

# **INTEGRATED REVIEW SERVICE FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT, DECOMMISSIONING AND REMEDICATION (ARTEMIS)**

## **MISSION TO SLOVENIA**

*Ljubljana, Slovenia*

*22-30 May 2022*

DEPARTMENT OF NUCLEAR SAFETY AND SECURITY  
DEPARTMENT OF NUCLEAR ENERGY



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

**ARTEMIS**



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INTEGRATED REVIEW SERVICE FOR RADIOACTIVE WASTE AND  
SPENT FUEL MANAGEMENT, DECOMMISSIONING AND  
REMEDICATION (ARTEMIS) MISSION  
TO  
SLOVENIA**

**Mission dates:** 22-30 May 2022  
**Location:** Ljubljana, Slovenia  
**Organized by:** IAEA

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**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

After initially requesting a combined IRRS ARTEMIS mission in January 2018, the Slovenian Nuclear Safety Administration (SNSA) requested the IAEA on 23 September 2019 to conduct ARTEMIS mission separately but not more than two or three months after the IRRS mission.

The conduct of the ARTEMIS mission and the preparation of the associated mission report have been carried out in due consideration of the IRRS mission conducted from 4 to 14 April 2022.

The objective of the ARTEMIS Peer Review Service was to provide independent expert opinion and advice on the radioactive waste and spent nuclear fuel management programme in the Republic of Slovenia, in line with the 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 based on the relevant IAEA Safety Standards and proven international practice and experiences, following the guidelines of the ARTEMIS review service.

The ARTEMIS review was focused on the evaluation of the current Slovenian national programme and national framework for executing the country's obligations for safe and sustainable radioactive waste and spent fuel management and decommissioning, as well as on the new draft National Programme covering the period 2023 to 2032. In developing the ARTEMIS mission report, the outcomes from the 2022 IRRS mission to Slovenia were taken into account.

The review was organized by the IAEA Department of Nuclear Safety and Security and the Department of Nuclear Energy and performed by a team of five senior international experts in the field of management of spent fuel and radioactive waste, supported by IAEA staff providing coordination and administrative assistance.

The preparatory meeting was held on 18 November 2021 and the Advanced Reference Material was submitted by the counterpart in March 2022 for the experts' review. Subsequent to this, the ARTEMIS review mission was conducted from 22 to 30 May 2022.

The Republic of Slovenia operates a Westinghouse two-loop pressurised light water reactor (the Krško NPP, jointly owned by the Republic of Croatia and Republic of Slovenia) with a nominal gross electrical output power of 727 MWe as well as a TRIGA Mark II research reactor, which is an open-pool type research reactor with a thermal power of 250 kW. Slovenia, through ARAO, operates a Central Storage Facility for radioactive waste (CSF) at Brinje which is responsible for the storage of low-and intermediate-level radioactive waste arising from medicine, industry and research and development. ARAO is also responsible for the long-term control and maintenance of Jazbec disposal site that accommodates mining wastes from exploitation and decommissioning of the former Žirovski Vrh uranium mine. The Boršt disposal site for hydrometallurgical tailings from the mine is currently the subject of measures to provide for safe closure before it also is transferred to ARAO for long-term control and maintenance.

Spent fuel from Krško NPP is currently stored under water in the spent fuel pool. In order to improve the safety of spent fuel storage as one of actions following the Fukushima accident, it was decided to construct a dry storage facility for spent fuel with a design lifetime of 100 years. The newly built dry storage facility will be operational in early 2023 and the first campaign for moving the spent fuel is scheduled for the second quarter of 2023.

A disposal facility for low activity and intermediate activity short-lived waste is planned to be built in the next four years. The Vrbina disposal facility is a modular, silo-type near-surface repository in silt layers of low permeability, and the waste will be disposed of at a depth of between 55 m and 15 m below ground level in uniform concrete containers in 10 layers of 99 units. According to the plan, one silo will have the capacity to accommodate that fraction (one half) of the low activity and intermediate activity short-lived waste generated from the operation and decommissioning of the Krško NPP that is the responsibility of the Republic of Slovenia, as well as similar wastes from the TRIGA Mark II research reactor and institutional radioactive waste generated within Slovenia that meets waste acceptance criteria for disposal at this facility.

The review team also noted that Slovenia has developed a programme relating to the deep geological disposal of spent fuel (SF) and high level waste (HLW).

During the ARTEMIS mission the team held discussions with the Slovenian Agency for Radwaste Management (ARAO), Nuclear Power Plant Krško, the operating company for the Krško NPP (NEK), the Slovenian Nuclear Safety Administration (SNSA) and the Fund for Financing the Decommissioning of the Krško NPP and Disposal of Radioactive Waste from the Krško NPP.

The ARTEMIS Review Team noted that Slovenia has developed and implemented a comprehensive, robust and well-functioning system for maintaining and further enhancing the safety and effectiveness of spent fuel and radioactive waste management programme.

However, the review team recommended the Government to coordinate all stakeholders in the National Programme to find mutually acceptable waste management solutions addressing legal agreements and physical constraints on continued waste storage that do not jeopardise the quality of final disposal arrangements at the Vrbina repository.

In addition, the ARTEMIS Review Team provided the Slovenian authorities with the following suggestions:

- ARAO should consider further developing guidance on the approach to demonstrating compliance of the packages prepared for disposal with the waste acceptance criteria that have been derived from the Vrbina disposal facility's safety assessment.
- ARAO should consider further developing decision criteria to facilitate selection of a preferred disposal strategy for HLW and spent fuel.
- ARAO should consider periodically updating internal and strategic objectives, aligned with future short and long term strategic needs, for the various elements of the Research, Development and Demonstration (RD&D) programme.
- The Government should consider the particular human resource needs of both the SNSA and ARAO in meeting their responsibilities for safe management of radioactive waste and spent fuel.

The ARTEMIS Review Team also identified one good practice in Slovenia's commitment to proactive pursuit of a wide range of opportunities for waste minimisation across all radioactive wastes in Slovenia.

In summary, the ARTEMIS Review Team considers that the Slovenian programme for management of spent fuel and radioactive waste is well developed, provides robustness, effectiveness and safety, now and in the future. Slovenia has demonstrated the commitment and ability to enhance the safety of radioactive waste and spent fuel management.



## I. INTRODUCTION

On 23 September 2019, the Slovenian Nuclear Safety Administration requested (SNSA) the IAEA to organize and carry out, in 2022, an ARTEMIS mission in Slovenia, as required of all EU Member States by 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.

The review was performed by a team of five 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 November 2021, and the receipt and review of Advanced Reference Material in March 2022, in May 2022 the ARTEMIS Review Team evaluated the Slovenian national programme and the national framework for executing country's obligations for safe and sustainable management of radioactive waste and spent fuel as well as decommissioning of facilities. In addition, the review addressed the new draft national policy, strategy and programme covering the period 2023 to 2032.

## **II. OBJECTIVE AND SCOPE**

The ARTEMIS review provided an independent international evaluation of Slovenia'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 Slovenia, a virtual preparatory meeting for the ARTEMIS Review mission, was conducted on 18 of November 2021. The preparatory meeting was carried out by the appointed Team Leader Mr Michael Egan, the IAEA coordinator and deputy coordinator Mr Gerard Bruno (replaced by Mr Andrey Guskov before the start of the mission) and Ms Felicia Nicoleta Dragolici, and the team of National Counterparts led by Mr Leon Kegel from ARAO with participation of representatives of the Ministry of Infrastructure and the SNSA.

The ARTEMIS mission preparatory team had discussions regarding:

- the Terms of Reference for the ARTEMIS review of the Slovenian strategy to fulfil obligations from article 14(3) of the Waste Directive;
- the specific characteristics and organisation of the ARTEMIS mission in Slovenia, as pilot 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 Slovenia in May 2022.

Mr Leon Kegel from ARAO was appointed as the national liaison officer for the Counterpart for the ARTEMIS mission and designated IAEA point of contact.

Slovenia provided IAEA with the Advance Reference Material (ARM) for the review in March 2022.

#### **B) REFERENCES FOR THE REVIEW**

The articles of the *Waste Directive*, the draft guidelines for the ARTEMIS review service and the responses to the self-assessment questionnaire were used as the basis for the review together with the ARM and materials presented during the mission and associated discussions. The complete list of IAEA publications used as the basis for this review is provided in Appendix E.

#### **C) CONDUCT OF THE REVIEW**

The initial Review Team meeting took place on Sunday, 22 May 2022 in Ljubljana, directed by the ARTEMIS Team Leader Mr Michael Egan, the ARTEMIS Team Coordinator Mr Andrey Guskov and the Deputy Team Coordinator, Ms Felicia Nicoleta Dragolici.

The ARTEMIS entrance meeting was held on Monday, 23 May 2022, with the participation of the representatives of ARAO, the Ministry of Infrastructure, the Jožef Stefan Institute and the SNSA senior management and staff. Opening remarks were made by Mr Leon Kegel (ARAO), Ms Petra Gražl (Acting Director, ARAO), Mr Igor Grlicarev (SNSA, the national liaison officer for the IRRS mission) and Mr Michael Egan, the ARTEMIS Team Leader. Mr Leon Kegel gave an overview of the Slovenian context.

During the ARTEMIS mission, a review was conducted for all review topics within the agreed scope, aiming to provide Slovenian 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 Monday, 30 May 2022. Opening remarks were made on behalf of ARAO acting director Ms Petra Gražl by Mr Leon Kegel. Mr Leon Kegel also gave opening remarks as the national liaison officer for the mission. A presentation of the results of the Review Mission was given by the ARTEMIS Team Leader Mr Michael Egan. Closing remarks were made on behalf of the IAEA by Ms Anna Clark, Section Head, Waste and Environmental Safety Section, Division of Radiation, Transport and Waste Safety, Department of Nuclear Safety and Security.

An IAEA press release was issued.

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

## 1.1. NATIONAL POLICY

### Slovenian position

National policy is set out in the Resolution on the National Programme for Management of Radioactive Waste and Spent Fuel, in accordance with the provisions of Article 124 of the Ionising Radiation Protection and Nuclear Safety Act (ZVISJV-1).

Key items of policy described in the currently applicable National Programme (ReNPRR16–25) include:

- Radioactive waste and spent fuel shall be managed in such a manner as to ensure an acceptable level of protection of human health and of the environment.
- The amount of radioactive waste generated during operation and decommissioning of facilities is to be kept to the minimum that is reasonably practicable in terms of both activity and volume. This should be achieved through the use of appropriate design and construction measures, as well as through re-use and processing techniques (see also Article 121 of the Ionising Radiation Protection and Nuclear Safety Act (ZVISJV-1)).
- Operations relating to the management of radioactive waste and spent fuel shall be undertaken in accordance with the National Programme and in a manner that takes into account the interdependencies of all management stages from generation to disposal. (see also Rules JV7, Article 6).
- The costs of the decommissioning and of the predisposal and disposal programmes for nuclear fuel cycle waste and spent fuel must be borne by the funds accumulated from levies paid on the generation of power from the Krško NPP.
- Spent fuel from the operation of Krško NPP since the start of commercial operations in 1983 has been stored in pools at the power plant. A dry storage facility is under construction on the site, with the aim that dry storage arrangements will be used for interim storage of all past and future spent fuel arisings, pending geological disposal. There is a “dual track” strategy for disposal of SF and HLW from the the Krško NPP, which considers both a multinational disposal option and the reference option of national geological disposal. The earliest date for disposal under a national programme is estimated to be 2065, more than twenty years after the current planned closure date for the power plant, while the design lifetime of the dry store is 100 years.
- Spent fuel from the TRIGA Mark II research reactor, which is now no longer eligible for repatriation to the USA without cost, will be stored on site until the research reactor is decommissioned, after which ARAO will assume responsibility for its safe management. As yet there is no defined strategy for final management of the fuel, but combination as part of the current dual track strategy for final disposal of fuel from the Krško NPP is one option. Costs relating specifically to the final management of spent research reactor fuel are borne by the state budget.
- Spent fuel is regarded as a usable resource material. Thus, although reprocessing of spent fuel is not currently envisaged as a central basis for strategic planning, neither is the potential future use of advanced methods for reprocessing completely excluded as a potential strategy, possibly linked to the development of multinational solutions. Spent fuel owners are required under the National Programme to monitor developments in technology and the possible opportunities they may present. Nevertheless, even if waste

volumes may be reduced substantially as a result of reprocessing, the National Programme recognises that the requirement for a policy of geological disposal remains.

