

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

## **MISSION TO CROATIA**

*Zagreb, Croatia*

*11-19 June 2023*

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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SPENT FUEL MANAGEMENT, DECOMMISSIONING AND  
REMEDICATION (ARTEMIS) MISSION  
TO  
CROATIA**

**Mission dates:** *11-19 June 2023*

**Location:** *Zagreb, Croatia*

**Organized by:** *IAEA*

**ARTEMIS REVIEW TEAM**

Ms Amélie de Hoyos	ARTEMIS Team Leader (France)
Mr Son Nguyen	Reviewer (Canada)
Mr Peter Bennett	Reviewer (Norway)
Mr Michael Egan	Reviewer (Sweden)
Ms Amy Huntington	Reviewer (UK)
Mr David Bennett	IAEA Team Coordinator
Ms Felicia Nicoleta Dragolici	IAEA Deputy Team Coordinator
Ms Kristina Nussbaum	IAEA Admin. Assistant

IAEA-2023

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

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## EXECUTIVE SUMMARY

At the request of the Government of Croatia, the International Atomic Energy Agency (IAEA) organized an Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation (ARTEMIS) peer review mission. The review mission was hosted by the Fund for financing the decommissioning of the Krško Nuclear Power Plant and the disposal of Krško NPP radioactive waste and spent nuclear fuel (“the Fund”).

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

- Management of radioactive waste from the Krško nuclear power plant (NPP).
- Establishment of a Radioactive Waste Management Center (RWMC) in Croatia at which radioactive waste is to be stored.

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.

Following to a virtual preparatory meeting in January 2023, and the receipt and review of Advanced Reference Material in March 2023, in June 2023 the ARTEMIS Review Team met in Croatia and evaluated the Croatian national framework, including the competent regulatory authority, and the implementation of the national programme for the safe and sustainable management of spent fuel and radioactive waste.

The ARTEMIS review took note of the findings from previous IAEA Integrated Regulatory Review Service (IRRS) reviews conducted in Croatia in 2015 and 2019.

The ARTEMIS Review Team considered that the Croatian counterparts are aware of the challenges of managing the radioactive waste in the country safely and are clearly committed to addressing them.

To maintain and further improve the safe management of radioactive waste and spent fuel in Croatia, the ARTEMIS Review Team made several recommendations as follows:

- The Ministry of the Interior should initiate without delay a revision of the Strategy and National Programme to provide clarity and consistency for planning, communication and decision making, including on the roles of the relevant organizations, planning assumptions and programme milestones.
- The Ministry of the Interior should ensure that the storage facilities at the Institute for Medical Research and Occupational Health and at the Institute Ruđer Bošković are required to comply with safety requirements, including clear allocation of ownership of waste and sources, and responsibilities for safety and monitoring of the facilities.
- The Ministry of the Interior should undertake inspections of all facilities that store sources and waste, including at the Institute for Medical Research and Occupational Health and at the Institute Ruđer Bošković.

- The Ministry of the Interior should update site selection criteria for the near surface disposal facility.
- The Ministry of the Interior, in consultation with the Fund and other relevant Governmental Bodies, should enhance arrangements for the planning, monitoring and delivery of the National Programme, including measures for identifying, reporting and mitigating programme risks, and for taking corrective actions as appropriate.
- The Ministry of the Interior should complete the Central Registry of Radioactive Waste and Disused Sources and take it into use.
- The Fund should finalise waste acceptance criteria (WAC) for the RWMC storage facilities at the Čerkezovac site and submit them to the regulator for approval in a timely fashion to allow receipt and safe storage of the waste packages.
- The Ministry of the Interior should develop guidance stating regulatory expectations for safety assessments to support authorization of radioactive waste storage and disposal facilities.
- The Ministry of the Interior should require safety demonstrations to be developed for the storage facilities at the Institute for Medical Research and Occupational Health and at the Institute Ruđer Bošković.
- The Government should urgently address the human resource needs of the regulatory body in the short term for the environmental impact assessment review and licensing review for the RWMC. The government should also plan to provide sufficient human resources for future phases of the radioactive waste management programme. Planning should be provided for developing and maintaining staff competence through formal training.
- The Fund should continuously evaluate the particular human resource needs in meeting its responsibilities for safe management of radioactive waste and spent fuel, both for the short and long term. The Fund should develop a plan for staff recruitment and retention, and maintenance of competence through training and/or research, development and demonstration. That plan should be mapped to the needs, objectives and milestones of the radioactive waste management programme.

The ARTEMIS Review Team provided the following suggestions:

- The Ministry of the Interior should consider revising the waste classification in Article 4 of the Ordinance on management of radioactive waste and disused sources to provide well-defined boundaries between waste classes and to support mapping between the waste classes and disposal arrangements defined in the National Strategy.
- The Government should consider urgently providing arrangements for the safe and secure centralized storage of institutional waste in Croatia.
- The Fund should consider identifying back-up strategies for waste storage in case the disposal facility is not ready to accept the waste at the point when Croatia is obliged to accept it from the Krško NPP.
- The Ministry of the Interior, in consultation with other relevant bodies, should consider developing guidance on siting a geological disposal facility.
- The Fund should consider revising its plans to allow enough time for the development and regulatory review of the safety assessment at the level of detail that is necessary to apply for the RWMC location permit.

The ARTEMIS Review Team commended the Croatian counterparts for the professionalism displayed by all staff and the commitment to safety. Croatia is encouraged to make the review public and to take the findings of the review into account.



## I. INTRODUCTION

On 10 December 2018, Fund for financing the decommissioning of the Krško Nuclear Power Plant and the disposal of Krško NPP radioactive waste and spent nuclear fuel (“the Fund”) requested the International Atomic Energy Agency (IAEA) to organize and carry out, in the second half of 2021, an Integrated Review Service for Radioactive Waste and Spent Fuel, Decommissioning and Remediation (ARTEMIS) review. On July 2020, the Civil Protection Directorate of the Ministry of the Interior further requested IAEA to postpone the ARTEMIS mission until the first half of 2023.

Croatia’s request for the ARTEMIS mission was made to satisfy its obligations under Article 14(3) of the Council Directive 2011/70/EURATOM of 19 July 2011 establishing a Community Framework for the Responsible and Safe Management of Spent Fuel and Radioactive Waste (hereinafter the *EU Waste Directive*).

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 preparatory meeting in January 2023, and the receipt and review of Advanced Reference Material in March 2023, in June 2023 the ARTEMIS Review Team evaluated the Croatian national framework, strategy and national programme for fulfilling the country’s obligations for safe and sustainable management of spent fuel and radioactive waste.

## **II. OBJECTIVE AND SCOPE**

The ARTEMIS review provided an independent, international evaluation of the Croatian national framework, including the competent regulatory authority, and the implementation of the national programme for the safe and sustainable management of spent fuel and radioactive waste.

The ARTEMIS review was performed against 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.

The ARTEMIS review considered the management of all types of radioactive waste in Croatia.

In addition, the review addressed amendments to the National Programme for the Implementation of the Radioactive Waste, Disused Sources and Spent Nuclear Fuel Management Strategy (Programme for the period until 2025 with a view until 2060). Special emphasis was given in the review to the following: Management of radioactive waste from the Krško NPP; and Establishment of the Radioactive Waste Management Center.

### **III. BASIS FOR THE REVIEW**

#### **A) PREPARATORY WORK AND IAEA REVIEW TEAM**

A preparatory meeting for the ARTEMIS Review, was conducted on the 16th of January 2023 online. The preparatory meeting was carried out by the appointed Team Leader Ms Amélie de Hoyos, the IAEA coordinator and deputy coordinator Mr David Bennett and Ms Felicia Nicoleta Dragolici respectively, and the team of National Counterparts led by Ms Andrea Rapić from the Fund, with participation of representatives of the Ministry of the Interior.

The meeting participants had discussions regarding:

- The Terms of Reference for the ARTEMIS review.
- 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 Croatia in June 2023.

Ms Andrea Rapić was appointed as the National Counterpart for the ARTEMIS mission and designated IAEA point of contact.

Croatia provided IAEA with the Advance Reference Material (ARM) for the review on 16 March 2023.

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

The review was made in accordance with Version 2.0 of the guidelines for the ARTEMIS review service. The Croatian responses to the ARTEMIS self-assessment questionnaire were used as a key basis for the review, together with the rest of the ARM and materials presented during the review mission and the associated discussions. In accordance with the Statute of the IAEA, the ARTEMIS review was made against the IAEA Safety Standards. Other IAEA publications were considered where relevant. A list reference material used for the review is provided in Appendix E.

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

The initial Review Team meeting took place on Sunday, 11 June 2023 in Zagreb, directed by the ARTEMIS Team Leader Ms Amélie de Hoyos, the ARTEMIS Team Coordinator Mr David Bennett and the Deputy Team Coordinator, Ms Felicia Nicoleta Dragolici.

The ARTEMIS entrance meeting was held on Monday, 12 June 2023. Opening remarks were made by Mr Josip Lebegner, Director of the Fund Ms Zdravka Tečić, Head of Sector for Radiological and Nuclear Safety of the Civil Protection Directorate of the Ministry of the Interior, Ms Amélie de Hoyos, ARTEMIS Team Leader and Mr David Bennett, IAEA Coordinator.

The ARTEMIS Review Team performed its review according to the terms of reference in Appendix A and the mission programme in Appendix B.

During the ARTEMIS mission, a review was conducted for all review topics within the agreed scope with the objective of providing Croatian authorities with recommendations and suggestions for improvement and, where appropriate, identifying good practice (Appendix C).

Lists of the abbreviations and reference materials used in the review are provided in Appendix D and Appendix E. During the review, the ARTEMIS Review Team visited the Krško NPP (Appendix F).

The ARTEMIS Exit Meeting was held on Monday, 19 June 2023. A presentation of the results of the Review was given by the ARTEMIS Team Leader Ms Amélie de Hoyos. Remarks on behalf of Ministry of the Interior were given by Ms Zdravka Tečić, Head of Sector for Radiological and Nuclear Safety, Civil Protection Directorate. Remarks on behalf of Ministry of Economy and Sustainable Development were given by Mr Vjekoslav Jukić, Head of Sector for energy policy and planning. Remarks and a description of the envisaged next steps on behalf of the Fund were given by Mr Josip Lebegner, CEO of the Fund. Closing remarks were made by Ms Anna Clark, Section Head of Waste and Environmental Safety Section, IAEA.

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

## 1.1. NATIONAL POLICY

### Croatian position

The national policy of the Republic of Croatia for the management of radioactive waste and spent nuclear fuel is founded on the following key features of the national position with regard to sources of radioactive waste and spent fuel:

- There are no nuclear power plants or research reactors on the territory of the Republic of Croatia, and there is no intention to build and operate such facilities.
- The publicly-owned Energy Utility Company Hrvatska elektroprivreda d.d. (HEP), is the co-owner of the Krško nuclear power plant (NEK) situated in Slovenia, and has an obligation to pay an annual fee to the Fund for the purpose of decommissioning of Krško NPP and management of its radioactive waste including spent fuel.
- Croatia has joint responsibility with Slovenia for decommissioning and waste management relating to the power plant.
- There are two storage facilities that previously supplied a national service for low and intermediate level radioactive waste from medical, industrial and research activities in Croatia (institutional radioactive waste), located at:
  - The Institute for Medical Research and Occupational Health (IMROH), which has been closed to the receipt of wastes since 2006;
  - The Ruđer Bošković Institute for scientific research (RBI), which has been closed to the receipt of waste since 2013.
- Both facilities still contain DSRS1 and institutional radioactive waste (principally disused sealed radioactive sources, but also small amounts of other materials) produced by the activities of the institutes themselves as well as wastes collected from other users during their periods of operation.
- DSRS and institutional radioactive waste arising from medical, industrial and research activities is kept by the users on their premises since the above national storage facilities stopped receiving wastes.

National policy is intended to reflect the international obligations of the Republic of Croatia as an EU member state and as a party to relevant international conventions. Policy is documented in several national legal instruments, of which the most central are described as being:

- Strategy for the Management of Radioactive Waste, Disused Sources and Spent Nuclear Fuel, adopted by the Croatian Parliament in 2014 (“the National Strategy”).
- The National Programme for the Implementation of the Strategy for Management of Radioactive Waste, Disused Sources and Spent Nuclear Fuel, published by the Government of Croatia in July 2018, as amended in December 2022 (“the National Programme”).

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<sup>1</sup> Croatia has not declared disused sealed radioactive sources (DSRS) kept at users premises to be radioactive waste. The international safety standards regard radioactive material for which no further use is foreseen to be waste. To ensure safety, DSRS have to be managed as radioactive waste in accordance with the safety standards.

- The Act on Radiological and Nuclear Safety (“the Act”), adopted 2013 and amended 2015, 2017, 2018, 2021 and 2022.
- The Bilateral Agreement between the Government of the Republic of Croatia and the Government of the Republic of Slovenia on regulating status and other legal relations related to investment, exploitation and decommissioning of the Krško Nuclear Power Plant, 2001 (“the Bilateral Agreement”).

The National Strategy from 2014 replaced an earlier version originally drafted in 2009 that was part of the negotiations for the accession of the Republic of Croatia to the European Union, the guidelines, goals and conclusions of which were never implemented.

The National Strategy document is intended to provide a comprehensive summary of national policy for the management of radioactive waste and spent nuclear fuel, consistent with Council Directive 2011/70/Euratom and with IAEA Safety Standards. Arrangements for the development and maintenance of the National Strategy are defined in Article 54 of the Act, with the Ministry of the Interior being responsible for proposing and coordinating regular revisions to Government, which then proposes the Strategy for adoption by the Croatian Parliament. The Ministry of the Interior also reports to the Government of the Republic of Croatia on progress with implementation of the Strategy.

The National Strategy highlights 19 key principles for the safe and responsible management of radioactive waste and spent nuclear fuel, consistent with international requirements and standards. The majority of these principles are also enshrined in Article 55 of the Act. The National Strategy also describes, among other things, the goals of the national programme, the division of responsibilities between different national actors, and strategic arrangements for the financing of activities relating to radioactive waste and spent nuclear fuel management.

Annex IV of the National Programme refers to Articles 10 and 11 of the Bilateral Agreement, which are considered to be of particular importance in terms of commitments to the management of radioactive waste and spent fuel. 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 agreements on common solutions 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 after the regular plant operational lifetime in 2023. Similar provisions apply to wastes 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 programme for the decommissioning of the Krško NPP, and the joint programme for the disposal of all wastes, to be updated at least every five years.

