSR 5, IAEA, Vienna (2011).

[9] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety of Nuclear Fuel Cycle Facilities, IAEA Safety Standards Series No. NS-R-5 Rev. 1, IAEA, Vienna (2014).

[10] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Energy Basic Principles, Nuclear Energy Series, NE-BP, Vienna (2008).

[11] INTERNATIONAL ATOMIC ENERGY AGENCY, Radioactive Waste Management and Decommissioning Objectives, Nuclear Energy Series, NW-O, Vienna (2011).

[12] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Fuel Cycle Objectives, Nuclear Energy Series, NF-O, Vienna (2013).

[13] INTERNATIONAL ATOMIC ENERGY AGENCY, Policies and Strategies for Radioactive Waste Management, IAEA Nuclear Energy Series No. NW-G-1.1, IAEA, Vienna (2009).

[14] INTERNATIONAL ATOMIC ENERGY AGENCY, Policies and Strategies for the Decommissioning of Nuclear and Radiological Facilities, IAEA Nuclear Energy Series No. NW-G-2.1, IAEA, Vienna (2012).

[15] INTERNATIONAL ATOMIC ENERGY AGENCY, Policy and Strategies for Environmental Remediation, IAEA Nuclear Energy Series No. NW-G-3.1, IAEA, Vienna (2015).

[16] INTERNATIONAL ATOMIC ENERGY AGENCY, Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, IAEA International Law Series No. 1, IAEA, Vienna (2006).

[17] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Glossary – Terminology used in Nuclear Safety and Radiological Protection, IAEA, Vienna (2018).

[18] Official Journal of the European Union No. L 199/48 from 2nd Aug 2011, COUNCIL DIRECTIVE 2011/70/EURATOM of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste, Brussels (2011).

APPENDIX F: SITE VISIT

On Wednesday, 30 November 2022, the Ministry together with STUK accompanied the ARTEMIS review team on a tour of Posiva's ONKALO geological disposal facility and encapsulation plant. The visit provided the experts an opportunity to see firsthand the progress that has been made in readying the geological disposal facility for spent fuel, which is currently in licensing and would be the first in operation in the world.

Prior to entering the underground facility, the review team was thoroughly briefed on all necessary underground safety measures and precautions as well as the functioning of the provided safety gear. The Posiva staff ensured a proper fit of the safety gear before entering the underground facilities.

Knowledgeable Posiva staff then drove the review team in two mini vans down the access ramp to the technical support and disposal level located at approximately 420 meters below ground surface in the crystalline host rock formation. The team entered the first of five already excavated deposition tunnels, in which deposition holes will be drilled and spent fuel containing canisters are planned to be disposed in just a few years. The team also toured a test alcove where the required technology and procedures for emplacing spent fuel canisters in deposition holes have been thoroughly designed and tested.

After exiting the underground, the team progressed to tour the encapsulation plant currently in the final stages of construction. Because the facility is an active construction site, a detailed safety briefing was held prior to entrance. The team observed the progress made to date. The main structures of the encapsulation plant are completed, and final installation of waste handling equipment and other required installations are currently ongoing.

While effort is still needed to fully ready the facilities for the full scale trial runs scheduled over the next two years, the review team was impressed with the overall progress made.

ONKALO Spent Fuel Deposition Tunnel