- Nuclear fuel cycle wastes will be disposed of either to the disposal facility that has recently been approved for construction at Vrbina, or (in the case of wastes not suitable for disposal to this facility) disposed of as part of the geological disposal programme for spent fuel. The current National Programme requires that the Vrbina repository should have the capacity to enable the disposal of “*any kind of LILW generated in Slovenia, except for small quantities of long-lived or other waste*”. This includes waste from decommissioning of the TRIGA Mark II research reactor. ‘Other waste’ in this context refers principally to wastes arising in the period after the planned closure of the Vrbina facility.
- Radioactive wastes and disused sources from institutional generators of waste and holders of radioactive material are collected for storage at the Central Storage Facility, operated by ARAO. In so far, as such wastes cannot be recycled or reused, they will (subject to confirming compliance with acceptance criteria for the Vrbina disposal facility) be co-disposed with nuclear fuel cycle wastes. Funding is provided by fees paid on the transfer of wastes to ARAO (which subsequently takes over responsibility), with any additional costs borne by the state budget.
- Radioactive waste containing naturally occurring radionuclides from the operation of the Žirovski Vrh mine are held within the Jazbec disposal site for mine tailings and the Boršt disposal site for hydrometallurgical tailings. The Jazbec site is closed and is subject to long-term control and maintenance as a national infrastructure facility under the responsibility of ARAO. The Boršt site is being prepared for closure. Once this has been authorised it will be managed in the same way as the Jazbec site. Funding for ARAO’s activities in relation to these disposal sites is provided from the state budget.

The National Programme is currently in the process of being revised, partly in order to reflect recent changes in legislation but also to account for updated management plans regarding waste disposal and decommissioning for the Krško NPP. Updates to policy described in the draft National Programme developed for the period 2023 to 2032 include the following:

- The disposal of wastes generated in Slovenia from the operation and decommissioning of the Krško NPP shall include only that half of the wastes that is the responsibility of the Republic of Slovenia. A proposal for determining ownership of the waste was set out in 2019.
- Priority should be given to decommissioning strategies that involve immediate dismantling. Options not involving immediate dismantling shall be rigorously justified (see also JV5 Rules, Article 50(9)).

Consideration is being given, albeit still at an early planning stage, to the construction of a new reactor adjacent to the existing Krško NPP.

### **ARTEMIS observation**

Although the National Programme for Radioactive Waste and Spent Nuclear Fuel Management does not necessarily always maintain a clear distinction between the policies on which national strategy is based and the guiding principles and objectives to be observed in its implementation, it is evident that strategic plans are defined in accordance with a number of underlying policy objectives and policy-related legislative provisions. The latter reflect harmonization with IAEA Safety Standards. Among other things, there is a clear understanding of expectations relating to how the final management of different radioactive waste streams should be funded, together

with a co-ordinated policy perspective on the responsibilities for decommissioning as well as for defining and implementing strategies for final disposal. The ARTEMIS Review Team considers the process for adoption of the National Programme – first by Government and subsequently by the National Assembly – to be consistent with the objectives of GSR Part 1 (Rev. 1) Requirement 10 relating to the responsibilities of government in relation to provision for the decommissioning of facilities and management of radioactive waste and spent fuel. Development of the programme is also consistent with the objectives of GSR Part 5 Requirement 2 regarding national policy and strategy on waste management.

The review team notes that the draft National Programme for the period 2023 to 2032, currently in preparation, does not change any elements of policy to a significant extent but makes adjustments and modifications to reflect changing circumstances since the existing Resolution was adopted. Thus, for example, policy relating to the Vrbina disposal facility now clarifies that the facility is no longer intended for the disposal of those wastes from the Krško NPP that are the responsibility of the Republic of Croatia. A predisposition towards immediate dismantling in association with the decommissioning of nuclear facilities reflects updates to underlying regulatory provisions.

The ARTEMIS Review Team was informed that an energy permit has been issued by the Ministry of Infrastructure for a 1000 ( $\pm 10\%$ ) MW(e) reactor unit adjacent to the existing Krško NPP. However, this was described as being only the first of many steps (potentially involving a national referendum) before an application for authorisation to construct such a reactor might be submitted. Against this background, the review team learned that new build is not mentioned at all in the draft National Programme currently in preparation. Whilst this is clearly a matter requiring nuanced judgment, the review team considers that ARAO may wish to consider whether an objective overview of the potential implications of new build for national policy and strategy on the management of radioactive waste and spent fuel could nevertheless contribute to transparency in the broader national debate.

## **1.2. LEGAL, REGULATORY AND ORGANISATIONAL FRAMEWORK (PARTLY REFERRING TO IRRS)**

### **Slovenian position**

Fundamental aspects of the organisational framework for decommissioning and the safe management of radioactive waste and spent fuel in Slovenia include:

- The establishment in 1987 of the Slovenian Nuclear Safety Administration as an independent regulatory authority with responsibility for (inter alia) matters relating to nuclear and radiation safety, radiation practices and the use of radiation sources, with the exception of medicine and veterinary medicine. The responsibility and competence of the SNSA are defined according to the Decree on Administrative Authorities within Ministries. Funding is provided from the state budget.
- The establishment of ARAO (Agencija za radioaktivne odpadke p.o.) by Decree in 1991 as a public utility for radioactive waste management. In addition to its responsibilities relating to the disposal of wastes from the Krško NPP, ARAO was subsequently transformed into a mandatory “Service of general economic interest” in the field of radioactive waste management. ARAO is responsible for planning and providing long-term, safe and cost-effective solutions for radioactive waste and spent fuel management. The agency is authorised to manage and carry out long-term control and maintenance

of disposal sites of hydrometallurgical tailings and mine waste tailings, as well as repositories for radioactive waste and spent fuel after their closure. Since 1999 ARAO has been required to provide services for managing wastes from small waste generators in the territory of Slovenia. Since 2000, in accordance with the “polluter pays” principle, waste generators or holders of radioactive material are required to pay a fee for the takeover of waste or disused radioactive sources into the Central Storage Facility for radioactive waste at Brinje.

- The establishment of Žirovski Vrh Mine d.o.o. in 1992 as a public enterprise with responsibility for decommissioning and remediation of the uranium production site. Funding is provided from the state budget.
- The establishment in 1995 of the Fund for Financing the Decommissioning of the Krško NPP and Disposal of Radioactive Waste from the Krško NPP. This is the major source of income for the work carried out by ARAO in respect of the planning and implementation of waste disposal.
- The establishment as a limited liability company in 2003 of Nuklearna elektrarna Krško d.o.o. (NEK) under the Treaty between the Government of the Republic of Slovenia and the Government of the Republic of Croatia on the regulation of the status and other legal relations regarding investment, exploitation and decommissioning of the Krško nuclear power plant.

According to the Ionising Radiation Protection and Nuclear Safety Act (ZVISJV-1), the National Programme shall be prepared by the government ministry competent for the environment, in cooperation with the ministry competent for energy, and subsequently adopted by the National Assembly of Slovenia for a period of 10 years. ARAO is the identified responsible agency for the expert basis required to develop the national programme.

In practice, the policy and programme issues addressed by ARAO in developing the National Programme for Management of Radioactive Waste and Spent Fuel reflect the combined inputs of a range of key stakeholders with strategic planning responsibilities, including (among others):

- the Krško NPP,
- the Jožef Stefan Institute (operator of Slovenia’s TRIGA Mark II research reactor),
- the Fund for financing the decommissioning of, and waste management from, the Krško NPP,
- the Žirovski Vrh Mine d.o.o. public enterprise with responsibility for the closure of waste disposal facilities associated with the former uranium production site.

The draft Programme prepared as a result of this consultation and negotiation process is then submitted to the SNSA for scrutiny and approval before being forwarded to the ministry for further consultation (see Figure 1).

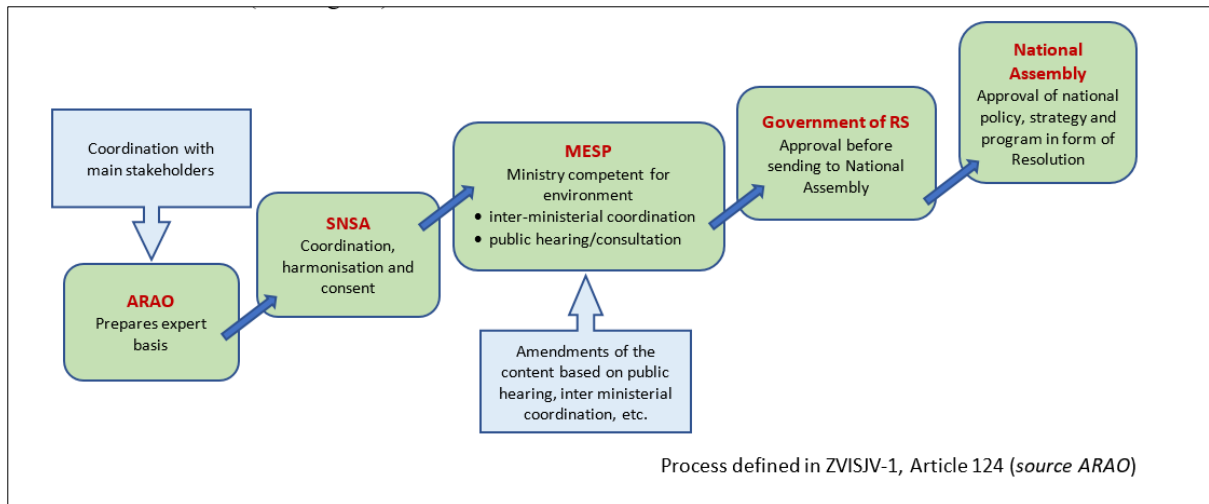
With regard to responsibilities for the nuclear power plant, there exists an *Agreement between the Government of the Republic of Slovenia and the Government of the Republic of Croatia on Regulation of the Status and Other Legal Relations Regarding the Investment, Exploitation and Decommissioning of the Krško NPP* (hereafter referred to as the Intergovernmental Agreement regarding governance of the Krško NPP). Wider policy issues addressed within the framework of this agreement include:

- Acknowledgement that decommissioning of the power plant and the management of its radioactive waste and spent fuel are the joint responsibility of the contracting parties.
- Undertaking that, in the event that agreement on a common solution cannot be found for disposal of radioactive waste and spent fuel during the originally planned operational



lifetime of the Krško NPP, the waste and spent fuel will be removed (one half by each party, bearing their own costs) within a period of two years. Similar provisions apply even to waste from decommissioning.

- Undertaking to ensure necessary funds for the preparation and execution of the decommissioning plan as well as funds to prepare and implement a programme for the disposal of radioactive waste and spent fuel.
- Preparation of a joint plan for the decommissioning of the Krško NPP, as well as the disposal of all wastes, to be updated every five years.



**Figure 1: Process for development of the National Programme for Management of Radioactive Waste and Spent Fuel**

Taken together, the allocation of responsibilities between different organisations in Slovenia, as well as the Intergovernmental Agreement regarding governance of the Krško NPP, establish an underlying framework for the development and implementation of more detailed policy and programme decisions on specific issues. The dominant importance of the Krško NPP in terms of the quantity of radioactive waste to be managed within Slovenia means that developments within the framework of the Agreement (for example, according to decisions taken during sessions of the Intergovernmental Commission responsible for its implementation, as well as the five-yearly updates of the decommissioning and waste disposal plans for the power plant) tend to have a significant impact on the National Programme.

### ARTEMIS observation

The basic legal and regulatory framework for oversight of the safe management of radioactive waste and spent nuclear fuel in Slovenia has been assessed in the recent IRRS Mission. Account has been taken of the outcomes from the IRRS Mission in assessments made by the ARTEMIS Review Team, but the legal and regulatory arrangements themselves are not addressed in the review.

Assignment of responsibilities within the national framework for decommissioning of facilities and the management of radioactive waste and spent fuel is a constituent of the provisions that need to be made by the government, in accordance with GSR Part 1 (Rev. 1) Requirement 10. The ARTEMIS Review Team considers that the organisational framework established in Slovenia is consistent with the objectives of this requirement, with legally defined roles and

responsibilities for different organisations to enable radioactive waste generated in facilities and activities to be managed in an integrated, systematic manner prior to disposal. Furthermore, the specific expectation that responsibility for maintaining institutional control after the closure of a disposal facility for radioactive waste shall be clearly assigned (paragraph 2.31 of GSR Part 1 (Rev. 1)) is clearly met by the duties assigned to ARAO, as well as the assignment of closed disposal facilities as national infrastructure facilities.