### **ARTEMIS observation**

It is evident that the guidelines, principles and goals defined in the National Strategy document have been defined in accordance with a number of underlying policy objectives and policy-related legal provisions. The latter reflect Croatia’s aim of achieving harmonization with relevant EU legislation and with IAEA Safety Standards. Among other things, there is a clear understanding of expectations relating to how the final management of different waste streams

should be funded. It also provides a coordinated policy perspective on the responsibilities of the Republic of Croatia with regard to defining and implementing strategies for the management of radioactive waste and spent fuel from the Krško NPP, in accordance with undertakings of the Bilateral Agreement with the Republic of Slovenia.

The ARTEMIS Review Team considers the process for adoption of the National Strategy – first by Government and subsequently by the Croatian parliament – 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 National Strategy document alongside the National Programme is also consistent with the objectives of GSR Part 5 Requirement 2 regarding national policy and strategy on waste management.

The ARTEMIS Review Team notes that the current National Strategy document was established in 2013, prior to its approval by the Croatian parliament in 2014. In the ten years that have passed since then, there have been a series of significant amendments and updates to related legislation, plans and programmes, including:

- The Act on Radiological and Nuclear Safety.
- The Act on Fund for financing the decommissioning of the Krško Nuclear Power Plant and the disposal of Krško NPP radioactive waste and spent nuclear fuel.
- Ordinance on Management of Radioactive Waste and Disused Sources.
- The Third Revisions to the Krško NPP Decommissioning Programme and the Krško NPP Radioactive Waste and Spent Fuel Disposal Programme, both of which are developed in the framework of the Bilateral Agreement.
- The National Programme for the Implementation of the Strategy for Management of Radioactive Waste, Disused Sources and Spent Nuclear Fuel (Programme for the period until 2025 with a view until 2060).
- A twenty-year extension to the operational licence for the Krško NPP, from 2023 to 2043, granted by the Slovenian Nuclear Safety Administration.
- Decisions of Intergovernmental Commission.

Some of these amendments reflect slippage with regard to achievement and planned delivery of goals outlined in the National Strategy. Others reflect changes to the scope and content of management plans for different elements of the National Programme, as well as changes in the responsibilities of different organizations within the national framework for radioactive waste management within Croatia. One consequence of this is that several items of information contained within the National Strategy document are no longer current. Even the National Programme (last formally amended as recently as December 2022) incorporates aspects that, according to information provided to the ARTEMIS Review Team during the mission, do not reflect current plans (see Section 2.1 of this report). Since the National Strategy and National Programme are vital tools for national and international communication regarding the national framework for radioactive waste management in Croatia, as well as providing support for planning and decision making, the ARTEMIS Review Team considers it essential that the documents provide consistent and correct information, to avoid delivering conflicting or misleading messages.



## 1.2. LEGAL, REGULATORY AND ORGANIZATIONAL FRAMEWORK

### Croatian position

Primary actors in the organizational framework for the radioactive waste and spent fuel management within the Republic of Croatia are:

- The Fund for financing the decommissioning of the Krško Nuclear Power Plant and the disposal of Krško NPP radioactive waste and spent nuclear fuel (“the Fund”). The Fund was legally established by a dedicated law approved by the Croatian Parliament in 2007 with the goal to collect and increase the value of funds required for financing 50% of the cost related to decommissioning of the Krško NPP and all the cost for the management of 50% of operational and decommissioning wastes and spent nuclear fuel from the power plant. In 2012, the Government identified the Fund as an expert organization for the development of the joint programmes for decommissioning and radioactive waste disposal from the Krško NPP, within the terms of the Bilateral Agreement. Then, by amendment to the Act on Radiological and Nuclear Safety in 2015, the Fund was further assigned responsibility for establishing a Radioactive Waste Management Center as an organizational unit and to implement all activities relating to the fulfilment of radioactive waste management obligations defined within the National Programme. According to the current structure of Government departments within the Republic of Croatia, the Fund is an agency under the Croatian Ministry of Economy and Sustainable Development, which is also the Ministry for the HEP utility company.
- The Ministry of the Interior (MoI). In addition to responsibilities for the development and maintenance of the National Strategy and the National Programme (see Chapter 2), the Ministry of the Interior, through its Civil Protection Directorate, is the appointed competent authority for regulation of activities related to radiological and nuclear safety within the Republic of Croatia. Its responsibilities include the drafting of acts, ordinances and regulations relating to radiological protection and nuclear safety, granting approvals and licences under the Act as well as undertaking corresponding inspection activities. MoI monitors delivery of the National Programme based on annual reports provided by the Fund, and then reports on progress to the Government. Furthermore, in accordance with Section 6.4 of the National Strategy, MoI’s responsibility for drafting the National Programme requires the Ministry to develop a strategy for the development of necessary human resources to sustain national capacity in the field of radioactive waste management.

Other Government ministries also play a role in the drafting and implementation of certain aspects of the legislative framework relating to the implementation of the National Programme (see below). For example, the Ministry of Physical Planning, Construction and State Assets is responsible for physical planning and implementation as well as for issuing permits for projects of State significance. An important basis for spatial planning in respect of such projects is the State Spatial Development Plan for Croatia, which is developed by the Ministry for approval by the Croatian Parliament.

The Ministry of Economy and Sustainable Development, in addition to being the Ministry for both the Fund and HEP, has particular responsibilities for coordinating the strategic environmental impact assessment of the National Strategy and Programme, as well as for coordinating and approval of project environmental impact assessments relating to the development of facilities under the Strategy. The Ministry of Economy and Sustainable



Development also carries out cross-border consultation activities relating to the potential transboundary impacts of Croatia's strategies, plans and programmes.

The ARTEMIS Review Team was informed that, against the background of there being no centralised facility for the supervised storage of institutional radioactive waste within Croatia since 2013, and following IAEA-supported upgrading of storage arrangements at the RBI facility in 2015, the former regulatory body State Office for Radiological and Nuclear Safety (SORNS) had started an initiative whereby RBI would consider providing such a service again. The initiative was unsuccessful. Relatively small volumes of DSRS and institutional radioactive waste are now kept in interim stores at the premises of those users of such sources and generators of such waste (around 100 in total) who have not been able to return them to the manufacturer or to find alternative uses.

The Croatian legal framework for radioactive waste management includes:

- The Act on Radiological and Nuclear Safety (OG 141/13, 39/15, 130/17, 118/18, 21/22 and 114/22).
- The Act on the Fund for Financing the Decommissioning and Management of Radioactive Waste and Spent Nuclear Fuel of the Krško Nuclear Power Plant (OG 107/07 and 21/22).
- Strategy for the Management of Radioactive Waste, Disused Sources and Spent Nuclear Fuel (OG 125/14).
- The National Programme for the Implementation of the Strategy for Management of Radioactive Waste, Disused Sources and Spent Nuclear Fuel (Programme for the period until 2025 with a view until 2060) (OG 100/18 and 156/22 2022).
- Ordinance on Management of Radioactive Waste and Disused Sources (88/2022).
- Energy Development Strategy of the Republic of Croatia until 2030 with a view to 2050 (OG 25/20).

As a member state of the European Union, the Croatian regulatory framework for radioactive waste management and the protection of workers and the public from the hazards associated with ionizing radiation is primarily laid down in the Act on Radiological and Nuclear Safety and secondary legislative acts issued on the basis of the Act. The Ordinance on Management of Radioactive Waste and Disused Sources is of central importance with regard to the regulation of facilities and activities relating to the management of radioactive waste and disused sources.

The Republic of Croatia is a party to a series of international treaties, conventions and agreements, with the intention that commitments undertaken in line with such instruments should ensure the maintenance of a high level of safety in the management of radioactive waste and spent fuel.

### **ARTEMIS observation**

The ARTEMIS Review Team notes that the organizational framework for radioactive waste management established in Croatia is consistent with the objectives of GSR Part 1 (Rev. 1) Requirement 10, with legally defined roles and responsibilities for different organizations and activities. Furthermore, the legal and regulatory framework for oversight of the safe management of radioactive waste and spent fuel is observed by the ARTEMIS Review Team largely to provide a systematic overall structure for the authorization of facilities and activities as well as for regulation, inspection and enforcement in Croatia. This includes the assignment of post-closure responsibilities in the case of disposal facilities.

However, the ARTEMIS Review Team considers it a weakness that the possession of radioactive waste, regardless of whether or not the facility in which the waste is stored is

operational, is not recognised as a practice that requires regulatory authorization. A practical consequence of this is that the storage facilities at IMROH and RBI have not been subject to regulatory control since they ceased to receive wastes, and no inspection and verification activities regarding the condition of the facilities or the wastes that they contain have been carried out at these sites by the regulatory body.

The ARTEMIS Review Team also notes that guidance on the application and implementation of different regulatory requirements defined in the Ordinance on Management of Radioactive Waste and Disused Sources has in some cases not been developed or is inappropriate. This also represents a weakness in cases where the applicant for authorization for the development of new facilities (in this case, the Fund) needs to have a good understanding of criteria that are relevant to decision making or implementation of a graded approach. The Review Team notes, for example, that Appendix 9 of the Ordinance refers to siting criteria that previously formed the background to the identification of Trgovska gora as the preferred location for a radioactive waste disposal site (Sections 10.1, 10.2 and Annex VIII of the National Programme). Such criteria would not be appropriate for use in the context of the planned renewed siting process intended to lead to selection of a preferred site for the planned near surface disposal facility.

<b>RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES</b>	
<b>Observation:</b> <i>The Strategy document was established some 10 years ago as a comprehensive summary of national policy. Since then there have been significant changes with regard to legislation, planning scenarios and the responsibilities of different organizations. Neither the Strategy document nor the National Programme (last formally amended as recently as December 2022) provide a consistent, up-to-date picture of the national framework for radioactive waste management or the milestones and assumptions associated with different goals.</i>	
<b>(1)</b>	<b>BASIS: GSR Part 5 Requirement 2 states that “[...] The national policy and strategy shall form the basis for decision making with respect to the management of radioactive waste.”</b>
<b>R1</b>	<b>Recommendation: The Ministry of the Interior should initiate without delay a revision of the Strategy and National Programme to provide clarity and consistency for planning, communication and decision making, including on the roles of the relevant organizations, planning assumptions and programme milestones.</b>

## RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES

**Observation:** *The storage facilities at IMROH and RBI are no longer receiving radioactive waste and are locked. They are not subject to regulatory authorization according to the current legislation. Independent regulatory verification of the contents of the storage facilities and the conditions of the waste they hold is not therefore undertaken.*

(1)	<b>BASIS: GSR Part 1 Requirement 23, para. 4.22 states that</b> “Authorization by the regulatory body, including specification of the conditions necessary for safety, shall be a prerequisite for all those facilities and activities that are not either explicitly exempted or approved by means of a notification process.”
(2)	<b>BASIS: GSR Part 5 Requirement 11, para. 4.22 states that</b> “Provision has to be made for the regular monitoring, inspection and maintenance of the waste and of the storage facility to ensure their continued integrity.”
(3)	<b>BASIS: GSR Part 5 Requirement 3, para. 3.9 states that</b> “The regulatory body has to carry out activities that are necessary to verify that requirements for safety and environmental protection are being met by the operator.”
(4)	<b>BASIS: GSG-16 para 2.5 states that</b> “The responsibility for radioactive waste can change during its management. There should be clarity at all times regarding both ownership of the waste and responsibility for safety.”
<b>R2</b>	<b>Recommendation: The Ministry of the Interior should ensure that the storage facilities at IMROH and RBI are required to comply with safety requirements, including clear allocation of ownership of waste and sources, and responsibilities for safety and monitoring of the facilities.</b>
<b>R3</b>	<b>Recommendation: The Ministry of the Interior should undertake inspections of all facilities that store sources and waste, including IMROH and RBI.</b>

## RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES

**Observation:** Croatia plans a renewed national strategic environmental assessment process leading to the selection in 2038 of a site for the near surface disposal facility. Appendix 9 of the Ordinance (88/2022) on the management of radioactive waste and disused sources refers to siting criteria that are acknowledged by the Counterpart as being insufficient for the planned national site selection process.

(1)	<b>BASIS: SSR-5 Requirement 2, para. 3.8 states that</b> “The regulatory body has to provide guidance on the interpretation of the national legislation and regulatory requirements, as necessary, and guidance on what is expected of the operator in respect of each individual disposal facility.”
R4	<b>Recommendation: The Ministry of the Interior should update site selection criteria for the near surface disposal facility.</b>

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

### **2.1. NATIONAL STRATEGY**

#### **Croatian position**

According to the Croatian terminology, National strategy is referred to as National Programme. This document is both a planning and communication tool within Croatia and a key deliverable in relation to the obligations of the Republic of Croatia under the Council Directive 2011/70/Euratom. Articles 57 and 58 of the Act on Radiological and Nuclear Safety define the function of the National Programme and assign responsibilities for its preparation and revision. The MoI coordinates the preparation of the National Programme on behalf of the Government, based on the provisions contained in the Strategy (Section 1.1) and in consultation with other relevant actors, in particular the Fund.

The National Programme provides information on the overall inventory of radioactive wastes for which management responsibility rests with the Republic of Croatia. It describes the management routes for different waste types together with plans for their development and implementation in the short and long term. Whereas the management of DSRS and institutional radioactive waste that is already on the territory of Croatia represents an important component of the programme, it must also address the management of Croatia's share of wastes arising from the operation of the Krško nuclear power plant. A central point of reference for the National Programme as a whole are the joint plans with Republic of Slovenia developed under the Bilateral Agreement for the decommissioning of the Krško nuclear power plant and the management of radioactive waste and spent fuel from the power plant.

Co-ordination between the management of operational and decommissioning wastes from the Krško NPP and those arising from institutional uses of radioactive sources and materials within Croatia is reflected in the National Programme through plans for the development of a shared management solution. The Fund, in fulfilling the responsibilities assigned to the organization under the Act on Radiological and Nuclear Safety, is seeking to construct a centralised facility for institutional radioactive waste and DSRS and long-term storage for the Croatian half of LLW and ILW from Krško NPP. A site for the facility has been identified at Čerkezovac, situated in the Trgovska gora region close to the border with Bosnia and Herzegovina.