The unique arrangements regarding governance of the Krško NPP and the power plant's fundamental significance for the Slovenian national programme mean that the National Programme is drafted with consideration of decisions and documents approved by the Intergovernmental Commission. Waste disposal and decommissioning plans for the Krško NPP are updated every five years as part of the process of shared governance for the power plant, requiring both parties to the Intergovernmental Agreement between Slovenia and Croatia to coordinate their strategic programmes. Progress in implementation by both parties, as well as key decisions made at sessions of the Intergovernmental Commission, can thus have implications for both the scope and the fulfilment of the National Programme. Observations by the ARTEMIS Review Team in later parts of this mission report regarding timeframes for the national strategy of Slovenia (Section 2.2) as well as the funding of decommissioning and waste disposal (Section 6) reflect this situation to some degree.

## 2. NATIONAL STRATEGY FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT

### 2.1. SCOPE

#### Slovenian position

National strategy for radioactive waste and spent fuel management is outlined in the National Programme for Management of Radioactive Waste and Spent Fuel, in accordance with the provisions of Article 124 of the Ionising Radiation Protection and Nuclear Safety Act. The current National Programme for the period 2016 to 2025 is scheduled to be replaced by a new Programme, currently in draft form, after the conclusion of a public hearing procedure, for the period 2023 to 2032. The update to the programme reflects, among other things, a revision of key milestones in the programme, updated cost assessments, and the introduction of key indicators for performance related to the primary objectives of the strategy.

The scope of the national strategy covers the management of spent fuel and all categories of radioactive waste, including NORM wastes from former uranium mining operations. Responsibility for the implementation of planned measures rests with identified actors, under the independent regulatory supervision of the SNSA and, in so far as the strategy addresses radioactive waste management in medicine, the Slovenian Radiation Protection Authority (SRPA).

Thirteen key components of national strategy are identified in the National Programme for the period 2016 to 2025. These are:

1. Radioactive waste management during the operation of nuclear and radiation facilities. This relates to the implementation of one of the guiding principles for the radioactive waste and spent fuel management in Slovenia, which is to keep the generation of radioactive waste to the minimum that is practically achievable, in terms of both activity and volume. Identified key actors with responsibility for implementing the strategy are the Krško NPP and the operator of the TRIGA Mark II research reactor.
2. Management of radioactive wastes generated through the use of radioactive sources in industry and research. Holders of radioactive sources are expected to endeavour to ensure that radioactive waste is not generated in greater quantities than is required for the implementation of their activities. Radiation sources are to be returned to suppliers or manufacturers. Where this is not possible, they are to be taken over by ARAO on the payment of a fee. ARAO is responsible for ensuring that appropriate treatment, conditioning and storage is undertaken.
3. Radioactive waste management in medicine. Radioactive waste generated by activities involving unsealed short-lived sources is subject to decay storage until it has decayed below clearance levels defined by prescribed criteria and may be discharged. Users of sealed radiation sources in medicine follow the same procedures as for users in industry and research.
4. Construction and operation of the Vrbinja repository. This concerns the construction of the repository as well as the disposal of the current inventory of the Central Storage Facility for radioactive waste at Brinje as well as that half of the Krško NPP operational waste inventory that is the responsibility of Slovenia, as soon as possible. This initial phase of operation will be followed by a standby phase, after which the repository will subsequently be used for the disposal of remaining operational and decommissioning wastes from the Krško NPP and the TRIGA Mark II research reactor, as well as for the

institutional waste arisings. Identified key actors are ARAO (construction and operation of the repository) and the Krško NPP (conditioning of its own wastes for disposal).

5. Spent fuel and HLW storage and disposal. Spent fuel is stored in the spent fuel pool at the Krško NPP before being transferred to the spent fuel dry storage facility, currently under construction. ARAO undertakes the work necessary to follow a dual-track policy regarding geological disposal (see Section 1.1) until a decision is taken on the specific solution to be implemented.
6. Decommissioning of the Krško NPP. The decommissioning program for the power plant is envisaged to be periodically reviewed in accordance with the Intergovernmental Agreement relating to its governance, and with regard to applicable Slovenian legislation and regulations.
7. Decommissioning of the TRIGA Mark II research reactor. The decommissioning program for the research reactor is to be maintained and reviewed in accordance with applicable Slovenian legislation and regulations regarding periodic safety review. Options for the final management of spent fuel are to be investigated.
8. Decommissioning of the Central Storage Facility for radioactive waste. Operation of the Central Storage Facility by ARAO will be maintained for as long as it is required, subject to continued authorization. When such use is completed, the facility will be decontaminated and handed over for other purposes.
9. The Jazbec and Boršt disposal sites at the former Žirovski Vrh Mine. At the Boršt mine site for the disposal of hydrometallurgical tailings, necessary works were implemented, but a regulatory decision related to the final closure of the site is awaited. As with the Jazbec disposal site, it will then be subject to long-term control and maintenance as national infrastructure facilities, managed by ARAO.
10. Management of radioactive waste containing naturally occurring radionuclides. Materials that contain naturally occurring radionuclides, arising as a result of industrial processes, are monitored by the SNSA with regard to their impact on the population and environment. Remedial actions are taken if permissible impacts are exceeded.
11. Releases of radioactive substances. The discharge of radionuclides into the environment as liquid or gaseous effluent is carried out in accordance with prescribed limits for individual nuclear or radiation facilities, as authorised by the SNSA and the SRPA.
12. Legislative and institutional framework and research and development to support implementation of the Resolution on the National Programme. The state is to maintain and update the legislative and institutional framework as required, ensure that the necessary research and development is undertaken to support implementation of the national programme, and provide implementation to the public on progress with implementation of the programme.
13. Plans for the period after the closure of repositories. The areas of closed repository sites will become national infrastructure facilities. Any necessary long-term environmental control and maintenance, including interventions if required, will be undertaken by ARAO under the administrative supervision of the SNSA.

In addition, a fourteenth component to the national strategy is identified in the draft update of the national programme for the period 2023 to 2032. This refers to:

14. Radioactive waste management in response to a nuclear or radiological emergency. The strategy is primarily developed for the management of radioactive waste arising as a result of an emergency at a nuclear power plant, but can also be adapted for application in the event of other radiological emergencies. Guidelines for the management of radioactive waste in such situations are to be periodically updated and supplemented by ARAO.

All components of the national strategy have defined sources and methods of financing.

With regard to the principle of transparency, information provision and public participation, the Republic of Slovenia complies with the principles of the Aarhus Convention. Transparency is ensured through public information strategies and by drawing attention of relevant interested parties to the possibility of participation. This includes participation in the formulation of the National Programme itself.

### **ARTEMIS observation**

The National Strategy for Slovenia is based on a broad and comprehensive analysis of activities relating to the management of radioactive waste and spent fuel. It encompasses the operation of existing facilities and activities (e.g., driving the continued minimisation of waste generation, in terms of both activity and volume) and as well as strategic plans and goals for the implementation of significant items of infrastructure required for long-term safe handling of waste and spent fuel.

The strategy is based on an analysis of the current situation, reflecting consideration of current and expected inventories, existing and planned facilities and activities, cost estimates and funding arrangements, human resources and research and development needs. It also considers the changes in the wider context for waste management in terms of broader national policy and interactions with the Republic of Croatia regarding governance of the Krško NPP. Comparing the existing National Programme with its draft replacement under the coordination of ARAO indicates a responsiveness to changing circumstances based on input from a range of key stakeholders with responsibility for different elements of the strategy.

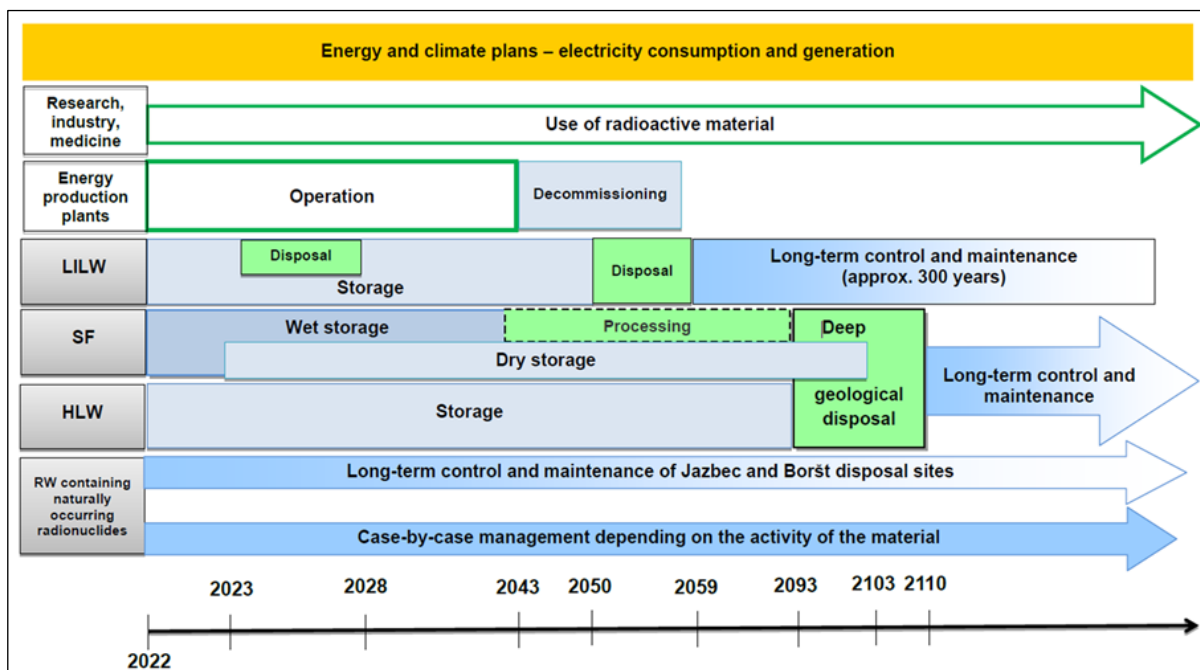
The ARTEMIS Review Team notes that the legally defined schedule for updating the National Programme for Management of Radioactive Waste and Spent Fuel is every ten years. The draft replacement currently in preparation is intended to be applicable for the period 2023 to 2032, and is therefore being produced for adoption by the National Assembly two to three years ahead of the required date. Such an approach is understood to reflect a flexible approach to ensuring that policy and programme adapt to changing circumstances.

## **2.2. MILESTONES AND TIMEFRAMES**

### **Slovenian position**

Key milestones relating to the construction, operation and decommissioning of specific facilities and development activities are listed in the National Programme for the period 2016 to 2025. These are in the process of being updated as appropriate in the draft Programme for the period 2023 to 2032. The draft update presents key timelines, adjusted to bring them into line with national programmes and strategies relating to economy, research and energy, according to Figure 2 below. Such considerations are the planned end of electricity generation at the Krško NPP in 2043, as well as the assumed continued operation of the TRIGA Mark II research reactor until at least 2024 (possible extension to 2043).

Other components of the national strategy are not linked to specific milestones, in so far as they relate to ongoing or cyclical activities and measures rather than development programmes.



**Figure 2: Timeframes of the National Programme**

Major milestones identified in the draft National Programme for the period 2023 to 2032 are:

- Construction of the Vrbina disposal facility between 2022 and 2024;
- Start of trial operation of the Vrbina disposal facility in 2024;
- First phase of disposal of Slovenian waste from the Krško NPP waste storage facility between 2024 and 2027;
- Wet storage of spent fuel at the Krško NPP until 2048 (five years after the cessation of reactor operation);
- Second disposal phase for Slovenian waste from the Krško NPP (including waste from decommissioning) between 2050 and 2058;
- Operation of the Krško NPP waste storage facility until 2050;
- Start of the expected 10-year operation of a geological repository for disposal of HLW and spent fuel in 2093. The specific method to be followed is dependent on the outcome of the “dual track” approach to selecting a preferred strategic solution.
- Dry storage of spent fuel on the site of the Krško NPP until 2103 (sixty years after the cessation of reactor operation). Fuel may be transferred earlier if an accelerated strategy for geological disposal is followed.

### **ARTEMIS observation**

The ARTEMIS Review Team was informed that it was determined by the Intergovernmental Commission in 2019 that joint solution to the disposal of Low and Intermediate Level Waste (LILW) from Krško NPP was not possible, meaning that each country must take care of its share by 2025 (although the option of a multinational disposal facility for spent fuel and HLW remains open).