The intention is to obtain a location permit for the facility during 2025, so that an operation commencement permit can be obtained by approximately 2028. Although the planned date for obtaining the location permit is now just two years away, some important uncertainties remain. For example, the Ministry of Physical Planning, Construction and State Assets which issues the permit, needs to ensure that the location of such a facility is consistent with the State Spatial Development Plan (SSDP) for Croatia, for which finalisation and parliamentary approval has been delayed. Furthermore, despite communication efforts undertaken by the Fund with local and regional stakeholders, including communities within Bosnia and Herzegovina, there remain uncertainties regarding possible delays caused by objections that may be raised during public hearings on the planned Environmental Impact Assessment.

Obligations on Croatia, via the Fund, to take possession of Croatia's share of wastes and spent fuel from the Krško nuclear power plant have different associated timescales, consistent with the joint plans developed under the Bilateral Agreement for the decommissioning of the Krško nuclear power plant and the management of radioactive waste and spent fuel from the power plant. For operational wastes produced at the power plant up to the original planned closure date of the power plant in 2023, Croatia is expected to take possession of its share of the wastes,

removing them from the waste store at the Krško NPP site, during the next two to three years. The Fund is in the advanced stages of procuring the services of a waste management services provider in a third country to transport, characterise, store and condition Croatia's share of the wastes within packages suitable for transfer to the planned storage facility at Čerkezovac.

Operational wastes generated at the Krško nuclear power plant from 2023 until the end of its extended operational lifetime in 2043 will be stored on site until the time at which it has been agreed that they, together with wastes arising from decommissioning of the facility, need to be removed. According to the most recent version of the joint plans for decommissioning of the Krško nuclear power plant and the management of radioactive waste and spent fuel from the power plant (3<sup>rd</sup> revision), transfer of ownership of Croatia's share of these wastes should take place between 2050 and 2060.

The National Programme anticipates that a near-surface disposal facility for Croatia's share of wastes from the Krško nuclear power plant will be designed, sited and constructed, within the territory of Croatia and in accordance with applicable authorization processes, enabling it to be taken into operation in 2060. Part of this work involves the implementation of a national siting programme and related strategic environmental assessment to select a preferred location. Once the disposal facility has been established, wastes will be removed from the interim storage facility at Čerkezovac for final disposal. Croatia's share of the second phase of operational and decommissioning waste arising from the Krško nuclear power plant will also be disposed of at this time. The National Programme does not currently envisage that additional interim storage capacity will be constructed.

As regards spent fuel from the Krško nuclear power plant, the newly constructed dry storage facility on the nuclear power plant site is currently receiving the first transfers of fuel elements from the fuel storage pool at the reactor. The facility has a design lifetime of 80 years, or 60 years after the end of the currently authorized extended operation lifetime of the nuclear power plant. The joint plans for decommissioning of the Krško nuclear power plant and the management of radioactive waste and spent fuel from the power plant (3<sup>rd</sup> revision) envisages two scenarios for starting the disposal of the fuel, that is after 2093 (base case), or 2065 (sensitivity case). The waste management organizations in Croatia and Slovenia, the Fund and ARAO, are co-operating on the development of potential joint solutions for the fuel, according to a range of different scenarios. However, if disposal of the fuel were to take place in Croatia, site selection for such a facility would not be expected to begin until 2050 at the earliest.

### **ARTEMIS observation**

The dominant importance of the Krško NPP, in terms of the quantity of radioactive waste that ultimately is the responsibility of the Republic of Croatia, means that developments within the framework of the Bilateral Agreement inevitably have a significant impact on the National Programme. Slovenia and Croatia co-operate in taking forward five-yearly updates of the programmes for decommissioning as well as waste and spent fuel management for the nuclear power plant, and there is a complex process of interaction between the two national programmes and the plans for the Krško NPP. The ARTEMIS Review Team notes that this means that it is not easy to demonstrate complete synchronisation both across the National Programme and between the National Programme and the agreed plans for the nuclear power plant. Such challenges are probably unique to the situation that exists between Slovenia and Croatia, and the ARTEMIS Review Team noted several apparent inconsistencies between what they were informed is the current position and that which is described in the different planning documents.



For example, the ARTEMIS Review Team observed that:

- The majority of programme documents refer to 2023-2025 as the period during which all operational radioactive wastes will be removed from the current storage building on the Krško nuclear power plant site. Whilst the Fund is in the late stages of procurement of a service to deal with 20% of its share of these wastes, it is difficult to see how Croatia can physically take possession of the remainder within the defined time period. The team was informed that Slovenia's plans to process the waste for acceptance at the silo disposal facility that is to be constructed at Vrbinja, close to the power plant site, are also unlikely to fulfil the joint commitment to remove all wastes by the end of 2025.
- The 3rd revision of the joint plans for decommissioning of the Krško nuclear power plant and the management of radioactive waste and spent fuel from the power plant refers to a previous versions of the National Programme in which it was anticipated that the Croatian near-surface disposal facility would be available in 2051. This date would be consistent with the stated aim in the joint planning documents that Croatia will take possession of the waste between 2050 and 2060, without the need for interim storage elsewhere. However, the updated National Programme now anticipates that the Croatian disposal facility will not be available until 2060 at the earliest, which presents challenges for strategic planning, since Croatia currently has no plans to extend the capacity of the planned interim storage facility at Čerkezovac.

The ARTEMIS Review Team is conscious of the unique challenges of working simultaneously with national and bilateral plans. The continued close collaboration between Croatia and Slovenia in relation to identifying an agreed common long-term management solution for spent nuclear fuel is encouraged by the Team.

According to the Review Team's understanding, the interplay between national and bilateral programme planning increases the need for clarity and consistency in communication, so that there is as far as possible one unique source of information relating to the programme content and milestones. With a central and significant reference point (the joint programmes for the Krško nuclear power plant) that is updated at least once every five years, it is easy to see how a desire to be consistent with such commitments when communicating the current status of strategic plans might lead to inconsistencies in the presentation or understanding of information. An example of this might be local community perceptions regarding the purpose and scope of the facilities that are planned to be constructed at Čerkezovac. The ARTEMIS Review Team strongly encourages efforts to ensure the consistency is maintained in the communication of strategic plans. The team also notes that there is potentially significant value to be gained from a focus on the identification and mitigation of risks for those components of the programme that lie on the critical path to meeting national commitments for the safe long-term management of the radioactive wastes for which Croatia is responsible. This, together with awareness and communication relating to potential back-up strategies, could help in monitoring and achieving progress against a more stable set of planning assumptions.

With regard to strategic and contingency planning for the management of institutional radioactive waste, the ARTEMIS Review Team notes that plans for the development of the national storage facility at Čerkezovac have been in place for many years, but implementation has apparently been delayed on several occasions. Meanwhile, following the cessation of receipt of disused sources or radioactive wastes in 2013 at the RBI storage facility, such materials have been kept on the premises of authorized users, although typically not within dedicated facilities for waste storage. Given that operation of the planned facility at Čerkezovac may still lie several years ahead, radiation safety and security considerations would suggest that

there is an interim need for a centralised storage solution (or early implementation of the new national facility to accommodate only these wastes) in order to provide more secure controls during the intervening period.

Furthermore, the ARTEMIS Review Team did not see any clear evidence of strategic plans for the long-term management of institutional radioactive waste beyond the time at which Krško wastes will be removed for disposal to the planned near surface disposal facility. It is understood that the aim is for the storage facility at Čerkezovac to be closed completely at this time, which means that disposal solutions (or continued storage elsewhere) will need to be provided for institutional radioactive waste. It appears therefore that the National Programme needs to be augmented to provide more clarity regarding strategy for these wastes beyond 2060.

## **2.2. MILESTONES AND TIMEFRAMES**

### **Croatian position**

A key set of milestones in the National Programme is related to establishment of the Radioactive Waste Management Center (RWMC) storage facilities at Čerkezovac, as well as activities associated with obtaining the location and construction permits for the facilities.

For the operational wastes generated at the Krško NPP up to 2023, the Fund plans to transport the first 20% of the Croatian share of this waste, currently stored on the nuclear power plant site in Slovenia, to a third country as soon as possible. The aim is that this first component of Croatia's share of responsibility for these wastes should be characterized by the end of 2024, to have it stored then treated and conditioned by the contractor for a maximum of five years, before finally being sent as packaged wastes to the storage facility by the end of 2028. According to the amended National Programme (December 2022), the waste will remain at the storage facility until 2060, at which point it will be retrieved and sent to a near-surface disposal facility at a location that remains to be determined.

For the DSRS and institutional radioactive waste, the Fund plans to procure characterization (needed only for a relatively small fraction of this waste) and condition services from an approved contractor, ideally within the country, before storing it at the Čerkezovac facility. As noted above, it is not entirely clear from the National Programme what arrangements are to be made to enable final disposal of institutional radioactive waste, whether in the planned disposal facility for Krško waste or elsewhere. However, the ARTEMIS Review Team was informed that at least that part of this institutional radioactive waste that consists of long-lived DSRS would most probably not be acceptable for disposal to the planned near-surface disposal facility. Options for these wastes include disposal together with spent fuel and HLW from the Krško nuclear power plant at a future geological disposal facility, or at a separate disposal facility of a design dedicated to the receipt of such small volumes of radioactive waste within Croatia.

The major milestones identified for the management of spent nuclear fuel coming from the Krško NPP, as well as the HLW that will arise from its future decommissioning, are determined within the combined programme being developed together with ARAO in Slovenia. These consist of dry storage of spent fuel on the site of the Krško NPP, potentially up to 2103 (sixty years after the cessation of currently approved extended reactor operation in 2043), followed by an assumed 10-year period of disposal operations at a geological disposal facility. The location of such a disposal facility is not defined; strategic plans are based on the fact that it might be located in the Republic of Croatia or the Republic of Slovenia, or potentially even elsewhere in the EU if an international disposal facility is established. An alternative scenario being explored in relation to the strategic plans envisages that such a geological disposal facility



could be available to start disposal operations in 2065, according to the 3<sup>rd</sup> revision of the Krško NPP disposal programme.

#### **ARTEMIS observation**

The ARTEMIS Review Team notes that while the overall programme goals have remained broadly stable since publication of the National Strategy in 2014, there is evidence of slippage in timescales associated with a number of strategic planning milestones. As noted previously, there is a need for clarity and consistency in communication, so that there is as far as possible one unique source of information that can be provided to all stakeholders regarding the milestones of strategic planning. The ARTEMIS Review Team strongly encourages efforts to ensure the consistency is maintained in the communication of milestones associated with strategic plans within the national framework for management of radioactive waste and spent fuel. Awareness and communication relating to risk factors associated with elements of the programme that lie on the critical path to implementation, together with potential back-up strategies in the event the milestones need to be changed, could help in monitoring and achieving progress against a more stable set of planning assumptions.

### **2.3. PROGRESS INDICATORS**

#### **Croatian position**

The National Programme does not provide progress indicators other than the dates associated with current programme milestones. The ARTEMIS Review Team was informed that MoI, in its most recent review of the Fund's annual progress reporting against the National Programme, had requested a more transparent presentation of progress in implementation as well as any obstacles to future progress.

#### **ARTEMIS observation**

The ARTEMIS Review Team supports the view that performance indicators used in monitoring progress in implementing the National Programme should be related to more than whether or not specific milestones are achieved. Given this historical evidence of slippage in the achievement of milestones, there is an apparent need for a process to identify, report and mitigate programme risks, especially for those milestones that lie on the critical path to achieving programme goals. The aim of such a process should be to identify and implement necessary corrective actions, contributing to the provision of a more stable and consistent basis for decision-making and communication with stakeholders in the National Programme (see also Section 1).

## RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES

**Observation:** *The achievement of milestones within the National Programme has been repeatedly delayed. A process for mitigation of programme risk is especially important for those milestones that lie on the critical path to achieving defined goals.*

(1)	<b>BASIS: GSR Part 2 para. 4.5 states that</b> “Senior management shall ensure that goals, strategies and plans are periodically reviewed against the safety objectives, and that actions are taken where necessary to address any deviations.”
(2)	<b>BASIS: GSG-16 para. 5.16 states that</b> “Radioactive waste management strategies should be developed taking full advantage of opportunities and synergies arising from national, regional and international cooperation and experience, where appropriate. Radioactive waste management strategies should include milestones and clear time frames for the achievement of these milestones.”
(3)	<b>BASIS: GSG-16 para. 5.57 states that</b> “When applying the management system for radioactive waste management facilities, consideration should be given as appropriate to the following: [...] (f) Key performance indicators;”
<b>R5</b>	<b>Recommendation: The Ministry of the Interior, in consultation with the Fund and other relevant Governmental Bodies, should enhance arrangements for the planning, monitoring and delivery of the National Programme, including measures for identifying, reporting and mitigating programme risks, and for taking corrective actions as appropriate.</b>

## RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES

**Observation:** *The absence of centralized arrangements for the storage of institutional radioactive waste within Croatia could have implications for safety and security in relation to the management of disused sources and contaminated scrap materials. A centralized storage facility for such waste is planned as part of the Radioactive Waste Management Center, but even under ambitious assumptions regarding its establishment, the facility may not be available to accept waste for several years.*

(1)	<b>BASIS: GSR Part 5 Requirement 11 states that</b> <i>“Waste shall be stored in such a manner that it can be inspected, monitored, retrieved and preserved in a condition suitable for its subsequent management. Due account shall be taken of the expected period of storage, and, to the extent possible, passive safety features shall be applied. For long term storage in particular, measures shall be taken to prevent degradation of the waste containment”.</i>
(2)	<b>BASIS: SSG-45 para. 4.80 states that</b> <i>“In instances where the operator has neither adequate storage facilities nor facilities or expertise for the conditioning of spent and disused sealed sources by encapsulation, arrangements should be made to transfer the sources to another licensed operator with proper and adequate facilities (e.g. a centralised conditioning or storage facility).”</i>
S1	<b>Suggestion: The Government should consider urgently providing arrangements for the safe and secure centralized storage of institutional waste in Croatia.</b>

## RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES

**Observation:** *It is planned to transport Croatia’s share of waste generated at the Krško NPP after 2023 directly to the planned near surface disposal facility in Croatia. There are risks associated with this strategy since processes for site selection and safety case development for disposal facilities are more complicated than those for storage.*

(1)	<b>BASIS: GSR Part 5 Requirement 6 states that</b> <i>“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: GSR Part 5 Requirement 11, para. 4.19 states that</b> <i>“Storage has to take place between and within the basic steps in the predisposal management of radioactive waste. Storage is used to facilitate the subsequent step in radioactive waste management; to act as a buffer between and within waste management steps [...]”.</i>
S2	<b>Suggestion: The Fund should consider identifying back-up strategies for waste storage in case the disposal facility is not ready to accept the waste at the point when Croatia is obliged to accept it from the Krško NPP.</b>

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

#### Croatian position

##### *Waste classification*

The national radioactive waste classification system is defined in Article 4 of the Ordinance on Management of the Radioactive Waste and Disused Sources. The radioactive waste is categorized as solid, liquid, and gaseous, given its physical and chemical properties. The scheme was based on the recommendations from the IAEA Classification of Radioactive Waste (IAEA Safety Standards Series No. GSG-1, 2009) and EC recommendations from 1999.