For that half of the wastes that is the responsibility of Slovenia, removal from the Waste Storage Building is contingent on the construction and licensing of the Vrbina repository for disposal operations. For the other half, removal is contingent on the implementation by Croatia of a strategy to enable the wastes to be transferred to interim storage within the country. It is

understood that uncertainties remain regarding whether either of these routes will be available at the necessary time. This is partly due to delays in the process of developing and authorizing construction of the Vrbina repository, including selection of the construction contractor, and also to other decisions with regard to waste handling and the availability of a suitable storage facility. The ARTEMIS Review Team was informed that, according to the agreed division of the waste packages between the two countries, and recognising the logistics of how they would need to be removed from the Waste Building (last in, first out), the first batch to be removed is the responsibility of Croatia. Meanwhile, the Waste Storage Building itself is already filled to very near full capacity.

Regardless of commitments made under the Intergovernmental Agreement, the ARTEMIS Review Team is aware of the importance to both parties of maintaining the safe operation of the Krško NPP, in part through providing for handling and storage of operational wastes. According to information provided by the Counterpart, further negotiation between the parties to the Intergovernmental Agreement may be needed in order to identify creative solutions for ensuring that safe operation is maintained while at the same time keeping focus on commitments to the removal of waste from the power plant. The waste management programme of the Republic of Croatia is outside the scope of this peer review, and the review team is in no position to identify findings relevant to Croatia. With regard to Slovenia's programme, however, the ARTEMIS Review Team considers it important to ensure that the quality of disposal arrangements is not compromised by possible efforts to accelerate construction of the Vrbina repository once the final go-ahead has been received.



## RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES

**Observation:** *The proposed draft National Programme for Radioactive Waste and Spent Fuel Management for the 2023–2032 period indicates that the waste disposal to the Vrbinja disposal facility is planned to start by the end of 2024. Construction of the Vrbinja disposal facility has not started yet.*

(1)	<p><b>BASIS: GSR Part 5 Requirement 6 states that</b> “<i>the interdependences among all steps in the predisposal management of radioactive waste, as well as the impact of the anticipated disposal option, shall be appropriately taken into account</i>”.</p>
(2)	<p><b>GSR Part 1 (Rev. 1) Requirement 7, para. 2.18 states that</b> “[...] <i>The government shall ensure that there is appropriate coordination of and liaison between the various authorities concerned in areas such as: [...]</i></p> <p><i>(5) Management of radioactive waste (including government policy making and the strategy for the implementation of policy); [...]</i></p> <p><i>(10) Land use, planning and construction; [...]</i></p> <p><i>This coordination and liaison can be achieved by means of memoranda of understanding, appropriate communication and regular meetings. Such coordination assists in achieving consistency and in enabling authorities to benefit from each other’s experience.”</i></p>
R1	<p><b>Recommendation:</b> <b>The Government of Slovenia should coordinate all stakeholders in the National Programme to find mutually acceptable waste management solutions addressing legal agreements and physical constraints on continued waste storage that do not jeopardise the quality of final disposal arrangements at the Vrbinja repository.</b></p>

Aspects of the “dual-track” policy and strategy for the development of long-term solutions for spent fuel and HLW are discussed in more detail in Section 4 of this report. The ARTEMIS Review Team notes, however, that the draft update for the period 2023 to 2032 takes as its central case the assumption that geological disposal (in one form or another) will not take place before 2093. This differs from the timescale in the current programme, where such a facility was assumed to be available from 2065 (now described as the “accelerated” variant).

One possible aspect of planning for a significantly later date may be the theoretical advantage of increased accruals to the disposal fund (provided that its investments continue to perform better than inflation in the cost basis). Furthermore, it could be considered to open up greater opportunity for solutions that are tailored to the specific needs of a country such as Slovenia. Moreover, there are evident advantages, not least for a relatively small organisation such as ARAO, associated with ensuring that the development and initial operations of the Vrbinja disposal facility are prioritised.

On the other hand, a very long development period requires justification against the principle (expressed in the National Programme) of managing radioactive waste and spent fuel in such a way as not to transfer burdens – not only in terms of cost, but also responsibility for continued safe operation of dry storage arrangements, as well as implementing the disposal programme



itself – on future generations. This underlines the importance of identifying how strategic R&D activities undertaken over (say) the next five or ten years are expected to support progress in identifying and ultimately implementing a preferred concept (see also Section 7).

## **2.3. PROGRESS INDICATORS**

### **Slovenian position**

The draft National Programme for the period 2023 to 2032 introduces detailed key performance indicators for evaluating progress for each of the component strategies identified in Section 2.1, with the aim of encouraging good practice and supporting the timely identification of a possible need for corrective measures.

Progress monitoring is otherwise carried out through an annual review of the implementation of the different component strategies. Once a year, the SNSA collects and verifies information from individual implementers regarding their respective measures and incorporates this in the Annual Report on Radiation and Nuclear Safety in Republic of Slovenia. This report is then submitted by the government to the National Assembly for approval. The report highlights the effectiveness of the implementation of measures to achieve strategic objectives and indicates possible improvements as an input to preparing updates of the national programme.

The operator of a radiation or nuclear facility is required under the JV7 Rules on radioactive waste and spent fuel management to prepare and maintain an action plan that must include measurable and verifiable performance indicators for planned processes and methods to achieve reductions in the generation of waste quantities and other impacts arising from radioactive waste and spent fuel. The plans are to be reviewed every two years. Implementation of the plans is verified as part of the SNSA's regulatory review.

### **ARTEMIS observation**

The ARTEMIS Review Team notes that the draft of the new edition of the National Programme introduces performance measures for each and every element of what is, as noted above, a broad range of component strategies, covering both ongoing activities and development activities. The review team encourages the use of appropriate indicators by ARAO and the Government to review the effectiveness of programme delivery against the different elements of the national strategy.

The application of performance indicators to ongoing or cyclical activities would normally be particularly appropriate if they were applied against the background of expectations regarding a progressive improvement in performance, rather than simply indicating that basic expectations are fulfilled. In a number of cases, the indicators developed for such activities within the draft programme would not appear to differ substantially from standard compliance with regulatory requirements. Achieving set milestones, such as the updating of programmes and documents according to a set cycle for ongoing activities, is likewise an indicator that targets are being achieved, but not necessarily that progress is being made. One potential approach might be to focus most attention on the definition of performance indicators on those aspects of strategy where progress is required or expected, or where particular problems need to be solved, even if this means that not all “strategy components” are covered.

Nevertheless, the ARTEMIS Review Team considers that the process of reporting on progress in strategy implementation to the National Assembly via the SNSA's Annual Report is a

significant and commendable aspect of transparency in so far as it provides a regular opportunity for insight into long-term programmes of work.

### 3. INVENTORY OF SPENT FUEL AND RADIOACTIVE WASTE

#### Slovenian position

The main generator of radioactive waste in Slovenia is the Krško NPP. Radioactive waste is also generated in industry, research and medicine.

According to the Advance Reference Material prepared by the counterpart, the national scheme for the classification of solid radioactive waste in Slovenia is adopted within the JV7 Rules on radioactive waste and spent fuel management. The categories and subcategories of solid radioactive waste, for which an equivalency table with IAEA's classification (Safety Guide GSG-1) has been provided, are presented below:

1. Transitional radioactive waste
2. Very low-level radioactive waste (VLLW)
3. Low activity and intermediate activity radioactive waste (LILW), which is further classified into:
  - 3.1 short-lived LILW, where the specific activity of the contained alpha emitters, having a half-life exceeding 30 years, is equal to or lower than 4000 Bq/g in any individual package but in no case greater than 400 Bq/g on average in the overall amount of LILW; and
  - 3.2 long-lived LILW, where the specific activity of alpha emitters exceeds the limitations applying to short-lived LILW
4. High-level radioactive waste (HLW)
5. Radioactive waste containing naturally occurring radionuclides.

Radioactive waste from uranium ore excavation and processing at the former Žirovski Vrh mine is disposed in the Jazbec disposal site for mining tailings and the Boršt disposal site for hydrometallurgical tailings. The Jazbec site, with a total activity of 21.7 TBq, was closed in 2015 and has since then been managed by ARAO. The Boršt site, with a total activity of 48.8 TBq, is currently under the responsibility of the uranium mine licensee and will be passed on to ARAO's responsibility once a safety analysis report (expected in 2022) proving that the site can be safely closed has been authorised by SNSA.

LILW (defined according to the classification scheme above) is generated by the operations of Krško NPP, from the TRIGA Mark II research reactor and from institutions (medicine, R&D and industry). Approximately 90% of the LILW comes from the Krško NPP and is stored in the waste storage building on the NPP site. This waste is owned in equal parts (in terms of both activity and volume) by Slovenia and Croatia and is planned to be finally disposed in each country, after being conditioned in N2d containers (for Slovenia) or RCC containers (for Croatia). The remaining 10% of the LILW, including operational waste from the TRIGA research reactor, is stored at the Central Storage Facility for radioactive waste located at Brinje.

The Krško NPP waste storage building, operated by NEK d.o.o. (a joint venture between publically owned Slovenian and Croatian energy companies), is at almost full capacity. In recent years, the volume of LILW stored at the nuclear power plant has gone through volume reduction methods, helping to maintain the total volume in storage between 2200 and 2300 m<sup>3</sup> during the period from the year 2000 to 2020, set against a total capacity of 2350 m<sup>3</sup>. Some storage space was also relieved by transferring equipment from the waste store to another building (the Waste Manipulation Building). Furthermore, regardless of the available capacity within the waste building, LILW packages stored at the NPP need to start being retrieved before 2025, as stated in the Intergovernmental Agreement between Slovenia and Croatia regarding governance of the Krško NPP.

The Central Storage Facility for radioactive waste at Brinje, operated by ARAO, is filled to approximately 80% of authorised capacity (90 m<sup>3</sup> of solid waste for a total capacity of 115 m<sup>3</sup>). This does not raise any immediate concern since a gross total of only about 3 m<sup>3</sup> are foreseen to require being taken into storage each year, and the use of volume reduction methods will reduce this volume. Furthermore, part of this waste will be sent to the Vrbina disposal facility during its first phase of disposal operations (currently foreseen in 2024-2027). Disused sealed radiation sources represent 96% of the stored activity.

As far as spent fuel at the Krško NPP is concerned, 1323 spent fuel assemblies are currently stored in the spent fuel pool, which has a capacity of 1383 assemblies. It is planned that 592 spent fuel assemblies (16 casks) should be transferred in 2023 to a dry storage facility, for which completion of construction is expected during 2022. A further 592 spent fuel assemblies are planned to be transferred to the dry storage facility in 2028. There is no spent fuel currently in storage at the TRIGA Mark II research reactor.

The national inventory is updated annually with the reference date being the last day of the year. This reporting includes new waste generated and any changes in previously recorded wastes. ARAO and NEK compile and maintain the radioactive waste inventory of their respective storage facilities using software packages and submit their data electronically to a national register of radioactive waste that is kept and maintained by the SNSA. Data provided by the waste generator is subject to internal (at the storage location) and external verifications (by the SNSA through inspections, and by ARAO in compiling inventories for safety assessment). The conditioning of waste is not reported explicitly. Volumes of processed and unprocessed wastes are, however, reported separately; where waste has yet to be conditioned, the planned treatment method is also recorded. Radiation sources held by radiation practices and by health and veterinary care providers are maintained on a public register by the SRPA.

Estimates of future waste arisings are based on the expected annual rates of waste generation, on the planned lifetime of facilities and on their decommissioning plans, where such estimates have been included in the plans. When such information is not available, ARAO bases its estimations on benchmarking against similar facilities in other countries with a nuclear programme. A preliminary estimate of the toxic inventory has been derived for the LILW that is intended for disposal to the Vrbina repository.

Slovenia acknowledges that the inventory of the already conditioned LILW packages currently in storage at the Krško NPP and within the Central Storage Facility for radioactive waste at Brinje present some uncertainties in terms of content of long-lived radionuclides, some of which are very difficult to measure and can typically only be estimated after applying scaling factors based on more easily measurable radionuclides such as cobalt-60 or caesium-137.

### **ARTEMIS observation**

The processes for maintaining the inventory in Slovenia is mature and all wastes currently held at facilities within the country have been characterized. The use of an electronic reporting system means that data needs only to be entered into the system once and this reduces the possibility for errors.

The ARTEMIS Review Team noted that the division of Slovenia's "LILW" category into "short-lived" and "long-lived" sub-categories within the radioactive waste classification system reflects the adoption by the country of the European Commission recommendation of 1999 and that the waste class dedicated to the category "long-lived LILW" (class 3.2) was neither associated with currently stored waste, nor to any specific waste management route other than geological disposal. The review team was informed that, if such waste were to be generated in

the future or identified within the stored LILW following further characterization, it would be managed in conjunction with the spent fuel intended for geological disposal as HLW.

The ARTEMIS Review Team considers that the identification of a waste class that is not associated to a specific waste route can bring confusion and that Slovenia's waste classification system could benefit from being simplified, as in IAEA's waste classification system for instance. In any case, it would be prudent to ensure that plans exist for the continued safe storage of any waste in the current LILW category that is not suitable for disposal at the Vrbina facility until a geological disposal route becomes available.

The ARTEMIS Review Team recognizes the undertakings and work carried out by the licensees to establish and declare the radioactive waste inventory of each nuclear and radiation facility and the good process followed by the SNSA to maintain this inventory at a national level. The ARTEMIS Review Team also considers that the estimations of waste arisings are based on sound data and that international benchmarking has been used in a satisfactory way to complement these estimations.

Based on analysis of the inventory of the LILW packages stored at Brinje and at the Krško NPP, ARAO is confident that the disposal packages to be produced (in N2d containers) will meet the waste acceptance criteria derived from the Vrbina facility's safety assessment. One of these requirements relates to the limitation of alpha emitting radionuclides in each individual package to 4000 Bq/g. However, the activities of these radionuclides are not provided in the waste packages record sheets because of the difficulties involved in their measurement. According to the IAEA Safety Standard SSR-5 Requirement 20, the waste packages accepted for emplacement in a disposal facility shall conform to criteria that are fully consistent with, and are derived from, the safety case for the disposal facility in operation and after closure. The team therefore suggests that ARAO should consider further developing its guidance on satisfactory approaches to demonstrating compliance with the Vrbina facility's waste acceptance criteria in relation to the preparation of waste packages for disposal.

## RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES

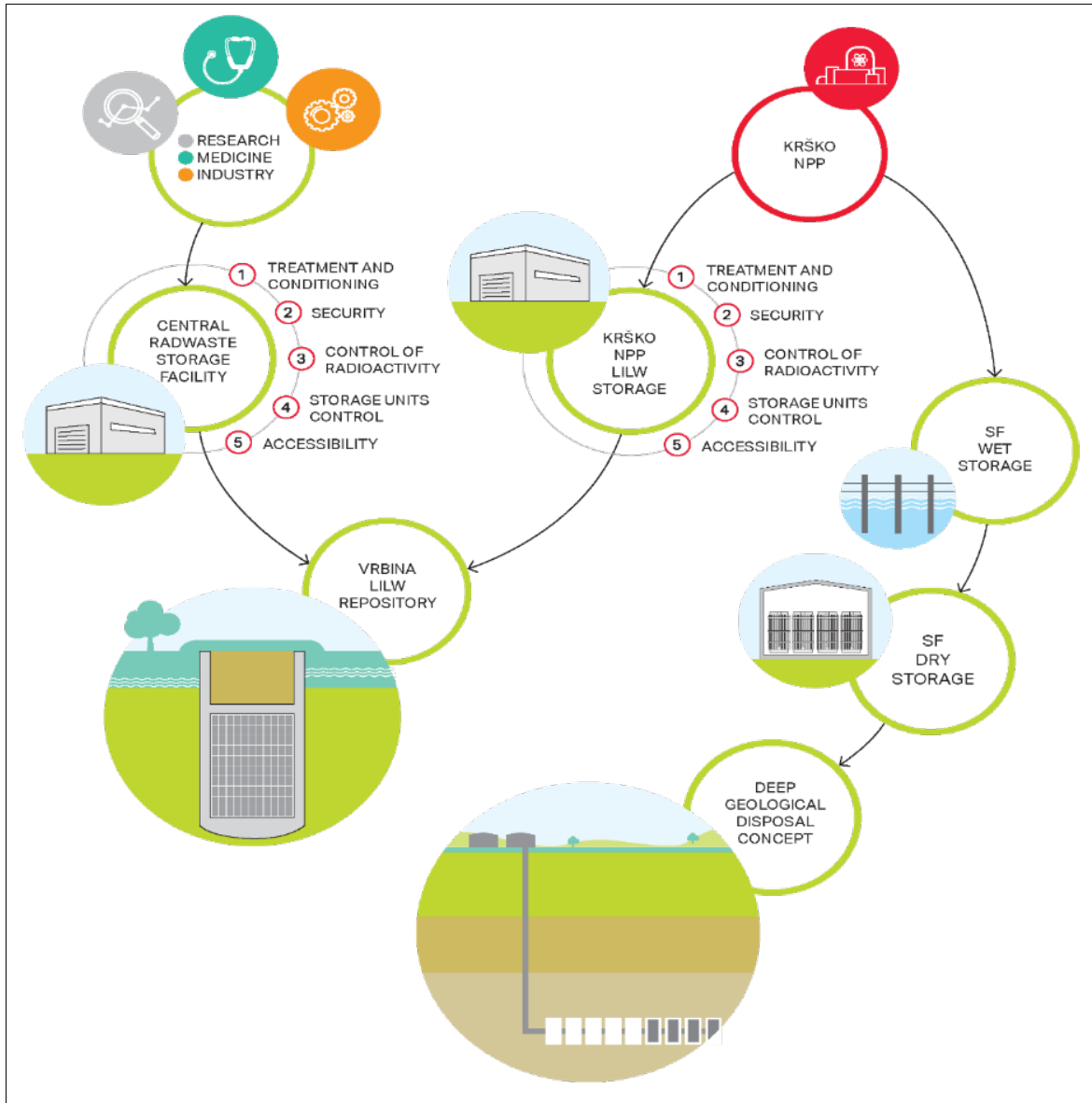
**Observation:** *Some of the long-lived radionuclides contained in the waste packages cannot readily be measured and must therefore be estimated. The method of estimation must provide sufficient confidence that the waste acceptance criteria for disposal are met.*

(1)	<b>BASIS: GSR Part 5 Requirement 6 states that</b> “ <i>the interdependences among all steps in the predisposal management of radioactive waste, as well as the impact of the anticipated disposal option, shall be appropriately taken into account</i> ”.
(2)	<b>BASIS: SSR-5 Requirement 20 states that</b> “ <i>waste packages and unpackaged waste accepted for emplacement in a disposal facility shall conform to criteria that are fully consistent with, and are derived from, the safety case for the disposal facility in operation and after closure</i> ”.
S1	<b>Suggestion:</b> ARAO should consider further developing guidance on the approach to demonstrating compliance of the packages prepared for disposal with the waste acceptance criteria that have been derived from the Vrbina disposal facility’s safety assessment.

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

##### Slovenian position

Slovenia has defined the technical solutions through to final disposal that it will use to manage all of the different wastes for which it has responsibility. This management scheme is illustrated in Figure 3 below.



**Figure 3: The scheme for management of radioactive waste in Slovenia**

Two disposal routes are planned:

1. A silo-type near surface disposal facility to be constructed at the Vrbina site, which will take the majority of the low activity and intermediate activity short-lived waste in the Slovenian inventory.

2. A geological repository for high level waste, including spent fuel to be declared as waste, together with any small volumes of other wastes that, because of their particular radiological characteristics or time of arising, cannot be disposed of to the Vrbina disposal facility.

Pre-disposal management follows two separate approaches, depending on the origin of the waste:

1. Institutional wastes arising from research and development, industry and medicine, which are managed by ARAO, processed as appropriate, and then stored at the Central Storage Facility for radioactive waste at Brinje;
2. Wastes arising from the Krško NPP operation, which are managed by the NPP operator and conditioned and stored at the NPP site.

#### *Central Storage Facility for radioactive waste (CSF)*

Institutional wastes from medicine, research and development and industry are collected by ARAO from their point of arising, processed for volume reduction purposes where appropriate, and then placed into interim storage. The CSF for institutional wastes is situated at Brinje, on the site of the Jožef Stefan Institute, about 10 km north east of Ljubljana. It has been operating since 1986 and has been managed by ARAO since 1999. It is a relatively small facility, approximately 10 m x 25 m in plan area, and 3.5 m high. There is a small entrance area and a separate machinery area at the back of the building that houses the filters for the ventilation system. The storage area is split into sections with internal walls. In almost all sections, processed waste is stored in metal drums on metal frames.

Particular endeavours are made to pursue opportunities for waste volume minimisation and one section is used for the temporary storage of waste awaiting processing. The facility is currently filled to about 80% of capacity but annual volumes of waste being generated are low and storage capacity is therefore not a critical issue.

There are processes in place for checking each stage in the management process, from collection of waste through processing to ongoing monitoring of its condition in storage.

Re-use of materials (including assisting the holders of sources to arrange for return to manufacturers) has been actively pursued. An example is the export of disused smoke detectors for recycling and reuse of the isotopes abroad, which ARAO has been implementing for the last few years. Depleted uranium was also exported for recycling in the past, but this option is currently unavailable.

An arrangement is in place for use of the nearby hot-cell facility at the Jožef Stefan Institute for waste processing. Volume minimisation of solid wastes accepted for storage is achieved primarily through dismantling to remove non-active components. Liquid wastes are solidified, and cutting equipment is available for downsizing larger items.

The operating licence for the CSF needs to be renewed every 10 years under arrangements for periodic safety review. The current licence runs until 2028. Several documents support the licence, including the safety case which covers normal operations and emergency conditions.

#### *Krško NPP Waste Management*

There are facilities on the Krško NPP site for the management of gaseous, liquid and solid wastes. A new Waste Manipulation Building was completed in 2018, which has enhanced the arrangements for waste management and, in particular, supported reduction of waste volumes for storage.



Gases generated during operation are treated using standard nuclear power plant gas management techniques and are then released slowly to the atmosphere. There is no need for scheduled discharge of larger gas quantities.

The liquid waste system collects material for re-use or discharge. Wastes are analysed and released, reused or kept for further processing. Since the late 1990s, volume reduction via evaporation, drying and filtration has been used extensively for liquid wastes.

Solid wastes arise directly or as a result of earlier processing. They are sorted and segregated as far as possible at the point of generation and then dried, if needed. Techniques such as supercompaction, incineration and melting are also used for volume reduction. Some of these services are carried out overseas. Where possible, segregation at source is used to support free release of materials that might otherwise be classified as radioactive waste.

There are written procedures controlling all operations, which are assured both internally and externally, through organisations such as WANO.

As a consequence of this focus on waste minimisation through active pursuit of re-use and minimisation opportunities, the waste volumes generated at the Krško NPP are considered to be relatively very low.

The waste storage building on NPP site is licensed by the SNSA as part of the overall authorization for the nuclear power plant. This building contains all the solid waste that has been generated since the start of operation of the NPP and is now very close to capacity. The volume of waste in store can only be reduced once the disposal facility is operational, or through the removal of those wastes (half of the total volume) that are owned by Croatia.

#### *Vrbina disposal facility*

The planned disposal facility for low activity and intermediate activity short-lived wastes is to be built at Vrbina, close to the Krško NPP site. This project has been delayed but construction is expected to start later in 2022. The surrounding area is largely flat, and the geology has a syncline form and is covered with permeable quaternary sediments (gravel) overlying low-permeability Miocene-sealed layers that extend to a depth of around 500 m. The water table in the quaternary lies approximately 5-7 metres below the ground surface. Water movement at depth is of the order of 2 mm per year. At the surface, flow rates in the aquifer are approximately 20 km per year (in the region of 1 mm per second).

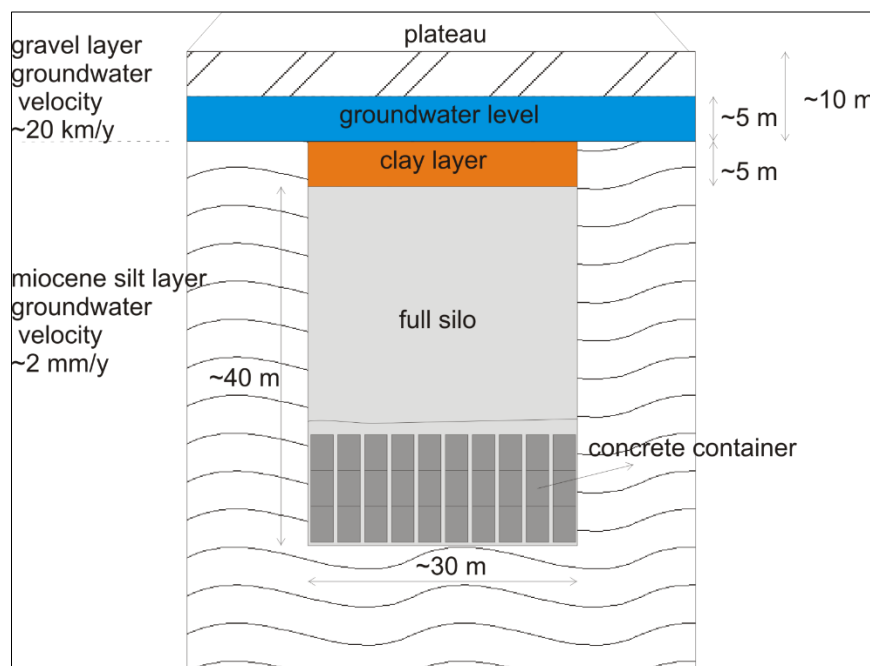
The facility will consist of a waste silo together with minor buildings at the surface providing technology and administrative facilities. The silo will have a 1.5 m concrete ring to a depth of almost 70 metres as well as secondary lining that is about 1 m thick. The deepest disposal horizon will be about 55 m below the surface. A schematic of the design is shown in Figure 4.