RW class	Typical properties
1. Exempt radioactive waste (EW)	Radioactive waste that meets the criteria for exemption from regulatory control
2. Very short-lived radioactive waste (VSLW)	Contains radionuclides with a half-life less than 100 days.
3. Very low level radioactive waste (VLLW)	Radioactive waste with higher activity of concentration than VSLW. Concentrations of long-lived radionuclides in this waste category are negligible.
4. Low level waste (LLW)	Radioactive waste containing radionuclides with a half-life less than 30 years and limited activity concentration of long-lived radionuclides (4.000 Bq/g for individual packages, i.e., 400 Bq/g for the total mass of radioactive waste. Heat generation rate in this waste is below 2 kW/m <sup>3</sup>
5. Intermediate level waste (ILW)	Radioactive waste with higher activity concentrations than LLW.
6. High level waste (HLW)	Radioactive waste with heat generation rate above 2 kW/m <sup>3</sup> .

##### *Records and reporting*

The generator, owner and radioactive waste holders are required to keep records according to their Radioactive Waste and Disused Sources Management Plan. The Ministry of the Interior is required to keep central records on radioactive waste and disused sources, based on information supplied by the waste holder. The data contained includes (or will include):

- Radioactive waste and disused sources kept by the Radioactive Waste Management Center.
- Radioactive waste and disused sources kept by other holders.
- Radioactive waste released into the environment.
- Radioactive waste and disused sources released from regulatory control.
- Radioactive waste and disused sources that are abroad due to treatment or storage or have been returned to the manufacturer.
- Radioactive waste and disused sources that were found without a legal holder and were handed over to the RWMC for further management.

From August 2019, information on radioactive sources in use and disused sources has been stored in the Regulatory Authority Information System (RAIS) (a software application developed by the IAEA to assist Member States in managing their regulatory control programmes in accordance with IAEA Safety Standards and guides). A Central registry of Radioactive Waste and Disused Sources is planned but not yet in use. When the Central registry is taken in use, data on all radioactive waste in Croatia (including DSRS stored at owners' facilities) will be reported annually and included in the registry.

### *Operational and decommissioning wastes from the Krško NPP*

The Krško NPP was originally planned to operate until 2023 but has recently been given a 20-year extension to its licence. The greater portion of the radioactive waste for which Croatia has responsibility arises from operation and future decommissioning of the Krško NPP. The operators of the plant define this operational waste as LILW. However, in line with the Croatian waste classification system, the waste will be referred to in this report as LLW and ILW. The operational waste is divided into the following six streams:

- Evaporator Concentrates and Tank Sludges.
- Spent Ion Resins.
- Spent Filters.
- Compressible Waste.
- Non-compressible waste.
- Specific waste.

The Krško NPP waste storage building, operated by NEK d.o.o. (a joint venture between the publically owned Slovenian and Croatian energy companies), is at almost full capacity. In recent years, the volume of low and intermediate level wastes 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, the waste 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.

In order to satisfy the Intergovernmental Agreement between Croatia and Slovenia, Croatia is planning to remove around 20 % of its 50 % of the total existing operational waste inventory (amounting to approximately 200 m<sup>3</sup>) by the end of 2025. The need for further characterisation of this material has been identified, which is planned to be carried out by a third country service provider under a commercial contract. The results of the characterisation will help to identify any requirements for additional conditioning of the waste to allow for safe storage in the new storage facilities of the RWMC. In September 2022, preliminary WAC for these facilities were defined to allow storage of the conditioned wastes.

Croatia has responsibility for 50 % of the LLW and ILW resulting from future decommissioning of the NPP and the spent fuel storage facility. These operations are planned to commence following shutdown of the NPP in 2043. The projected Croatian portion of the operational and decommissioning wastes from the Krško NPP is shown below.

Period of LILW generation	Mass	Volume	Activity
	(t)	(m <sup>3</sup> )	(TBq)
1983–2017	2.438,7	1.147,5	29,9
2018–2023	132,0	81,7	7,2
2024–2043	441,9	273,3	21,7
<b>Total operational LILW</b>	<b>3.012,6</b>	<b>1.502,5</b>	<b>58,8</b>
2043–2058 (decommissioning LILW)	1.430,0	1.421,0	2,5
2103–2106 (LILW from decommissioning of the SNF dry storage)	196,0	203,7	0,4
<b>Total decommissioning LILW</b>	<b>1.626,0</b>	<b>1.624,7</b>	<b>2,9</b>

### *Spent nuclear fuel and high level waste*

The Croatian half of the spent fuel inventory, as present in 2023 and estimated for 2043, is as follows:

Source and classification of RW		IGE number and mass, 2023	Activity, Bq	Expected IGE number and mass, 2043	Expected activity, Bq
Operation of Krško NPP	High RW	749 440 t	$2,7 \times 10^{20}$	1,142 670 t	$4,2 \times 10^{20}$
Decommissioning of the Krško NPP	High RW	-	-	- 41 t	$1,23 \times 10^{16}$

The spent fuel at the Krško NPP is being transferred from wet to dry storage. The plant operator has identified challenges with the requirements to update the spent fuel database to take account of the new storage system and of the maintenance of Lifetime quality records, including which documents are required and data on which parameters should be stored.

In addition to the spent fuel, approximately 82 tonnes of HLW will arise from decommissioning. This HLW comprises mostly of activated material from the In-Core Instrumentation System, Nuclear Instrumentation System and Rod Control and Position System. The total activity of HLW is assessed to be  $2.46 \times 10^{16}$  Bq. Dominant nuclides are Co-60 (from Baffle Plates, Core Barrel, Thermal Shield, Cladding Reactor Vessel, Insulation and Reactor Vessel) and Eu-152 (from Biological Shield). It is planned to pack the reactor pressure vessel internals and high activated components in seven Holtec HI-SAFE containers.

### *Institutional Radioactive Waste and DSRS*

In Croatia itself, there are no spent fuel management or nuclear facilities in operation or in the process of decommissioning. Two main storage facilities containing institutional radioactive wastes and disused sealed radioactive sources (DSRS) are located in the following institutes (although these are not permitted to accept further wastes):

- Radioactive waste storage facility at the Institute for Medical Research and Occupation Health (IMROH).
- Radioactive waste storage facility within the premises of the Institute Ruđer Bošković (RBI).

Both storage facilities contain radioactive waste and disused sources from medicine, industry, science, education, and past public use. The storage facility at the IMROH was operational from 1959 until 2000. In June 2006, a partial waste segregation, characterization, conditioning, and packing into lead containers was carried out with the assistance of the IAEA. The storage facility at the RBI was closed in 2013 (meaning that no further waste could be accepted). Remediation of the facility, including waste segregation, characterization, treatment, conditioning, and packing into lead containers, was carried out in July 2015. These remediation works produced LLW, in the form of wood, metal scraps, paper and cardboard, etc. Some characterisation of the radioactive waste was performed, including identification of radionuclides, activity determination, and measurement of source dimensions and dose rates. It is planned to transfer all these wastes to the new storage facilities at the RWMC, and additional characterisation and conditioning is required before transfer. This characterisation will be obtained through a public procurement process and will be performed either on-site or at a TSO facility. It is planned to perform conditioning of these wastes either on site (using mobile



facilities where necessary) or on the site of an authorized institution. Croatia plans to export the waste for conditioning if domestic conditioning is not possible. Some further remediation may be necessary when the storage facility is subsequently decommissioned, should it be found to be contaminated. There are also plans to export most Category 1 and 2 disused sources, with support from the USA and IAEA.

Disused sources and small amounts of institutional waste are kept at approximately 100 other locations within the country. The other institutional waste is predominantly generated in nuclear medicine and is mainly very short-lived. As such it is released from regulatory control following decay. DSRS will be declared to be radioactive waste when the RWMC storage facility is established, unless they can be reused.

Estimations of the radioactive waste volume and characteristics stored in the IMROH and RBI storage facilities are given below.

Radioactive waste type	IMROH storage		RBI storage		Total	
	Volume (m <sup>3</sup> )	Activity (Bq)	Volume (m <sup>3</sup> )	Activity (Bq)	Volume (m <sup>3</sup> )	Activity (Bq)
Short lived	0.5	6.0×10 <sup>11</sup>	7,03	6,84×10 <sup>11</sup>	7,53	1,28×10 <sup>12</sup>
Long lived	1.0	9.1×10 <sup>11</sup>	2,81	1,14×10 <sup>12</sup>	3,81	2,05×10 <sup>12</sup>
<b>Total</b>	<b>1.5</b>	<b>1.5×10<sup>12</sup></b>	<b>9,84</b>	<b>1,82×10<sup>12</sup></b>	<b>11,34</b>	<b>3,33×10<sup>12</sup></b>

It is estimated that the total volume of institutional radioactive waste will increase in the next 40 years due to the remediation of the RBI storage facility. In addition, the activity of the long-lived radioactive waste will be doubled, due mainly to the smoke detectors (Am-241 and Ra-226) currently stored at locations of the DSRS holders, which need to be dismantled, conditioned and stored. The maximum estimated quantity of institutional radioactive waste and DSRS that will be generated up to 2060 is 100 m<sup>3</sup> with a total activity of 2.7 x 10<sup>13</sup> Bq.

### ARTEMIS observation

The waste classification system adopted in Croatia is based on IAEA recommendations (GSG- 1) and provides in principle an appropriate division for waste. However, the ARTEMIS Review Team observes that the waste classification specified in Article 4 of the Ordinance (OG 88/22) on Management of Radioactive Waste and Disused Sources is not fully aligned with waste management routes defined within the National Strategy (see Chapter 2). For example, the boundaries and relationships between activity content in VLLW and VSLW are not sufficiently well quantified.

The inventory of wastes arising from the Krško NPP is maintained by the operator (NEK), using mature and appropriate processes. The review team believes that the relevant Croatian organizations have sufficient information on the waste to allow for planning of its further management.

The ARTEMIS Review Team notes that the processes for maintaining the inventory of radioactive wastes produced in Croatia are still under development, i.e., the Central Registry of Radioactive Waste and Disused Sources is not yet in use. At present, only sources in use and DSRS are recorded in RAIS. Other inventories of radioactive wastes are not reported. The team believes that use of such an electronic reporting system will allow the data to only be entered into the system once, which reduces the possibility for errors.

All waste currently held at facilities within the country has been characterized to a certain degree but the requirement for further characterisation has been identified and processes are in place to conduct them.



## RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES

**Observation:** *The national waste classification in Article 4 of Ordinance (88/22) on management of radioactive waste and disused sources is not fully aligned with the waste management routes defined within the National Strategy.*

(1)	<b>BASIS: GSR Part 5 Requirement 9 states that</b> “ <i>At various steps in the predisposal management of radioactive waste, the radioactive waste shall be characterized and classified in accordance with requirements established or approved by the regulatory body.</i> ”
(2)	<b>BASIS: GSR Part 5 Requirement 9, para. 4.12 states that</b> “ <i>Radioactive waste may be classified for different purposes, and different classification schemes may be used in the successive steps in waste management. The most common classification scheme is that made from the perspective of its future disposal.</i> ”
S3	<b>Suggestion: The Ministry of the Interior should consider revising the waste classification in Article 4 of the Ordinance on management of radioactive waste and disused sources to provide well-defined boundaries between waste classes and to support mapping between the waste classes and disposal arrangements defined in the National Strategy.</b>

## RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES

**Observation:** *Currently only sources in use and DSRS are recorded in RAIS. The Central Registry of Radioactive Waste and Disused Sources is planned, which will also include radioactive waste. Its implementation, as a more appropriate tool than that currently used for managing the national radioactive waste inventory, is necessary to meet inventory reporting requirements.*

(1)	<b>BASIS: GSR Part 3 para. 2.35 states that</b> “ <i>The regulatory body shall make provision for establishing, maintaining and retrieving adequate records relating to facilities and activities. These records shall include:</i> — <i>Registers of sealed sources and radiation generators;</i> [...] — <i>Inventories of radioactive waste and of spent fuel.</i> ”
R6	<b>Recommendation: The Ministry of the Interior should complete the Central Registry of Radioactive Waste and Disused Sources and take it into use.</b>

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

### Croatian position

Croatia has defined the technical solutions through to final disposal that it will use to manage the different wastes for which it has responsibility. Two disposal facilities are planned:

- A near-surface disposal facility, for which the site yet has to be identified, which will take the low and intermediate activity, short-lived waste arising from the operations of Krško NPP and from institutional use within Croatia.
- A shared geological disposal facility for high level waste, including spent fuel to be declared as waste, together with any volumes of other wastes that, because of their particular radiological characteristics or time of arising, cannot be disposed of to near-surface disposal facility.

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

- Operational wastes arising from the Krško NPP operation up to 2023 that are the responsibility of Croatia, and which are currently managed by the NPP operator, will be conditioned in RCC containers in another country or at the Krško NPP site and sent for storage at the Long-term storage facility which is planned to be constructed at the Radioactive Waste Management Center (RWMC) at Čerkezovac.
- Operational wastes arising from the Krško NPP operation after 2023 and its subsequent decommissioning will be stored on the NPP site before being transferred directly to the near-surface disposal facility.
- Spent nuclear fuel and high level waste arising from decommissioning will be stored on the NPP site before being transferred directly to the geological disposal facility.
- Institutional wastes arising from research and development, industry and medicine and disused sealed radioactive sources within Croatia, currently kept in stores that do not meet IAEA's requirements for safe storage, will be, after further characterization and reconditioning for some of them, transferred to the Central storage facility to be constructed at the RWMC at Čerkezovac.