The safety case in support of construction was approved in early 2022 and there is a plan to begin construction in 2022. Once construction is complete, there will be a trial operational period requiring authorization from the SNSA before a full operational licence can be issued.

Waste will be overpacked for disposal in concrete N2d containers. The current design envisages use of a container which is about 3 m high, and this allows for flexibility in packing different types and sizes of waste drums. Any space between the drums will be filled with grout. Waste will be transferred to disposal depth and positioned within the silo using a crane. A maximum of 99 disposal containers will be positioned in each layer within the silo. Once two layers of containers have been emplaced, the space around them will be filled with grout. The silo is designed to have a capacity of 990 N2d containers. The most recent inventory estimate suggests that the total number of containers required for disposal of all Slovenian waste from the Krško

NPP, together with institutional waste from the CSF and decommissioning of the TRIGA Mark II research reactor will be around 950.

Emplacement of waste will take place in two main campaigns. Once the waste currently in store has been disposed, there will be a period of much lower activity until final decommissioning of the nuclear power plant. During this standby (idle) phase, all the infrastructure at the site will be maintained. Following the second campaign, consisting primarily of the emplacement of decommissioning waste, a concrete lid will be installed, followed by clay layer. The closed facility will be a concrete monolith, thus providing stability against possible disruptive earthquake events.



**Figure 4: Schematic of the silo design of the Vrbinja disposal facility**

### *Spent nuclear fuel storage*

Spent nuclear fuel at the Krško NPP is currently stored under water at the plant. A new dry store is currently about 70% complete. The final design of the store was selected following an options study and an open tender exercise.

The safety concept is based on a US design but has required modification in order to comply with the requirements of Slovenian regulations and local community demands. The main adaptation is that, although the concrete waste containers were originally designed for outdoor storage, they will be housed in a building. The building provides a degree of extra shielding and protection. The store has capacity for 70 containers. However, current estimates are that only 62 containers will be required. Waste transfer from the reactor pond is scheduled to start in 2023. Further campaigns have yet to be scheduled.

### *Spent nuclear fuel disposal*

The estimated date in the draft of the updated National Programme for availability of a geological disposal facility for spent fuel or HLW is 2093. An alternative strategy involving earlier disposal assumes that disposal could begin in 2065. Planning for disposal is at a preliminary stage, with a variety of strategic options and implementation variants under consideration. Work to date has mainly focussed on consideration of the costs of

implementation, in order to support the basis for determining payments to the waste disposal and decommissioning fund.

A reference design has been developed for a single disposal facility for all the fuel from the Krško NPP. The design was based on the Swedish KBS-3V concept and assumed access to the facility via a drift or ramp, with a nominal transport distance from Krško of 200 km, since no candidate locations have been identified. A number of design variants have also been considered, including change in the spacing of disposal tunnels according to different thermal properties of the host rock, the effect of alternative disposal depths, and use of shaft access rather than drift access. The post-closure monitoring that would be required under Slovenian regulation was also included in the plans.

The basic components of the dual track approach in the Slovenian strategy are the possibility of construction of a geological repository within the territory of Slovenia, or alternatively the utilization of disposal services provided by a multinational facility. The latter approach is being pursued through participation in the ERDO Association. Within these two primary options, a range of variants is being considered for comparison purposes, including:

- Alternative dates for the start of disposal (2065 or 2093)
- Construction of the repository in alternative geological formations (crystalline or sedimentary rocks)
- The development of a market for advanced reprocessing techniques to enable recovery of the usable resources from spent fuel
- Deep borehole disposal, in which spent fuel and/or HLW would be disposed of in thin-walled containers at depths in excess of 1500 m

Progress with the appraisal of the primary options as well as the variants for implementation is reviewed every five years.

#### *Mine waste disposal sites*

ARAO also has responsibility for post-closure monitoring of a uranium mine tailings disposal site at Jazbec, associated with the former Žirovski Vrh uranium mine, about 45 km west of Ljubljana. Extraction of ore took place in the period 1982 to 1990. The initial closure of the mine was temporary but soon became permanent and the mine closure was completed in 2006. Remediation of the mine tailing site was completed in 2015 and the site was then authorised for closure. The conditions of closure required an extended period of long-term control and maintenance which is being carried out by ARAO. Funding for this activity is provided from state funds and ARAO is required to report regularly to the SNSA and the local community. The conditions at the site are stable and with discharges and estimated public exposures below regulatory limits.

A hydrometallurgical tailings site associated with the former mine exists at Boršt, near the Jazbec site. The tailings were disposed of on an area that was later found not to be stable. In 1990, after very heavy rains, a landslide occurred within the bedrock underneath the disposal body, at a depth of about 50 metres. This affected a significant fraction of the disposal body and led to displacements within the cap. Work to stabilise the tailings body was carried out and a drainage system installed. In 2008, during intensive work on the implementation of the final arrangement of the hydro-metallurgical tailings, the landslide was reactivated. Additional remediation measures have been installed to divert water flows within the bedrock. Moreover, observation and control indicate that stability has been improved, while estimated public exposures from the effluent are within regulatory limits for members of the public.

Various scenarios have been evaluated to consider potential evolution of the system, including the complete collapse of disposal site and spreading of tailings. Once an updated safety report

has been formally accepted by the SNSA, the site will be authorised for closure. Long-term control and maintenance will become the responsibility of the state, undertaken by ARAO. The planned work will include maintenance of drainage channels, measurements of effluent and ground stability and annual reporting to the public and the regulator.

### **ARTEMIS observation**

Waste management and spent fuel management activities in Slovenia are well-planned and implemented. The proposed disposal solutions included in the baseline plan are appropriate for the wastes to which they apply and are consistent with a graded approach.

The processes for management of institutional waste are mature and appear well-managed. There are checks at each stage of the process. Waste volumes on an annual basis are small and generally stable or slightly decreasing with time. The work and achievements associated with using the waste hierarchy are particularly commended by the review team as they demonstrate active pursuit of opportunities for re-use of materials, and minimisation of residual waste volumes across all waste types. The shared use of the hot cells at the research facility represents efficient use of facilities and will, in turn, contribute to reduced volumes of decommissioning wastes once the facilities are finally decommissioned.

Facilities within the Waste Manipulation Building at the Krško NPP are relatively new, having been completed in 2018. They, together with other initiatives involving reduction at source as well as overseas treatment methods, enable the waste management at the site to be particularly efficient. Overall, innovation in waste treatment and space planning at the site has been effective in recent years in enabling continued operation of the plant despite the fact that storage facilities on the NPP site are almost full.

Plans for deep geological disposal are at a comparatively early stage of development, which the ARTEMIS Review Team considers appropriate, given the planned date of implementation. The consideration of a range of potential options is appropriate for an early stage and the inclusion in the most recent draft national programme of a formal Key Performance Indicators (KPI) on assessment of alternatives is considered to be very helpful. However, it is not clear when or on what basis the selection of the preferred strategy will be made. It is therefore suggested that decision criteria be developed to aid assessments geared towards the identification of a preferred strategic option.

The plans described by ARAO to deliver their role in institutional control of the closed sites relating to historical mining activities appear proportionate.

## RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES

**Observation:** *ARAO is considering a range of potential options for HLW and spent fuel disposal. There is no information regarding when and on what basis the selection of the preferred option will be made.*

(1)	<b>BASIS: GSR Part 2 Requirement 10 states that:</b> <i>“Processes and activities shall be developed and shall be effectively managed to achieve the organization’s goals without compromising safety.”</i>
(2)	<b>BASIS: SSR-5 Requirement 4 states that:</b> <i>“Throughout the process of development and operation of a disposal facility for radioactive waste, an understanding of the relevance and the implications for safety of the available options for the facility shall be developed by the operator. This is for the purpose of providing an optimized level of safety in the operational stage and after closure.”</i>
S2	<b>Suggestion:</b> <b>ARAO should consider further developing decision criteria to facilitate selection of a preferred disposal strategy for HLW and spent fuel.</b>

## RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES

**Observation:** *Waste minimisation opportunities are proactively pursued for all waste types in Slovenia.*

(1)	<b>BASIS: GSR-5 Requirement 8, para. 4.8 states that</b> <i>“The reuse and recycling of materials has to be applied to keep the generation of radioactive waste to the minimum practicable, provided that protection objectives are met.”</i>
GP1	<b>Good practice:</b> <b>The commitment to proactive pursuit of a wide range of opportunities for waste minimisation across all radioactive wastes in Slovenia is exemplary.</b>

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

### Slovenian position

The safety demonstrations of the radioactive waste and spent fuel management facilities in Slovenia rely on the development of safety assessment reports, environmental impact assessments and emergency preparedness. The general contents expected of the safety analysis reports, which are subject to periodic reviews, are provided in the JV5 Rules. Effective management systems are aimed for and the use of a graded approach is permitted.

#### *Vrbina disposal facility*

A safety report, corresponding to the construction application, was provided by ARAO in final version in 2021. Based on important site studies and a detailed conceptual silo design, safety evaluations were carried out for the operational and post-closure phases of the facility and used to derive preliminary waste acceptance criteria as well as limits on long-lived radionuclides.

For the operational phase, a list of postulated initiating events was selected, leading to the identification of design basis accidents and beyond design basis accidents consisting of fire, package drops, airplane crash followed by an explosion and fire, terrorist attack and earthquake. The possibility of defects in the silo's barriers leading to uncontrolled inflow from the aquifer into the silo was assessed in design development, and the measures in place (in particular drainage arrangements) were demonstrated to be sufficient to manage such an event without having implications on the disposal facility's safety.

Safety during the post-closure phase of the Vrbina facility was assessed following the IAEA ISAM methodology: a list of safety functions and SSCs are identified and a list of altered scenarios, including early failure of the engineered barriers, surface erosion, changes in hydrological conditions and inadvertent intrusion, were derived from a selected list of FEPs and assessed.

The assessment of the normal and altered scenarios for the operational and post-closure phases of the Vrbina facility shows that the regulatory dose limits to workers and the public are respected. Doses to non-human biota have been evaluated. This safety assessment report was first given a positive opinion from an external expert organisation, in accord with regulatory requirements for independent review. The SNSA then approved and issued preliminary consent relating to radiation and nuclear safety in 2021 as part of the procedure for issuing an environmental consent. The SNSA's final consent for the construction was issued in early 2022. At the time of the mission, the authorization process for construction was awaiting final decisions relating to above-ground infrastructure.

#### *Central Storage Facility for radioactive waste*

For the Central Storage Facility for radioactive waste at Brinje, operated by ARAO, a safety demonstration was last revised in 2018. It notably relies on the defence in depth principle and on passive safety functions of most SSCs. HAZOP and SAFRAN safety assessment tools were used and lead to the identification of postulated initial events and to the assessment of accident scenarios such as package drop, fire, airplane crash, power outage, lightning strike, earthquake, human intrusion and drum corrosion. The conclusions of the evaluations show that the impacts associated with these scenarios would be acceptable.

#### *HLW and SF disposal*

Regarding the planned HLW and SF disposal facility, for which ARAO is responsible, a concept of geological repository based on the Swedish KBS-3V disposal concept in hard rock was introduced in 2004. The preliminary safety evaluation in 2009 associated with this project includes a performance assessment based on generic data (literature and experience from other projects) which are partly consistent with Slovenia's environmental conditions. ARAO's plan is to derive a safety case based on real data once a site is chosen and characterized in several decades.