### *Current storage of Krško NPP operational wastes*

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 in other countries. Where possible, segregation at source is used to support free release of materials that might otherwise be classified as radioactive waste. As a consequence of this focus on waste minimisation, the storage facility, which contains all the solid waste that has been generated since the start of operation of the NPP, has been able to keep accepting waste packages up to the present day. It is however critical to reduce the volume of waste in this store. Since this waste is owned in equal share with Slovenia, and because Slovenia's disposal facility where this waste will be sent shall only become operational in a few more years, it has become necessary for Croatia to remove around 20 % of its half of the waste as soon as possible. This is planned in the beginning of 2024. The removal of Croatia's share of the remaining waste generated before 2023 is dependent on the establishment of the RWMC facilities at Čerkezovac.

#### *Current storage of Krško spent nuclear fuel*

Spent nuclear fuel at the Krško NPP has been stored under water in the spent fuel pool at the plant. A dry storage facility (using Holtec's HI-STORM FW system) has been constructed on the NPP site. The facility received its operating licence (valid for 80 years) from the Slovenian Nuclear Safety Administration in October 2022 and the first fuel assemblies were transferred into storage in April 2023. In the the first fuel loading campaign, a total of sixteen HI-STORM FW casks are being placed in dry storage.

The safety concept of the dry storage facility 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 themselves provide all required safety functions and are thus suitable for outdoor storage, they are housed in a building which provides a degree of extra shielding and soft environmental protection. The store has capacity for all spent fuel which will be generated up to the planned shut down in 2043, with an overcapacity of ca 15 per cent, in line with general recommendations.

#### *Current storage of Croatian institutional waste*

There are two main storage facilities for institutional radioactive waste and DSRS:

- Radioactive waste storage facility at the Institute for Medical Research and Occupation Health (IMROH).
- Radioactive waste storage facility within the premises of the Institute Ruđer Bošković (RBI).

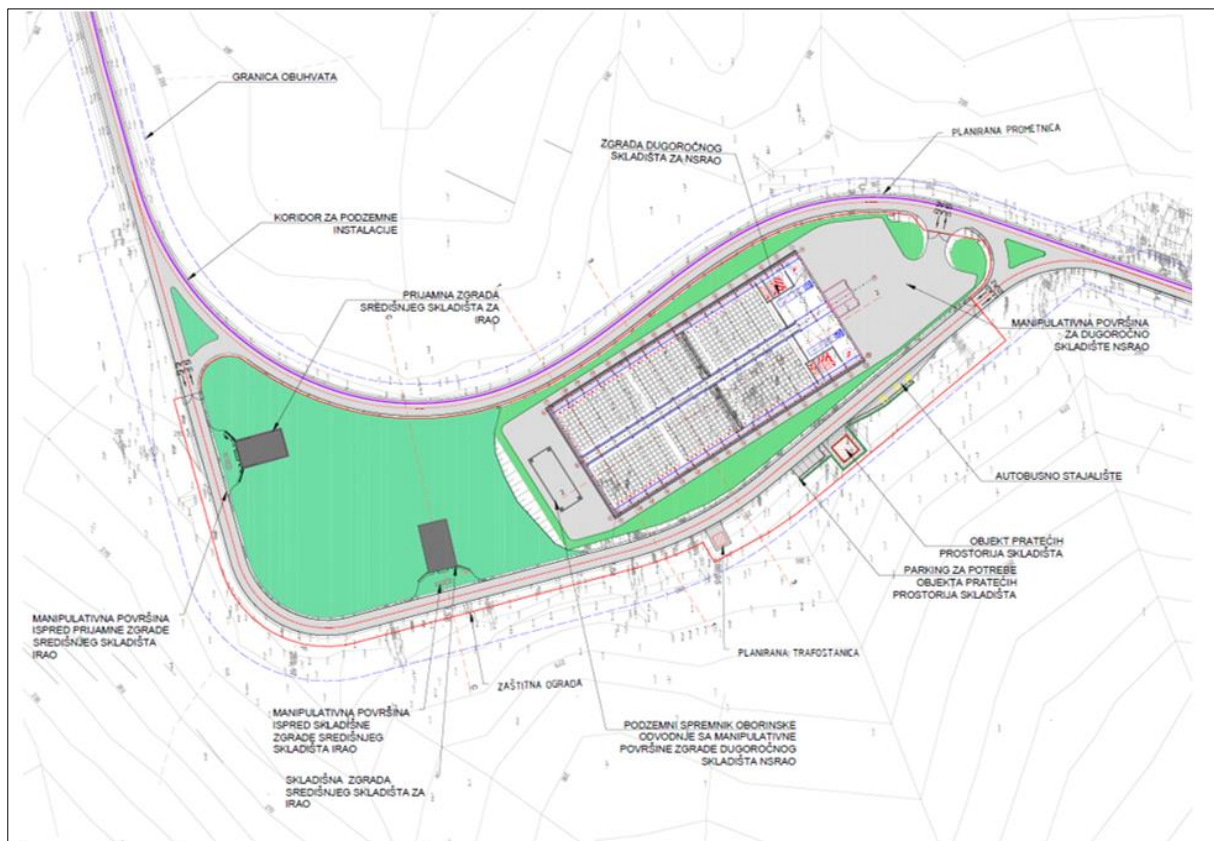
Both contain radioactive waste and disused sources from medicine, industry, science, education, and past public use. The storage at the IMROH was operational from 1959 until 2000. In June 2006, a partial waste segregation, characterization, conditioning, and packing into lead containers was carried out with the assistance of the IAEA. The RBI storage facility was closed by the regulatory body in 2013 due to the inadequate storage of radioactive waste and DSRS. A project to remediate the RBI storage facility, including waste segregation, characterization, treatment, conditioning, and packing into lead containers, was carried out in July 2015. Both facilities are currently not subject to authorization and since they are unable to accept new wastes, there are institutional radioactive waste and DSRS still kept at the owner's sites, at around 100 different locations.

### *Radioactive Waste Management Center storage facilities*

The Radioactive Waste Management Center (RWMC) storage facilities that are planned to be constructed at the Čerkezovac site, with an operational life time of about 40 years, comprise: (i) the “Central Storage Facility” for the Croatian institutional radioactive waste and DSRS and (ii) the “Long-term Storage Facility” for Croatia’s half of the operational waste which has been generated by the Krško NPP operations up to 2023.

The Central Storage Facility for institutional radioactive waste and DSRS consists of two buildings: the reception building and the storage facility. Those two buildings are existing U-20-type arch storage facilities that are to be reconstructed for the purpose of the Central storage. Preliminary waste acceptance criteria have been defined, based on international experience.

The long-term Storage Facility consists of a new reinforced concrete building with a surface area of 6330 m<sup>2</sup> and a height of 17.2 m. The waste will be stored in Reinforced Concrete Containers (RCC). These are cubic containers with external dimensions of 1.7x1.7x1.7 m, a maximum weight of 15 tons, and a useful internal volume of 2.85 m<sup>3</sup>. The total required storage capacity is 2450 RCC containers, and the total possible storage capacity is 2484 RCC.



*RWMC layout. The two arches for the Central storage facility (for institutional radioactive waste) are the grey boxes with red dots in the lower left hand part of the green-shaded area, and the Long-term storage facility (for NPP wastes) is the large grey-shaded area within the green-shaded area*

The location for the RWMC is the Čerkezovac site, located on the southern slope of the Trgovska gora massif. The site is located at a distance of about 2 km to the east and 4 km to the south from the state border with Bosnia and Herzegovina, which coincides with the Una river.

Characterisation of the site is underway, and up to now has included:

- Geological, hydrogeological, hydrological and geophysical studies (ended early 2023).
- Determination of zero state radioactivity of the area (ended in 2022).
- Evaluation of seismic hazard of the area (ended in 2022).
- Road accessibility study (2022).
- Demining of this former military site (ended early 2023).

#### *Treatment and conditioning*

Croatia plans to emplace the low and intermediate level wastes produced up to 2023 from the Krško NPP in Reinforced Concrete Containers (RCC) for storage at the RWMC and subsequent disposal. This packaging was chosen based on its widespread international use, its suitability for transport and handling and because it can be later used for transport, storage and disposal in a near-surface disposal facility.

Most of the operational waste at the Krško NPP which is the responsibility of Croatia is stored in Tube Type Containers (TTC). The dimensions of the TTCs preclude their emplacement in RCCS, and thus repacking of these wastes is required.

According to the decision of Intergovernmental Commission, Croatia is obliged to remove around 20 % of its half of the total existing waste inventory (amounting to approximately 200 m<sup>3</sup>) in the beginning of 2024. Croatia plans to send this waste to a service provider in a third country for characterization and conditioning after a maximum of five years storage at that facility. Negotiations for these services are at an advanced stage and Croatia expects to enter into a contract in the near future. Removal of the remaining 80 % of Croatia's share of the waste generated before 2023 is dependent on establishment of the Long-term storage facility at Čerkezovac. Not all of this waste is expected to require additional treatment, in which case it is agreed that conditioning will be done on the Krško NPP site. Additional treatment, if required, will be done in a third country.

Croatia plans to transfer all disused sources and institutional waste to the Central storage facility, and additional characterisation is required before transfer. This characterisation will be obtained through a public procurement process and will be performed either on-site or at a TSO facility.

Generic WAC for the storage facility were developed in 2018, based on typical international criteria. They were refined in 2022 after introducing some specificities related to the Long-term storage facility at the Čerkezovac site. Final WAC will be defined before wastes are transferred to the facility.

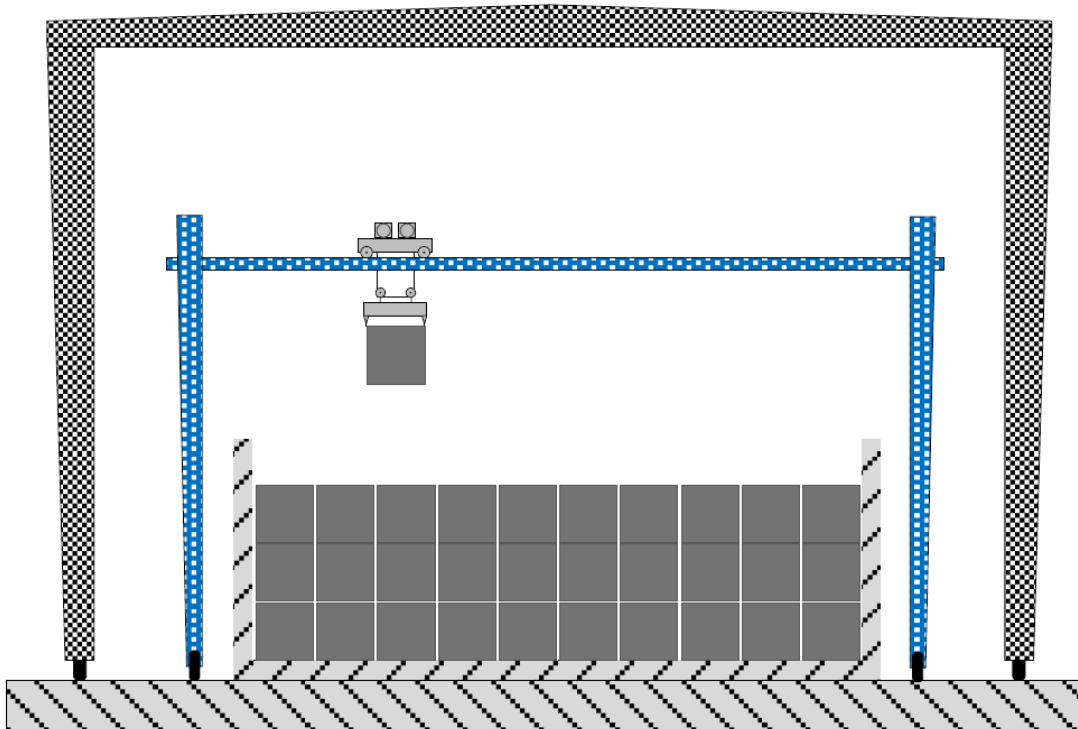
#### *Near surface disposal for institutional radioactive waste and for LLW and ILW from the Krško NPP*

The location of a disposal facility for the short-lived low level and intermediate level waste was initially planned in the Croatian legislation to be in the Trgovska gora area, i.e., in the vicinity of the RWMC. However, this decision was based on now superseded regulations, and Croatia is now planning to restart a national site selection process.

A concept design for the disposal facility has been produced. It will be of the near surface type, utilizing reinforced concrete cassettes for the placement of the RCCs. Each concrete cassette or cell will have dimensions 19 x 24 x 7 m (w x d x h), with a capacity of 390 RCCs. A total of four disposal facility cells are needed for the inventory. Most of the RCCs will contain NPP waste, but capacity will be installed for a further 98 containers with institutional radioactive



waste and for radioactive waste generated by decommissioning of the RWMC. The facility will occupy an area approximately 50 x 70 m.



*Conceptual design for near-surface disposal facility*

The programme for site selection for the disposal facility will be drafted in 2028.

#### *Spent nuclear fuel disposal*

The estimated date 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.

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/Finnish KBS-3V concept in crystalline rock 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.

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

- Baseline scenario for start of disposal is 2093.
- Alternative date for the start of disposal is 2065.
- Construction of the disposal facility in alternative geological formations (crystalline or sedimentary rocks).
- 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.

Potential geological environments for the construction of a geological disposal facility have been identified in Croatia.

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

### **ARTEMIS observation**

The radioactive waste management facilities that Croatia plans to construct (RWMC storage facilities and near surface disposal facility) are intended to provide complete lifetime management for all low and intermediate level, short-lived wastes for which Croatia has responsibility.

Croatia and Slovenia plan for a shared disposal facility for spent fuel and HLW (from decommissioning of the Krško NPP) on the territory of either of the two countries. The base case scenario for the disposal facility has the programme beginning in 2053. An alternative scenario is that the programme could begin in 2027. The corresponding dates for start of operation are 2093 and 2065. There is a requirement for a regulatory basis to be in place before a meaningful site selection process for the construction of a geological disposal facility can commence.

The ARTEMIS Review Team notes that there is a potential gap in the strategy for long-lived low and intermediate level waste, for instance should it not be possible to export all category 1 and 2 DSRS according to current strategies.

Operation of the RWMC is planned from 2025 until 2060, after which the wastes will be transferred to the disposal facility and the RWMC will be decommissioned. A concept design for the facility has been produced, including preliminary WAC, and some site characterisation work has been conducted.

According to the decision of Intergovernmental Commission, Croatia is obliged to remove around 20 % of its half of the total existing LLW and ILW inventory (amounting to approximately 200 m<sup>3</sup>) from the Krško NPP in the beginning of 2024. The review team observed that plans for the long-term management of this waste, although defined in principle (transport to a third country service provider for characterization, possible conditioning, and storage, before transfer to the RWMC) involve complex interdependencies. Specifically, the envisaged contracts with the third country service provider foresee storage for five years. The ARTEMIS review team considers it important to ensure that appropriate time is taken to define the WAC affecting the final packaging of the wastes and that this is not compromised by concerns about meeting contractual deadlines (see Chapter 5).

The waste will need to comply with the relevant facility WAC. As of today, the preliminary WAC for the RWMC are mainly based on international experience, using WAC from other facilities employing RCC-type containers, but not being entirely aligned with the RWMC since the safety assessment for this facility has begun recently (see chapter 5). Development of approved WAC and waste package specifications may therefore impact the critical path for receipt of the waste at the RWMC. The review team also observes that the tight schedule for approval of the RWMC location permit may adversely impact the critical path for receipt of waste at the facility.

Finally, regarding Croatia's plans to transport wastes from the Krško NPP generated after 2023 directly to the near surface disposal facility, that is without storage in Croatia, the review team highlights that the processes for site selection and safety case development for disposal facilities are more complicated than those for storage. There are risks associated with the potential unavailability of the disposal facility to accept the waste at the point when Croatia is obliged to

take over from Krško (around 2050 or 2060). Consequently, Croatia may need to consider the possible need for some additional storage arrangements as a back-up intermediate management strategy.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
<p><b>Observation:</b> <i>The procurement of services for transport, characterisation, storage and conditioning of D6 drums from the Krško NPP foresees storage for up to five years. The availability of WAC derived from the safety case for the RWMC storage facilities at the Čerkezovac site is a necessary input for finalising waste package specifications to guide waste conditioning. The complexity of these arrangements represents a risk for managing interdependencies between waste management steps.</i></p>	
(1)	<p><b>BASIS: GSR Part 5 Requirement 12 states that</b> “Radioactive waste acceptance criteria. Waste packages and unpackaged waste that are accepted for processing, storage and/or disposal shall conform to criteria that are consistent with the safety case.”</p>
(2)	<p><b>BASIS: GSR Part 5 Requirement 6, para. 3.23 states that</b> “In considering possible options for the processing of waste, care has to be taken to avoid conflicting demands that might compromise safety. It is not consistent with an integrated approach to optimize one step in the predisposal management of radioactive waste in such a way that it imposes significant constraints on the subsequent steps or forecloses viable options.”</p>
R7	<p><b>Recommendation: The Fund should finalise WAC for the RWMC storage facilities at the Čerkezovac site and submit them to the regulator for approval in a timely fashion to allow receipt and safe storage of the waste packages.</b></p>

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
<p><b>Observation:</b> <i>There are currently no regulations or guidance in place covering the site selection process for a geological disposal facility for spent nuclear fuel and other high level waste.</i></p>	
(1)	<p><b>BASIS: GSR Part 1 (Rev. 1) Requirement 32 states that</b> “The regulatory body shall establish or adopt regulations and guides to specify the principles, requirements and associated criteria for safety upon which its regulatory judgements, decisions and actions are based.”</p>
S4	<p><b>Suggestion: The Ministry of the Interior, in consultation with other relevant bodies, should consider developing guidance on siting a geological disposal facility.</b></p>



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

### Croatian position

The safety demonstrations of the radioactive waste and spent fuel management facilities in Croatia rely on the development of safety cases and environmental impact assessments, as prescribed in Article 35 of the Ordinance on Radioactive Waste and Disused Sources Management (OG 88/22). Safety cases have yet to be developed in Croatia, with the studies aiming toward this achievement being currently elaborated at varying levels of development for the different waste management facilities. Given its importance in Croatia's waste management program, the development of the documentation related to the safety demonstration of the future RWMC is the Fund's priority.

#### *Waste stored on the Krško NPP site in Slovenia*

Croatia's share of LLW and ILW and spent fuel from the operations of the Krško NPP are stored on the NPP site. The safety demonstrations of the respective storage buildings are included in a safety analysis report dedicated to the Krško NPP.

#### *Current institutional waste storage facilities*

Remediation of the storage facility located in IMROH was carried out in 2006 with the assistance of the IAEA and under the supervision of the former State Office for Radiation Protection. This allowed some characterisation, classification and conditioning of the waste stored. This facility is currently closed and does not hold any licence.

The storage facility located in RBI, which was not licensed for properly receiving institutional radioactive waste and DSRS was closed by the State Office for Radiation Protection in 2013. A need for some remediation work at that site has been identified because of some level of contamination of the building structure.

Because these facilities are not licensed, and even though they contain radioactive material, they are not subject to regulatory oversight. They however undergo safeguards inspections every year and the surrounding sites are subject to radiological (dose) monitoring. The Ministry of the Interior considers, even if no safety demonstration exists for either of these facilities, that they are sufficiently safe for the waste to remain stored for several more years.

Finally, because the remaining institutional radioactive waste and DSRS in Croatia could not be stored in the closed IMROH and RBI storage facilities, the wastes are currently held at the owner's sites in approximately 100 different locations in the country. In the framework of surveillance of these sites, the DSRS undergo regular inspections from the Ministry of the Interior.

#### *Planned Radioactive Waste Management Center (RWMC)*

The Fund, with the help of subcontractors, has initiated in 2022 the development of a safety case for the RWMC. This safety case will include three separate safety assessments dedicated to: (i) the central storage facility for the institutional radioactive waste, (ii) the long-term storage facility for the Krško NPP waste and (iii) the transport of waste to the RWMC. The safety case will also include waste acceptance criteria and packaging specifications for the transport and storage of the waste at the RWMC. So far, generic WAC has been elaborated based on international experience.

The safety strategy to be followed for the safety demonstration of the RWMC is currently at the stage of initial development. As such, the Fund plans:

- To make use of the defence in depth concept through the use of successive multi-barriers around the waste.
- To elaborate a management system that shall allow the development of processes and procedures covering all activities to be carried out in the RWMC (relevant regulations and guidelines are already identified in this aim).
- To assess the impact of scenarios representative of the expected normal conditions of the site as well as anticipated operational occurrences. A list of relevant scenarios has been identified and the results of the safety assessment will be compared, when available, with the dose limits and constraints internationally considered in radiological protection.

In view of evaluating the adequacy of the Čerkezovac site, geological, hydrogeological, hydrological, geophysical, geotechnical, seismic and ecological data have been acquired up to mid-2023. According to Croatia, the site characteristics, notably the shale-dominant nature of the site's substratum and the absence of groundwater levels encountered in the four deep boreholes (three at 40 m and one at 198 m) located at the site, are favourable for the emplacement of the two main storage facilities of the RWMC.

The Fund expects to submit a safety case late 2025 in support of an application for the facility's construction permit expected in 2026. This safety case is expected to derive the WAC and necessary waste package specifications to ensure that the waste will be conditioned in a way that meets the specificities of the RWMC, notably its foreseen storage period of several decades. However, a timing issue arises as the first phase of Croatian waste from the Krško NPP that will be sent to a 3rd country for conditioning in RCCs will need to be taken over by the RWMC after a period of maximum 5 years of storage in that country.

Regarding the safety case development at the subsequent stages of the facility establishment (location, design, construction, trial operation, operation commencement), plans are presented which foresee increasing levels of details of the documentation.

#### *Near-surface disposal for the institutional radioactive waste and LLW from the Krško NPP*

Croatia plans to prepare a programme for the siting process of the near-surface disposal facility in 2027. For this facility, expected to be operational by 2060, the Fund plans to initiate the safety case development after 2038.

#### *HLW and spent fuel disposal*

Regarding the planned shared HLW and spent fuel disposal facility a concept of geological disposal facility based on the Swedish KBS-3V 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 or Croatia's environmental conditions. The plan is to derive a safety case based on real data once a site is chosen and characterized in several decades in Croatia or Slovenia.

#### **ARTEMIS observation**

The ARTEMIS Review Team notes that a contents list for a safety assessment report is defined in Appendix 5 of the Ordinance (88/2022) on the management of radioactive waste and disused sources, while appendices 8 and 9 describe "special design requirements" for near-surface storage and disposal facilities, respectively. The ARTEMIS Review Team observes however that such provisions are only briefly described and that there is no supporting regulatory guidance relating to their practical application that would help to ensure a good understanding of regulatory expectations regarding application of a graded approach in safety assessments for

licensing and permitting processes. Despite this, the Fund has identified the expected major components considered as necessary inputs to the various revisions of the safety case for the different phases of the RWMC development (location, construction, design, trial operation, operation commencement and decommissioning); these components appear consistent with international practices for this type of facility.

The ARTEMIS Review Team recognizes the efforts made by the Fund towards developing a safety case and an EIA in view of obtaining the necessary permits for the RWMC storage facilities. So far, Croatia has acquired site knowledge which can be used as an input to the safety evaluations in support of siting of the storage facilities.

Although the preliminary step toward the elaboration of a safety assessment has been initiated, with a first identification of the relevant scenarios to be considered, the ARTEMIS Review Team notes that the associated dose calculations have not yet started. Therefore, the ARTEMIS Review Team sees it as a challenging issue to acquire calculation results in a timely manner to allow the development by 2024 of the safety case and environmental impact assessment reports for siting the RWMC. The ARTEMIS Review Team also notes that the development of this safety case is needed for the derivation of WAC and waste package prescriptions necessary for the conditioning of the Croatian waste from the Krško NPP that shall be transported from the 3<sup>rd</sup> country to Croatia around 2028. In addition, given the 40-year minimal duration of waste storage at the RWMC, the ARTEMIS Review Team highlights the need to define, in the WAC and waste package specifications, the specific requirements and packages properties that will allow the future RCC containers to be safely retrieved at the end of the storage period, and most importantly that will not impede the possibility to ultimately dispose the waste.

Regarding the storages facilities at IMROH and RBI which ought to remain safe until the establishment of the central storage foreseen in five to ten years, the team believes that safety demonstrations are needed to justify that the waste they contain will remain safely stored up to its transfer to the RWMC storage facilities.

Finally, the ARTEMIS Review Team understands that the Fund's efforts on safety case development are currently directed to the urgent need to construct and operate the RWMC. This may be the reason for the absence of detailed studies on the establishment of the near-surface disposal facility, for which a programme for site selection is expected to start around 2027.

However, despite the expected availability of a long-term predisposal management center which allows time to develop the safety demonstration of the future near-surface disposal facility, the team sees it as important to consider starting the near-surface disposal safety case development earlier than the year 2038 presently planned by the Fund.

## RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES

**Observation:** *There is a lack of regulatory guidance on how to fulfill the requirements for safety assessments for authorization processes and the application of a graded approach.*

(1)	<b>BASIS: GSR Part 1 (Rev. 1) Requirement 24, para. 4.34 states that</b> <i>“The regulatory body shall issue guidance on the format and content of the documents to be submitted by the applicant in support an application for authorization.”</i>
(2)	<b>BASIS: GSR Part 5 Requirement 14, para. 5.7 states that</b> <i>“The extent and detail of the safety case and the safety assessment have to be commensurate with the complexity of the operation and the magnitude of the hazards associated with the facility and activities.”</i>
(3)	<b>BASIS: SSR-5 Requirement 2, para. 3.8 states that</b> <i>“The regulatory body has to provide guidance on the interpretation of the national legislation and regulatory requirements, as necessary, and guidance on what is expected of the operator in respect of each individual disposal facility.”</i>
<b>R8</b>	<b>Recommendation: The Ministry of the Interior should develop guidance stating regulatory expectations for safety assessments to support authorization of radioactive waste storage and disposal facilities.</b>

## RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES

**Observation:** *There is no documentation justifying the safety of the storage facilities at IMROH and RBI.*

(1)	<b>BASIS: GSR Part 5 Requirement 11 states that</b> <i>“Waste shall be stored in such a manner that it can be inspected, monitored, retrieved and preserved in a condition suitable for its subsequent management. Due account shall be taken of the expected period of storage, and, to the extent possible, passive safety features shall be applied. For long term storage in particular, measures shall be taken to prevent degradation of the waste containment”.</i>
(2)	<b>BASIS: GSR Part 5 Requirement 14 states that</b> <i>“The safety case for a predisposal radioactive waste management facility shall include a description of how all the safety aspects of the site, the design, operation, shutdown and decommissioning of the facility, and the managerial controls satisfy the regulatory Requirements. The safety case and its supporting safety assessment shall demonstrate the level of protection provided and shall provide assurance to the regulatory body that safety Requirements will be met”.</i>
<b>R9</b>	<b>Recommendation: The Ministry of the Interior should require safety demonstrations to be developed for the storage facilities at IMROH and RBI.</b>

## RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES

**Observation:** *The safety assessment calculations for the RWMC, which are an essential component of the safety case and environmental impact assessment, have just begun. The safety assessment results are required early 2024 to enable time for regulatory review prior to submitting an application for the facility’s location permit expected in 2025.*

<b>(1)</b>	<p><b>BASIS: GSR Part 5 Requirement 15 states that</b> <i>“The safety case and its supporting safety assessment shall be documented at a level of detail and to a quality sufficient to demonstrate safety, to support the decision at each stage and to allow for the independent review and approval of the safety case and safety assessment. The documentation shall be clearly written and shall include arguments justifying the approaches taken in the safety case on the basis of information that is traceable.”</i></p>
<b>S5</b>	<p><b>Suggestion: The Fund should consider revising its plans to allow enough time for the development and regulatory review of the safety assessment at the level of detail that is necessary to apply for the RWMC location permit.</b></p>

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

### Croatian position

According to the Bilateral Agreement, the Republic of Croatia and the Republic of Slovenia are jointly responsible for the spent fuel arising from the Krško NPP, along with the decommissioning of the NPP. The Republic of Croatia will be directly responsible for the management of half of the LLW and ILW arising from the Krško NPP, and the institutional wastes and DSRS currently stored within Croatia.