#### *Uranium mine wastes*

In the case of the uranium mine and mill tailings disposal sites, the final safety report for the Jazbec site was developed by Žirovski Vrh uranium mine d.o.o. as operator of the disposal site mine facilities in 2015 and was in 2019 amended by ARAO and approved by the SNSA. Meanwhile for the Boršt site, where environmental remediation has been completed, a safety report for closure authorization is expected to be submitted to the SNSA in the near future by the public company RŽV d.o.o. as owner of the mine facilities. If the safety report supports formal closure of the disposal site, it will be handed over to ARAO for long-term control and maintenance.

#### **ARTEMIS observation**

The safety demonstration of Slovenia's waste management facilities relies on safety assessment reports which are available for all facilities.

The contents of the safety assessment reports for the Brinje and Vrbina facilities, which were presented to the ARTEMIS Review Team, appear to be developed at a sufficient level of detail with regards to their safety level and stage of development. The ARTEMIS Review Team recognized the quality of these safety assessments which notably make use of safety assessment tools that are widely used internationally and follow IAEA guidance for scenario development.



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

### Slovenian position

#### *Cost estimation*

Estimates for the cost of management of wastes for which Slovenia has responsibility have been developed following the methodologies set out in guidance from the IAEA and other international bodies (OECD/NEA, IGD-TP, EURAD) and have been benchmarked by comparison with experience from other infrastructure projects in Slovenia as well as from countries with more advanced experience in waste disposal projects and decommissioning. The scope of the estimates includes all the activities associated with waste management including:

- costs of decommissioning, as well as the storage and disposal of low activity and intermediate activity short-lived wastes and spent fuel;
- costs such as the operational costs of the Waste Management Organisation;
- costs for compensation payments related to restricted land use;
- costs of fees for land access or land purchase.

The cost for each activity is developed using a ‘bottom-up’ approach, based on the detail of work breakdown structure developed for each activity. The resulting estimates are presented in a series of detailed tables to allow scrutiny and comparison. The estimated costs (capital and overnight) are grouped according to their nature (e.g., construction and equipment), and the time at which they will be incurred (siting, construction, operation, decommissioning, closure, long-term control). A contingency is recognised, where appropriate. Projected annual costs have been derived throughout.

For the NPP wastes, cost estimates are performed separately for Slovenia and Croatia, in order to enable the specifics of each programme, for example the different choices in terms of container design and disposal schedule, to be reflected accurately.

For ongoing activities, such as operation of the storage facility at Brinje, future costs are estimated based on historic and current information on actual expenditure and consideration of future demand for these activities. Costs associated with future activities are necessarily less certain and have been based on information available for similar infrastructure construction projects in Slovenia and similar nuclear facilities overseas.

The estimated decommissioning costs for the TRIGA Mark II reactor have been based on those for a similar facility in Finland, which is already in the process of decommissioning. The costs of deep geological disposal of spent fuel are based on estimates derived for the Swedish KBS-3V disposal concept which has been used as a reference case, with appropriate assumptions for the Slovenian situation in respect of parameters such as waste volumes, packaging and geological conditions.

Institutional control of closed radioactive facilities is a legal requirement in Slovenia. The costs of this activity are estimated based on operational monitoring costs and future requirements of the post-operating control of radioactivity and long-term surveillance.

#### *Financing arrangements*

Fees are paid by the institutional waste generators to ARAO for taking charge of spent sources that cannot be returned to the supplier, and for other wastes. The fees are levied at the point of waste collection. The price of the various services is published and is updated every 5 years. A provision for the costs of processing and storage is included in the fees. Support for regular



operation of the store, as well as final disposal cost, is not fully covered in the waste management fees but is supplemented by the state budget.

ARAO is also supported from the state budget in respect of its costs for providing expert support to the state when drawing up strategic and planning documents relating to radioactive waste and spent fuel management, long term control and maintenance of closed disposal sites (currently Jazbec, later also Boršt and in the longer term closed disposal facilities), as well as other mandated tasks.

Some funding is also provided to ARAO from international bodies such as the EC and IAEA as part-funding for international activities, such as collaborative R&D.

Under the terms of the Intergovernmental Agreement regarding governance of the Krško NPP, the owners of the power plant make financial contributions for decommissioning and waste management according to levies set by their respective governments on the production of energy. A dedicated fund has been established in Slovenia and a parallel fund has also been established (albeit at a later date) in Croatia. Both cost estimates and fund performance are reviewed regularly.

In Slovenia, the payment was initially fixed at 0.3 Euro cents per kWh. By the decision of Slovenian Government, the payments were subsequently increased to 0.48 Euro cents per kWh, starting August 1st 2020. In January 2022, the payments to the Slovenian NEK fund was further increased to 1.20 Euro cents per kWh in order to ensure that sufficient inputs to the fund would be made in coming years, partly as a result of projections relating to fund performance.

The fund in Slovenia is subject to a number of rules and regulations. The assets from the fund can be used solely for:

- financing of preparation and execution of projects of safe and final disposal of SF and RW from the Krško NPP,
- financing of preparation and execution of the project for safe decommissioning of the Krško NPP,
- payment of compensation to local authorities for restricted land use for the repository for SF and RW from the Krško NPP until its closure in accordance with the Decree on the criteria for determining the compensation rate due to the restricted use of areas and intervention measures in nuclear facility areas,
- financing of services of ARAO in the performance of the mandatory service of general economic interest of disposal of SF and RW from the Krško NPP.

The Fund's operations are supervised by the Slovenian Government, which must give its consent to the Fund's investment policy, financial plan, the annual accounts as described in the annual report on the Fund's operating activities. 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 operations,
- the Fund is led by the Management Board, appointed by the National Assembly of the Republic of Slovenia, the Government of Slovenia and the local authorities,
- the Supervisory Board oversees the work of the Director and the Management Board and reports to the National Assembly of the Republic of Slovenia.

Consistent with international practice and the requirements of the Joint Convention, the Slovenian government stands as the financier of last resort.

### **ARTEMIS observation**

It is clear that Slovenia sets high importance on ensuring that there is sufficient financial provision for the safe management of its radioactive waste, right through to the closure of all final disposal facilities. Slovenia has developed detailed cost estimates for all of the activities necessary for the safe management of its radioactive wastes, to the point of disposal and beyond by also incorporating requirements for institutional control once the facility has been closed. These estimates have been developed using the methods recommended in international guidance. 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.

There are clear processes for funding the required activities in decommissioning and waste management based on the ‘polluter pays’ principle. Funds collected 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 finance will be available when required. There are processes in place for updating the fees to ensure that they are sufficient, considering the updates in both cost estimates and fund performance.

A potential risk, recognised by the Slovenian authorities, is inevitably related the multinational ownership of the nuclear power plant. Finance for activities that must be carried out in Slovenia is provided on part by funds under the control of the Croatian Government. If this funding were not to be maintained, or if unforeseen expenditures were to be incurred, there is a potential risk of shortfall in financial provision that would be, at least in part, out of the control of Slovenia.

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

### **Slovenian position**

Within Slovenia, there are estimated to be about 30 full-time equivalents (FTE) with specific technical expertise in radioactive waste and spent fuel management. A number of the individuals who hold this expertise work on radioactive waste management as only part of their role and so the total number of individuals with some technical experience is significantly more than 30. These skills are held either at the operator, regulator, research or technical support organisations. Capacity building is differently organised at different institutions.

Slovenian regulation requires that the investor or operator of a radiation or nuclear facility shall have a capability plan and that this plan must be updated every 10 years. A formal gap analysis is performed as part of this plan. For ARAO, the most recent plan was published in 2021. There are currently 22 employees at ARAO and, within this number, the specialist technical expertise totals about 15 FTE. The current capability plan projects an increase in employment up to 40, to allow for the operation of the new disposal facility, to perform maintenance and long-term control at the Boršt disposal site, and to pursue options for the management of spent fuel and HLW.

The increase in personnel required to deliver ARAO's additional responsibilities, has relatively recently been added to the 5 years program that is awaiting government approval. Within the regulatory body, an increase in staff numbers is not possible as there are restrictions on the number of public employees in Slovenia.

ARAO is a mandatory general economic interest public utility service, and the number of employees is defined by the Government. At present, there are four organisational units and several independent services, including the QA/QC Service and the Radiation Protection Service. ARAO has a qualified staff who perform all phases of institutional radioactive waste management as a mandatory service of general economic interest and a staff competent to manage the licensing phase for the LILW repository, where subcontractors are also involved in performing specialised tasks.

In 2012 the Slovenian Government suspended recruitment in the public sector. This downward trend over the past few years halted at the end of 2018 and in 2019 as the number of employees increased by four staff working in the field of the Vrbina repository project.

ARAO has a clear strategy on the capacity building and training of the new employees. There is a budget foreseen for the education and training of new personnel. However, recruitment of staff with the necessary technical skills and experience has proved challenging as there is significant competition for technical skills from other industries. Therefore, ARAO adopted a strategy of employing younger professionals who have been involved in specialised professional training courses and other types of education. In the last few years, special attention has been devoted to the professional development of employees working in the field of the Vrbina repository project.

Staff obtain both national and international training. Training is mandatory on joining the organization and there is further training whenever an individual moves to a new role within the organization. Ongoing professional development is provided through participation in training courses, workshops, seminars and conferences in order to maintain the high quality of the team and its outputs. Staff turnover is low and so ARAO has a solid body of experienced employees with a long-term career at ARAO. In the following years some retirements are foreseen, but the age profile of the employees means that these will be only within the

administrative support functions. Recently, the government has approved employment of some additional personnel.

The SNSA, with 41 permanent employees across all areas of responsibility at the end of 2021, has a “systematic approach to training” system aimed at ensuring competences and optimising the training and internal organisation of the Safety Administrations. Updates on job positions, required tasks and competences is done annually during career planning interviews. However, the total number of staff is strictly limited by the Government. The state budget is the only source of financing for the SNSA’s basic activities. The SNSA has its own share of the Ministry’s budget and is independent in allocating funds for programmes, projects and other expenses from its budget. However, the Safety Administration has a limit on new employments and the staff allocated to the authorization, review, regulations and guides relating to radioactive waste and spent fuel is very small. Future activities related to radioactive waste disposal and spent fuel will be very intense and adequate regulatory guidance is necessary.

#### *RD&D activities*

Slovenia is currently in the early stages of setting up a long-term programme of research, development and demonstration (RD&D) activities concerning radioactive waste and spent fuel management. RD&D activities are described within the draft Resolution on the National Programme for Radioactive Waste and Spent Fuel Management for the 2023–2032 Period. They are to be carried out for all phases of radioactive waste and spent fuel management, from the generation, processing, treatment, storage to disposal, as well as for the long-term control and maintenance of closed repositories. The decree secures funding on long term basis: 5-year long-term programs and 2-year business plan. ARAO monitors international development and participates in working groups within the international alliances and membership of Slovenia in international organisations in the field of reprocessing, disposal and operation of radioactive waste repositories.

In the draft national programme for the period 2023 to 2032, Strategy 12 defines the measures for the implementation geared towards RD&D activities, as well as KPI’s for their monitoring. These are:

- *The state ensures that RD&D activities are carried out in radioactive waste and spent fuel management through ARAO or as part of a wider research programme implemented in accordance with this radioactive waste and spent fuel management programme and the Nuclear and Radiation Safety Resolution – continuously; and*
- *Every 3 years, ARAO draws up a programme for RD&D activities in radioactive waste and spent fuel management and includes it in the long-term programme for a period of five years. The Government of RS ensures the adoption and adequate financing for the execution of the long-term programme.*

ARAO is involved in the EC EURAD Project as a participant and they also nominated TSO partners and third parties for specific work packages that were relevant for Slovenian situation. The topics were related for example to research on concrete. In the second EURAD wave, ARAO has decided to participate only as an end user due to other priorities related to the Vrbinja disposal facility.

#### **ARTEMIS observation**

There are good plans in place for the recruitment and training of staff with the necessary technical skills for the safe management of radioactive waste within Slovenia. The formal requirement for a skills plan is helpful in this respect.

Within ARAO, the approach of using ARAO staff to deliver most of the key responsibilities and having only limited reliance on subcontractors also provides robustness in terms of retaining key skills and knowledge within the organisation. Nevertheless, the ARTEMIS Review Team notes that ARAO has a wide range of responsibilities for the current size of organization. The ARTEMIS Review Team notes that the strategic plan for human resources is awaiting government approval.

The approach of recruiting young professionals and then training them within ARAO is both innovative and effective in providing the necessary skills in a competitive labour market. The ongoing commitment to professional development is also valuable.