### *Cost estimation*

The estimates relating to the Krško NPP are developed with input from the Slovenian waste management organization, ARAO, and the Krško NPP. The cost estimates presented in the National Programme relating to the Krško NPP Decommissioning Programme and Krško NPP Radioactive Waste and Spent Nuclear Fuel Disposal Programme are formally revised at least every five years. The estimates are revised to allow for new information on waste arisings and volumes, and changes in market rates. The cost revisions enables the annual fee that the Croatian electricity company, Hrvatska elektroprivreda d.d. (HEP), has to pay to be adjusted to reflect current values. A reassessment of the estimates was carried out in 2019 and the updated values will be reported in the fourth revisions of the Krško NPP Decommissioning Programme and Krško NPP Radioactive Waste and Spent Nuclear Fuel Disposal Programme, which are currently being prepared.

The scope of the estimates covers all the activities associated with the management and disposal of wastes up to 2110, as applicable, including:

- Long-term storage of the wastes from the Krško NPP at the planned RWMC in Čerkezovac site, including costs for licensing of the Center.
- Preliminary estimates for the planned LLW and ILW near-surface disposal facility, including an R&D programme as well as licensing, construction and operation of the facility.
- Long-term storage of spent fuel at the Krško NPP including operating and decommissioning costs of the dry spent fuel storage facility.
- Preliminary estimates for a new spent fuel disposal facility including an R&D programme, construction, operation and decommissioning of the facility and transport of the spent fuel.
- Compensation for restricted land use, taxes and contingency.
- Programmes of stakeholder education and information.

The estimates have been based on benchmarking, market research and preliminary estimates from contractors. The estimates are presented for five costs categories: (1) Investment costs, (2) Operational costs, (3) Contingency, (4) VAT and (5) Compensation to local community for restricted land use.

As the estimated costs of waste management are in part related to the timescales for implementation of facilities and to the waste volumes, and in line with international best practice, a contingency figure was added to the estimated costs. For near-term projects, such as the RWMC storage facilities, a contingency figure of 10% was deemed appropriate. For long-term projects such as the near-surface disposal facility for LLW and ILW, where there is more uncertainty both in timings and waste arisings, a figure of 30% was deemed appropriate. The ultimate decision on the contingency value that is included in the National Programme resides



with the Croatian Government's 'Coordination Committee', as the Croatian Government will be ultimately responsible for any short fall in the value of the fund.

The estimates presented appear to be based on a series of well documented assumptions regarding dates and waste arising profiles and on a defined scope. The costs of geological disposal of spent fuel and HLW from the Krško NPP are based on estimates derived for the Swedish KBS-3V disposal concept which has been used as a reference case, with appropriate assumptions with respect to parameters such as waste volumes, packaging and geological conditions to reflect the Croatian context. Costs have also been developed for long-term monitoring and maintenance of the LLW and ILW near-surface disposal facility.

The costs for development of the Central storage facility, the costs of operating the storage facilities at IMROH and RBI and their decommissioning are also estimated in a separate document.

### *Financing arrangements*

The financing of the Krško NPP Decommissioning Programme and the Krško NPP Radioactive Waste and Spent Nuclear Fuel Disposal Programme is split between the Republic of Croatia and the Republic of Slovenia. Via the Act on the Fund for Financing the Decommissioning of the Krško Nuclear Power Plant and the Disposal of the Krško NPP Radioactive Waste and Spent Nuclear Fuel, the Republic of Croatia has established the Fund for Financing the Decommissioning of the Krško Nuclear Power Plant and the Disposal of the Krško NPP Radioactive Waste and Spent Nuclear Fuel (the Fund), to meet the requirements under the Bilateral Agreement. In terms of finance, the Fund is responsible for the acquisition, maintenance and increase of the value of funds.

As set out in the Act on the Fund for Financing the Decommissioning of the Krško Nuclear Power Plant and the Disposal of the Krško NPP Radioactive Waste and Spent Nuclear Fuel, the Fund is responsible for financing:

- The preparation, drafting, revision and implementation of the Krško NPP Decommissioning and Disposal Programme.
- The organization, construction, maintenance, management and operation of the RWMC.
- Management and disposal of radioactive waste and spent nuclear fuel from the Krško NPP and the decommissioning of the Krško NPP.
- Management of radioactive waste and disused sources originating from the territory of the Republic of Croatia.
- Fees paid to local and regional self-government units on whose territory the radioactive waste management facilities owned by the Fund are established or located.
- Operational costs of the Fund.

For the safe management of radioactive waste and spent fuel from Krško NPP, annuities are paid to the Fund by HEP, the co-owner of the NPP. Operating on the 'polluter pays' principle, fees are paid to the Fund by the waste generators and/or owners of the DSRS. For wastes where the owners are unknown or untraceable, as a result of an owner going bankrupt and for orphan sources, the Republic of Croatia is liable for the costs. For the wastes stored within, and the decommissioning of, the storage facilities at IMROH and RBI, the Republic of Croatia is also liable.

It is stated that HEP will pay in the amount of 9.76 million euros per year, on a quarterly basis to the Fund until the Krško NPP ceases to operate or until the planned amount of funds needed to finance the Krško NPP Decommissioning Programme and Krško NPP Radioactive Waste and Spent Nuclear Fuel Disposal Programme are realised. The amount that HEP has to pay is

revaluated every five years based on the revised cost estimates for the Krško NPP Decommissioning Programme and Krško NPP Radioactive Waste and Spent Nuclear Fuel Disposal Programme. In the event that the value of the fund is not sufficient to finance the decommissioning and disposal of radioactive waste and spent fuel from the Krško NPP, the financial obligation is transferred to the Government of the Republic of Croatia.

The Fund is also responsible for increasing the value of the fund by investing the money in certain low risk schemes. The following principles must be considered before an investment is made:

- Investment safety.
- Investment diversity.
- Maintaining appropriate liquidity.

The Fund submits the financial plan each year to the Government for approval. The Fund ensures it discharges its duties with regards to increasing the value of the fund but is conservative and only considers investments such that it is exposed to low risks, according to the Fund's investment policy.

### **ARTEMIS observation**

There is a clear demonstration that Croatia places a very high importance on ensuring that there will be sufficient funds to manage all the radioactive waste it is, and will be, responsible for. Croatia has developed detailed cost estimates for all the activities it expects to be necessary for the safe management of radioactive wastes, from development of facilities through to their decommissioning/closure. Although there is uncertainty associated with disposal facilities to be developed in the future, cost estimates have been developed for such illustrative facilities to indicate the potential liability.

The funding sources for the management of radioactive waste are based on the 'polluter pays' principle and are clearly described. There is a mechanism to regularly review the value of the fund and adjust payments if necessary. The Fund has a duty to increase the value of the fund via investments but adheres to a set of principles such that the fund is only exposed to low risks.

The ARTEMIS Review Team notes that there is not yet a site identified for either the near-surface disposal facility for LLW and ILW or for the geological disposal facility for spent fuel and HLW. Cost estimates for such future facilities are, therefore, inevitably uncertain and will be refined as the programme progresses.

It is recognised that the Republic of Croatia carries a risk that any shortfall in the value of the fund will need to be covered by the state.



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

### **Croatian position**

As a country with no nuclear power plants or research reactors on its territory, Croatia has yet to develop a significant infrastructure for radioactive waste management and this is reflected in the level of human resources allocated to such activities. However, Croatia recognizes that the National Programme will require a significant change in resource requirements for the two main parties, the Fund and the Ministry of the Interior. Croatia's self assessment is that existing human resources in the Republic of Croatia are sufficient for the current level of activity in the area of waste management, but for the implementation of the National Programme, the existing resources are inadequate. There is a need to develop and implement a structured capacity building programme, relying on staff recruitment, retention and training in order to fulfil the human resources required for the implementation of the National programme.

### *Education and training*

Croatia recognizes the need to develop and implement a proper nation-wide education and training programme in order to build the short and long-term human resource needs for the National Programme. To do so, Croatia plans to:

- Establish cooperation with educational, research and scientific institutions for the purpose of professional training and to re-introduce courses covering the issues of radioactive waste, DSRS and spent fuel and methods of their management and, in general, the issue of safety culture.
- organize specialist courses providing practical knowledge in the area of radioactive waste, DSRS and spent fuel management.
- Encourage cooperation between state bodies, the industry and academic community at the national and international level to create a functional framework for support to education and training.
- Align educational programs with professional requirements of the industry and standards of radiological and nuclear safety.
- Encourage cooperation with internationally recognized institutions that have developed radioactive waste, DSRS and spent fuel research, development, and management programs.

### *Ministry of the Interior*

Article 7.a. Point 4 of the Act on Radiological and Nuclear Safety states that the Ministry of the Interior is obliged to employ an appropriate number of staff with qualifications, experience and expertise necessary to fulfil its obligations and may use external scientific and technical resources and expertise in support of its regulatory functions. Human resources are considered a deciding factor in achieving the goals defined in Section 5 of the Strategy.

At the Ministry of the Interior, radiological and nuclear safety activities are performed in the Sector for Radiological and Nuclear Safety, the Sector for Inspection Affairs and the Department for Radiological and Nuclear Emergencies. The total planned number of professional staff within the regulatory body section of the Ministry of the Interior is 32. Currently, 15 are employed, all university graduates in the field of natural sciences, biotechnology and technical sciences, of which 2 have Doctoral degree and 1 has a Masters degree. The Ministry plans to hire two new employees by the end of 2024 according to the government's decision.

The education of the regulatory staff is mostly carried out through IAEA technical cooperation projects, and in cooperation with the European Commission and US Department of Energy, along with other training, meetings, workshops, and fellowships, but also in direct cooperation with universities and scientific institutes.

As a state administration body, the Ministry of the Interior is financed from the state budget. If necessary, the Ministry can use external scientific and technical professional resources for decision-making based on reliable and transparent radiological safety, nuclear safety, and nuclear security requirements (following the legal provisions stipulated in the current legislation).

#### *Radioactive material holder or licence holder*

According to Article 10 of the Ordinance on Management of Radioactive Waste and Disused Sources (OG 88/22), the holder or owner of radioactive material, radioactive waste or disused sources should appoint a person responsible for radioactive waste and disused sources management. That person should have completed an undergraduate or graduate university degree in the field of technical or natural sciences. That person should also have undertaken a special professional training qualification related to handling ionising radiation sources and the application of radiation protection measures which is acquired either through formal education, specialised education or additional education, which shall be substantiated by written evidence. Evaluation and determination of adequate capacities of the person responsible for radioactive waste and disused sources management is performed by the Ministry of the Interior as a part of the process of issuing consent for Radioactive Waste and Disused Sources Management Plan.

#### *Fund – Radioactive Waste Management Center*

The Fund currently employs 7 people in the field of radioactive waste management, who hold degrees in geology and mining, biology and chemistry, electrical and mechanical engineering. There is currently no formal training plan for these employees and training is provided on an individual basis. The employees of the Fund regularly participate in IAEA projects, workshops and training sessions as well as in meetings and training activities organized by the OECD Nuclear energy agency (NEA) and in EURAD projects and meetings. The Fund cooperates with expert, scientific and educational organizations in Croatia in the field of safe management of DSRS, radioactive waste and spent fuel. International best practice experience is gained from cooperation with waste management organizations and technical and scientific organizations from other countries, some of which have signed memorandum of understanding with the Fund. The Fund is a member of ERDO Association that endorses a long-term programme of joint activities aimed at identifying specific solutions for the issues of radioactive waste and spent fuel predisposal and disposal management and advancing joint projects. Membership in ERDO also enables the Fund to exchange experience in the development and implementation of national radioactive waste and spent fuel management programmes with other member countries, and to be involved in the development and participation in joint projects.

Prior to establishment of the RWMC at Čerkezovac, the Fund intends to formalize an annual education and training plan to meet the requirements prescribed by regulations and best industry practices.

#### *External scientific resources*

In the Republic of Croatia, academic and scientific research institutions have been identified, along with their educational and research capabilities for implementation of activities under the National Programme. Research projects conducted in scientific institutions include, but are not limited to, areas such as: the Krško NPP operation safety improvement and assessment, compaction and characterization of operational radioactive waste, monitoring ionising radiation

levels in the environment, assessment of the impact of nuclear and radiological accidents on the environment, etc.

Scientific and research institutions in the Republic of Croatia have the expertise necessary to determine hydrological, geological and seismological characteristics of locations, and prepare and design appropriate buildings and containers. They are also able to conduct safety analyses and environment impact assessments applicable to radioactive waste management projects. If needed, that knowledge may be activated for the purpose of radioactive waste management in the Republic of Croatia at the request and with the coordination of the regulatory authority or organizations responsible for radioactive waste management.

### **ARTEMIS observation**

The ARTEMIS Review Team observes that Croatia has not established a national framework for competence building in preparation for both the short and long-term milestones of the Programme. In particular, for the two main parties, the Fund, as the waste management organization, and the Ministry of the Interior, as the regulatory body, the ARTEMIS Review Team observes that there is insufficient human resources for achieving the short-term goal for the establishment of the RWMC storage facilities and a lack of planning for human resources to reach subsequent goals of the National Programme:

- The Fund has currently only 7 technical staff directly responsible for conducting all activities leading to the implementation of the RWMC storage facilities and therefore is outsourcing all of the main activities (such as the development of conceptual design, safety assessment and safety case of waste management facilities and environmental impact assessment) to external experts. Since the Fund is the ultimate owner of the deliverables of these outsourced activities developed to support the licence/permit applications of the RWMC storage facilities, it needs to have sufficient and competent human resources to review and accept these deliverables.
- There is also insufficient human resources from the Ministry of the Interior for the review of the Safety Case Report and the licence/permit applications for the RWMC storage facilities and waste management facilities in general. The review team was told that the Ministry of the Interior had difficulty in recruiting and retaining staff, especially professional personnel competent in the review of safety cases and safety assessments, which are key supporting activities for both the Safety Case Report and the licence/permit assessment. Even if the Ministry of the Interior can rely on external experts to a certain extent for such reviews, competence is needed within the Ministry to accept the external experts' review results and to ultimately take decisions based on these results.