The resource constraint on public sector employment has the consequence that the SNSA has to limit its activities and to prioritise only those tasks which it is able to deliver within its headcount and budget. This limitation was highlighted in the recent IRRS mission, but the ARTEMIS mission has identified that the situation is of particular concern with regard to the regulation of waste management, not least in view of the increasing scope of the national programme, with a number of critical milestones and objectives to be addressed within the next five years.

ARAO set out a list of its planned research, development and demonstration activities in the Resolution on the National Programme for Radioactive Waste and Spent Fuel Management for the 2023–2032 Period. The review team considers that the approach of gaining the experience by participating in international collaborative projects is effective in terms of expenditure and staff resource. It ensures that knowledge is transferred and exchanged in the international environment and participate in joint RD&D activities that directly benefit Slovenian projects while enabling Slovenian researches to contribute to European progress in this field.

The review team observes that the current emphasis of the R&D programme is on the short term needs, e.g. related to the Vrblina disposal facility and suggests that there is a structured periodic update of internal and strategic objectives aligned with future short and long term strategic needs, e.g., choices related to the options of the disposal of high level waste and spent fuel.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
<b>Observation:</b> <i>ARAO has provided in the draft National Programme a description of past and current research, development and demonstration activities. The emphasis in the objectives is on short term needs.</i>	
(1)	<b>BASIS:</b> SSR 5 Requirement 3, para. 3.13 states that “ <i>The operator has to conduct or commission the research and development work necessary to ensure that the planned technical operations can be practically and safely accomplished, and to demonstrate this. The operator likewise has to conduct or commission the research work necessary to investigate, to understand and to support the understanding of the processes on which the safety of the disposal facility depends. [...]</i> ”
S3	<b>Suggestion:</b> ARAO should consider periodically updating internal and strategic objectives, aligned with future short and long term strategic needs, for the various elements of the RD&D programme.

## RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES

**Observation:** *The scope of the programme for management of radioactive waste and spent fuel is increasing, with a number of critical milestones and objectives to be addressed within the next five years.*

(1)	<b>BASIS: GSR Part 1 (Rev. 1) Requirement 10 states that:</b> “ <i>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.</i> ”
S4	<b>Suggestion:</b> The Government should consider the particular human resource needs of both the SNSA and ARAO in meeting their responsibilities for safe management of radioactive waste and spent fuel.

## **APPENDIX A: TERMS OF REFERENCE**

# **ARTEMIS Review of Slovenia's National Programme on Radioactive Waste and Spent Fuel Management**

## **Terms of Reference**

### **1. Introduction**

After initially requesting in January 2018 a combined IRRS ARTEMIS mission, the Slovenian Nuclear Safety Administration eventually requested on 23 September 2019 the IAEA to organize a back-to-back IRRS ARTEMIS mission.

Slovenia requested the ARTEMIS review 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 that request, the ARTEMIS review will be carried out in May 2022 in a coordinated manner with the IRRS mission, scheduled in April 2022. The given ARTEMIS review will be organized in the IAEA by the Department of Nuclear Safety and Security and the Department of Nuclear Energy.

### **2. Objective**

The ARTEMIS review, performed by an international peer review team selected by the IAEA, will provide an independent international evaluation of Slovenia's radioactive waste and spent fuel management programme, based on the relevant IAEA Safety Standards and proven international practices.

### **3. Scope**

The given ARTEMIS review will evaluate the Slovenian national programme and the national framework for executing country's obligations for safe and sustainable radioactive waste and spent fuel management. In addition, the review will address the new draft national policy and programme covering the period 2023 to 2032.

The outcomes from the 2022 IRRS mission to Slovenia will be taken into account, where relevant and appropriate to avoid unnecessary duplication in line with the Reference Guidelines on the Preparation and Conduct of IRRS-ARTEMIS back-to-back Missions, applicable for situations when an IRRS mission is hosted before an ARTEMIS mission. These guidelines do not substitute IRRS and ARTEMIS guidelines, respectively, but supplement them with the specific provisions that need to be taken into account while conducting back-to-back missions.



#### 4. Reference material

The review will cover all documentation submitted by National Counterpart for the considered 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 mission, National Counterpart will include in the reference material the sections of the IRRS Reference material relevant to the ARTEMIS mission (specific parts of the 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.

It must be noted that for IRRS-ARTEMIS back-to-back missions, identified overlaps will be addressed only by one mission, either IRRS or ARTEMIS, depending on the scope and nature of each one of them. As such, 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 the **Annex 1** (such a 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 mission will be English.

The National Counterpart is ARAO. The National Counterpart Liaison Officer for the review is Mr Leon Kegel.

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

- Self-assessment: questionnaire was made available to Slovenia as of **March 2021**.
- Preparatory Meeting: **18 November 2021 (WebEx meeting)**.
- The reference material (in English) and the results of the self-assessment questionnaire will be provided to the IAEA as soon as they are available and not later than **22 March 2022**.
- Questions based on the preliminary analysis of the reference material and the self-assessment results will be provided by the review team by **8 May 2022**.
- Peer review mission: **22 to 30 May 2022 (9 days)**:
  - Sunday: arrival of experts and their meeting.
  - Monday to Wednesday: interviews/exchange/discussion with Counterparts on the basis of preliminary analysis and drafting of recommendations and suggestions.

- Thursday: drafting of the report - finalization of recommendations and suggestions - delivery of recommendations/suggestions/good practices – fact checking by Counterparts.
- Friday: discussions of recommendations and suggestions with the Counterparts - drafting of the report and delivery to the Counterparts (Review Team).
- Saturday: fact checking of draft report by Counterparts - internal reflection of comments by Review Team - discussions with the Counterparts.
- Sunday: finalization of draft report by Review Team.
- Monday: delivery of final draft report – exit meeting – closure.

## **6. International peer review team**

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

- Five 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 a common 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 successfully participate in both IRRS and ARTEMIS missions.
- Two IAEA staff, to coordinate the mission. The Coordinator of the ARTEMIS review is Mr Gerard Bruno from the Waste and Environmental Safety Section of the Department of Nuclear Safety and Security. The deputy coordinator is Ms Felicia Nicoleta Dragolici from the Waste Technology Section of the Department of Nuclear Energy.

One IAEA staff for administrative support. A senior member of IAEA staff from the Department of Nuclear Safety and Security will oversee the closure of the review meeting.

The peer review team will be led by a Team Leader, assisted by a Deputy Team Leader, comprising from the review team as defined in the ARTEMIS draft guidelines. The Team Leader will be Mr Michael Egan, SSM, Sweden. The IAEA will inform the National Counterpart regarding the composition of the proposed review team prior to submission of reference material.

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 must be agreed by the National Counterpart in advance to the mission.

## **7. Reporting**

The findings of the peer review will be documented in a final report that will summarise the proceedings 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 organization or Member State or the IAEA.

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

## **8. Funding of the peer review**

The cost estimate for the ARTEMIS review includes travel costs, per diem of the peer review team (external experts and the IAEA staff) in line with the IAEA Financial Regulations and Rules.

The cost of the ARTEMIS review is estimated to the amount of 30 000 EUR. The cost of the mission will be covered by Slovenia in one part by direct extra budgetary contribution to the IAEA (TC) and for the other part through the Slovenian National Project of the Technical Cooperation Department of the IAEA. Slovenia is aware that the review cost includes 7% programme support costs.

If the actual cost of the ARTEMIS review exceeds the estimated costs (30 000 EUR), then it would be assessed, if there are still funds on the Slovenian National Project to cover these excess costs. If there are no such funds, Slovenia agrees to cover such excess costs.

**These Terms of Reference have been agreed between the IAEA and the Slovenian ARAO during the preparatory meeting held on-line on 18 November 2021.**

## **Annex 1**

### **List of reference material provided by the counterpart**

- Responses to the ARTEMIS Self-assessment Questionnaire
- Resolution on National Programme for Managing Radioactive Waste and Spent Nuclear Fuel for period 2016-2025 (ReNPRRO16-25)
- new draft of the Resolution on National Programme for Managing Radioactive Waste and Spent Nuclear Fuel for period 2023-2032 (ReNPRRO23-32)
- Third revision of the NPP Krško Decommissioning Program
- Third Revision of the Krško NPP Radioactive Waste and Spent Fuel Disposal Program
- Relevant regulations and legislation
- 7th Joint Convention National Report
- Specific parts of IRRS Self-assessment report dealing with radioactive waste and spent fuel management
- Draft IRRS mission Report

## APPENDIX B: MISSION PROGRAMME

Time	Sun, 22 May	Mon, 23 May	Tue, 24 May	Wed, 25 May	Thurs, 26 May	Fri, 27 May	Sat, 28 May	Sun, 29 May	Mon, 30 May	
8h30 – 10h00	Arrival of Team Members	<b>9h00 Opening</b>  General presentation  Feedback on IRRS findings (legal and regulatory aspects of RW and SF management)	Inventory  Concepts, Plans and technical solutions	Cost estimates and financing	Session reserved for further discussions if required/ drafting of the report	<b>9h00 – 11h00 Presentation and discussions of Recommendations and Suggestions with the Counterparts</b>	Drafting of the report  <b>Draft report to be sent to the Counterparts</b>	<b>Xh00 Internal reflection of comments xh00 Discussions with the Counterparts on the draft report</b>	Delivery of final draft report  <b>EXIT MEETING</b>	
10h00 - 12h00		National Policy and Framework								
12h00 - 13h00		Lunch	Lunch	Lunch	Lunch	Lunch	Lunch	Lunch		
13h00 – 16h00		National Strategy	Safety case and safety assessment	Capacity building	<b>Finalization of Recommendations and Suggestions</b>	Drafting of the report	Counterparts review the draft report	Finalising draft report		Departure of Team Members
16h30 - 17h30		Team meeting	Team meeting	Team meeting						
	19h00 Artemis team meeting (dinner)	Drafting of the report	Drafting of the report	Drafting of the report	Drafting of the report					

**APPENDIX C: RECOMMENDATIONS AND SUGGESTIONS**

<b>Area</b>		<b>R: Recommendations S: Suggestions G: Good Practices</b>	<b>Recommendations, Suggestions or Good Practices</b>
2.	<b>NATIONAL STRATEGY FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT</b>	<b>R1</b>	<b>The Government of Slovenia should coordinate all stakeholders in the National Programme to find mutually acceptable waste management solutions addressing legal agreements and physical constraints on continued waste storage that do not jeopardise the quality of final disposal arrangements at the Vrbina repository.</b>
3.	<b>INVENTORY OF SPENT FUEL AND RADIOACTIVE WASTE</b>	<b>S1</b>	<b>ARAO should consider further developing guidance on the approach to demonstrating compliance of the packages prepared for disposal with the waste acceptance criteria that have been derived from the Vrbina disposal facility's safety assessment.</b>
4.	<b>CONCEPTS, PLANS AND TECHNICAL SOLUTIONS FOR SPENT FUEL AND RADIOACTIVE WASTE MANAGEMENT</b>	<b>S2</b>	<b>ARAO should consider further developing decision criteria to facilitate selection of a preferred disposal strategy for HLW and spent fuel.</b>
		<b>GP1</b>	<b>The commitment to proactive pursuit of a wide range of opportunities for waste minimisation across all radioactive wastes in Slovenia is exemplary.</b>
7.	<b>CAPACITY BUILDING FOR RADIOACTIVE</b>	<b>S3</b>	<b>ARAO should consider periodically updating internal and strategic objectives, aligned with future short and long term strategic needs, for the various elements of the RD&amp;D programme.</b>

Area	<b>R: Recommendations</b> <b>S: Suggestions</b> <b>G: Good Practices</b>	<b>Recommendations, Suggestions or Good Practices</b>
<b>WASTE AND SPENT FUEL MANAGEMENT – EXPERTISE, TRAINING AND SKILLS</b>	<b>S4</b>	<b>The Government should consider the particular human resource needs of both the SNSA and ARAO in meeting their responsibilities for safe management of radioactive waste and spent fuel.</b>



## **APPENDIX D: LIST OF ACRONYMS USED IN THE TEXT**

ARAO – Slovenian Agency for Radioactive Waste Management

CSF – Central Storage Facility for radioactive waste

HLW – High Level Waste

IAEA – International Atomic Energy Agency

IRRS – Integrated Regulatory Review Service

KPI – Key Performance Indicator

NEK – Nuklearna elektrarna Krško, the operating company for the Krško NPP

RD&D – Research, Development and Demonstration

SF – Spent Fuel

SNSA – Slovenian Nuclear Safety Administration

SRPA – Slovenian Radiation Protection Authority

## 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).