For the longer term goals of the National Programme (establishment of near-surface and geological disposal facilities) the ARTEMIS Review Team notes that although the need for staff recruitment, retention and competence maintenance is recognized by Croatia, there is no structured capability planning to fulfill that need, either from the Fund or the Ministry of the Interior.

Finally, in-house research is not envisaged for the Fund and independent regulatory research is not being considered by the Ministry of the Interior. The team highlights that engagement of waste management organizations and regulatory bodies in research and development is best international practice in the field of radioactive waste management. This is an important component in waste management programmes, since it helps develop and maintain staff competence, allowing them to make science-based and safety-based conclusions, recommendations or decisions.

## RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES

**Observation:** *The Ministry of the Interior has indicated that it has insufficient human resources for the short term for the review of safety cases in support of the environmental impact assessment and licence application for the RWMC. Furthermore, no long-term planning exists for recruiting and retaining competent staff for the licensing review of future applications, including for the near surface disposal facility and for the disposal of spent fuel and high level waste.*

(1)	<p><b>BASIS: SF1 Principle 2, para. 3.10 states that</b> “<i>The regulatory body must:</i></p> <ul style="list-style-type: none"> <li>— <i>Have adequate legal authority, technical and managerial competence, and human and financial resources to fulfil its responsibilities;</i></li> <li>— <i>Be effectively independent of the licensee and of any other body, so that it is free from any undue pressure from interested parties;[...]</i>”</li> </ul>
(2)	<p><b>BASIS: GSR Part 1 (Rev. 1) Requirement 3 states that</b> “<i>The government, through the legal system, shall establish and maintain a regulatory body, and shall confer on it the legal authority and provide it with the competence and the resources necessary to fulfil its statutory obligation for the regulatory control of facilities and activities.</i>”</p>
(3)	<p><b>BASIS: GSR Part 1 (Rev. 1) Requirement 18 states that</b> “<i>The regulatory body shall employ a sufficient number of qualified and competent staff, commensurate with the nature and the number of facilities and activities to be regulated, to perform its functions and to discharge its responsibilities.[...] 4.12 The human resources plan for the regulatory body shall cover recruitment and, where relevant, rotation of staff in order to obtain staff with appropriate competence and skills, and shall include a strategy to compensate for the departure of qualified staff.</i>”</p>
R10	<p><b>Recommendation: The Government should urgently address the human resource needs of the regulatory body in the short term for the environmental impact assessment review and licensing review for the RWMC. The government should also plan to provide sufficient human resources for future phases of the radioactive waste management programme. Planning should be provided for developing and maintaining staff competence through formal training.</b></p>

## 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 few years. Currently, the Fund has seven technical staff responsible for the safe implementation of the programme, and has identified the need to increase its human resources in order to fulfill its responsibility.*

(1)	<p><b>BASIS: SF1 Principle 1, para. 3.6 states that:</b> <i>“The licensee is responsible for:</i></p> <ul style="list-style-type: none"> <li><i>— Establishing and maintaining the necessary competences;</i></li> <li><i>— Providing adequate training and information;</i></li> <li><i>— Establishing procedures and arrangements to maintain safety under all conditions;</i></li> <li><i>— Verifying appropriate design and the adequate quality of facilities and activities and of their associated equipment;</i></li> <li><i>— Ensuring the safe control of all radioactive material that is used, produced, stored or transported;</i></li> <li><i>— Ensuring the safe control of all radioactive waste that is generated.”</i></li> </ul>
(2)	<p><b>BASIS: GSR Part 2 Requirement 9 states that</b> <i>“Senior management shall determine the competences and resources necessary to carry out the activities of the organization safely and shall provide them.”</i></p>
R11	<p><b>Recommendation:</b> <b>The Fund should continuously evaluate the particular human resource needs in meeting its responsibilities for safe management of radioactive waste and spent fuel, both for the short and long term. The Fund should develop a plan for staff recruitment and retention, and maintenance of competence through training and/or research, development and demonstration. That plan should be mapped to the needs, objectives and milestones of the radioactive waste management programme.</b></p>

## APPENDIX A: TERMS OF REFERENCE

### Terms of Reference

#### 1. Introduction

On 10 December 2018, the Croatian Fund for financing the decommissioning of Krško NPP and the disposal of Krško NPP radioactive waste and spent nuclear fuel (“the Fund”) requested the International Atomic Energy Agency (IAEA) to organize and carry out, in the second half of 2021, an Integrated Review Service for Radioactive Waste and Spent Fuel, Decommissioning and Remediation (ARTEMIS) review. In July 2020, the Civil Protection Directorate of the Ministry of the Interior further requested IAEA to postpone the ARTEMIS mission until the first half of 2023.

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

The review will be performed by an international peer review team selected by the IAEA.

The ARTEMIS review will be led by the IAEA Department of Nuclear Safety and Security who will be supported by the IAEA Department of Nuclear Energy.

#### 2. Objective

The ARTEMIS review will provide an independent, international evaluation of the Croatian national framework, including the competent regulatory authority, and the implementation of the national programme for the safe and sustainable management of spent fuel and radioactive waste.

#### 3. Scope

The ARTEMIS review will evaluate the Croatian national framework, strategy and national programme for fulfilling the country’s obligations for safe and sustainable management of spent fuel and radioactive waste. In addition, the review will address amendments to the National Programme for the Implementation of the Radioactive Waste, Disused Sources and Spent Nuclear Fuel Management Strategy (Programme for the period until 2025 with a view until 2060).

Special emphasis will be given in the review to the following:

- Management of radioactive waste from the Krško NPP.
- Establishment of the Radioactive Waste Management Center.

It was agreed to exclude from the review consideration of the following:

- Remediation of NORM locations in Croatia.

Results from the IAEA Integrated Regulatory Review Service (IRRS) Follow-up mission to Croatia conducted in October 2019 will be taken into account as appropriate to avoid unnecessary duplication.

#### **4. Basis for the review**

The ARTEMIS review will be based on the relevant IAEA Safety Standards and proven international practice and experiences, following the guidelines (Version 2, December 2018) of the ARTEMIS review service.

#### **5. 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.

All documents for the purpose of the ARTEMIS review shall 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.

#### **6. Modus operandi**

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

The National Counterpart is the Croatian Fund for financing the decommissioning of Krško NPP and the disposal of Krško NPP radioactive waste and spent nuclear fuel. The National Counterpart Liaison Officer for the review is Ms Andrea Rapić.

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

- Self-assessment questionnaire: available to Croatia as of 5 May 2021.
- Preparatory Meeting: 16 January 2023 (WebEx meeting).
- Notification by IAEA to the Counterparts on the review team composition by 16 January 2023.
- Submission of reference material by 17 March 2023 (including the completed self-assessment).
- Submission of questions from the review team to the National Counterpart based on preliminary review of the reference material by 26 May 2023.
- The ARTEMIS review mission will be conducted from 11 to 19 June 2023 in Zagreb, Croatia. The provisional schedule for the review mission is provided in Annex 2.



## **7. International peer review team**

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

- Five qualified and recognized international experts from government authorities, regulatory bodies, waste management organizations, or technical support organizations with experience in the safe management of radioactive waste.
- Two IAEA staff to coordinate the mission. The Coordinator of the ARTEMIS review is Mr David Bennett from the Waste and Environmental Safety Section of the Department of Nuclear Safety and Security of IAEA. The Deputy Coordinator is Ms Felicia Dragolici from the Waste Technology Section of the Department of Nuclear Energy of IAEA.
- One IAEA staff for administrative support.

A senior staff member from the Department of Nuclear Safety and Security of IAEA will oversee the closure of the review.

The peer review team will be led by a Team Leader from the review team, Amelie de Hoyos from IRSN, France. 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 Counterpart will be notified of any proposed observers; the presence of any observers will be agreed in advance of the mission.

## **8. Reporting**

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

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

## **9. Funding of the ARTEMIS review**

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

The cost of the ARTEMIS review were paid to the IAEA as voluntary contribution before the start of the mission. Croatia is aware that the review cost includes 7% programme support costs. If it is necessary to pay VAT, then VAT shall be paid by the Fund according to Croatian financial laws

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

**These Terms of Reference were agreed on 16 January 2023 between the IAEA and the Croatian Fund for financing the decommissioning of Krško NPP and the disposal of Krško NPP radioactive waste and spent nuclear fuel, on behalf of the Government of Croatia, during the preparatory meeting held on-line.**

## **Annex 1: List of reference material**

1. *Responses to the ARTEMIS Self-assessment Questionnaire*
2. *Laws, regulations and regulatory guidelines (including waste classification, concept of clearance, radiation sources categorization)*
3. *Overview of the constitutional and legal framework in Croatia*
4. *National Programme for Radioactive Waste Management*
5. *Radioactive Waste, Disused Sources and Spent Nuclear Fuel Management Strategy 7th National Report of Croatia on the implementation of the obligations of the Joint Convention*
6. *Questions and answers to the 7th JC National Report*
7. *IRRS Follow-up Mission Report*
8. *3rd National Report on the implementation of Council Directive 2011/70/Euratom (2021)*
9. *Amendments to the National Programme the period until 2025 with a view until 2060*
10. *3rd Revision of the Krško NPP Decommissioning Programme and Radioactive Waste and Spent Fuel Disposal Programme*

## APPENDIX B: MISSION PROGRAMME

Time	Sun, 11 June	Mon, 12 June	Tue, 13 June	Wed, 14 June	Thurs, 15 June	Fri, 16 June	Sat, 17 June	Sun, 18 June	Mon, 19 June
9h00 – 10h00	Arrival of Team Members	<b>Opening</b> General presentation	Depart 8h00 Visit to Krško NPP (tbc)  &	Inventory of Institutional Waste	Session reserved for further discussions if required/ drafting of the report	Presentation and discussions of Recommendations and Suggestions with the Counterparts	Drafting of the report  Draft report to be sent to the Counterparts	Internal reflection on comments  10h30 Discussions with the Counterparts on the draft report	<b>Exit Meeting</b>  Delivery of final draft report
10h00 - 12h00		National Policy and Framework	Inventory of SF and RW	Safety case and safety assessment					
12h00 - 13h00		Lunch	Lunch	Lunch	Lunch	Lunch	Lunch	Lunch	Lunch
13h00 – 16h00		National Strategy	Return to Zagreb by 14h00  Concepts, Plans and technical solutions	Cost estimates and financing  Capacity building	Finalization of Recommendations and Suggestions	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	Drafting of the report	Drafting of the report	Drafting of the report	Drafting of the report				

## APPENDIX C: RECOMMENDATIONS AND SUGGESTIONS

Area		R: Recommendations S: Suggestions G: Good Practices	Recommendations, Suggestions or Good Practices
1.	<b>NATIONAL POLICY AND FRAMEWORK FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT</b>	R1	The Ministry of the Interior should initiate without delay a revision of the Strategy and National Programme to provide clarity and consistency for planning, communication and decision making, including on the roles of the relevant organizations, planning assumptions and programme milestones.
		R2	The Ministry of the Interior should ensure that the storage facilities at IMROH and RBI are required to comply with safety requirements, including clear allocation of ownership of waste and sources, and responsibilities for safety and monitoring of the facilities.
		R3	The Ministry of the Interior should undertake inspections of all facilities that store sources and waste, including IMROH and RBI.
		R4	The Ministry of the Interior should update site selection criteria for the near surface disposal facility.

Area		R: Recommendations S: Suggestions G: Good Practices	Recommendations, Suggestions or Good Practices
2.	<b>NATIONAL STRATEGY FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT</b>	R5	The Ministry of the Interior, in consultation with the Fund and other relevant Governmental Bodies, should enhance arrangements for the planning, monitoring and delivery of the National Programme, including measures for identifying, reporting and mitigating programme risks, and for taking corrective actions as appropriate.
		S1	The Government should consider urgently providing arrangements for the safe and secure centralized storage of institutional waste in Croatia.
		S2	The Fund should consider identifying back-up strategies for waste storage in case the disposal facility is not ready to accept the waste at the point when Croatia is obliged to accept it from the Krško NPP.
3.	<b>INVENTORY OF SPENT FUEL AND RADIOACTIVE WASTE</b>	S3	The Ministry of the Interior should consider revising the waste classification in Article 4 of the Ordinance on management of radioactive waste and disused sources to provide well-defined boundaries between waste classes and to support mapping between the waste classes and disposal arrangements defined in the National Strategy.
		R6	The Ministry of the Interior should complete the Central Registry of Radioactive Waste and Disused Sources and take it into use.

Area		R: Recommendations S: Suggestions G: Good Practices	Recommendations, Suggestions or Good Practices
4.	<b>CONCEPTS, PLANS AND TECHNICAL SOLUTIONS FOR SPENT FUEL AND RADIOACTIVE WASTE MANAGEMENT</b>	R7	The Fund should finalise WAC for the RWMC storage facilities at the Čerkezovac site and submit them to the regulator for approval in a timely fashion to allow receipt and safe storage of the waste packages.
		S4	The Ministry of the Interior, in consultation with other relevant bodies, should consider developing guidance on siting a geological disposal facility.
5.	<b>SAFETY CASE AND SAFETY ASSESSMENT OF RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT ACTIVITIES AND FACILITIES</b>	R8	The Ministry of the Interior should develop guidance stating regulatory expectations for safety assessments to support authorization of radioactive waste storage and disposal facilities.
		R9	The Ministry of the Interior should require safety demonstrations to be developed for the storage facilities at IMROH and RBI.
		S5	The Fund should consider revising its plans to allow enough time for the development and regulatory review of the safety assessment at the level of detail that is necessary to apply for the RWMC location permit.
7.	<b>CAPACITY BUILDING FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT – EXPERTISE,</b>	R10	The Government should urgently address the human resource needs of the regulatory body in the short term for the environmental impact assessment review and licensing review for the RWMC. The government should also plan to provide sufficient human resources for future phases of the radioactive waste management programme. Planning should be provided for developing and maintaining staff competence through formal training.



Area	<b>R:Recommendations</b> <b>S: Suggestions</b> <b>G: Good Practices</b>	<b>Recommendations, Suggestions or Good Practices</b>
<b>TRAINING AND SKILLS</b>	R11	<p>The Fund should continuously evaluate the particular human resource needs in meeting its responsibilities for safe management of radioactive waste and spent fuel, both for the short and long term. The Fund should develop a plan for staff recruitment and retention, and maintenance of competence through training and/or research, development and demonstration. That plan should be mapped to the needs, objectives and milestones of the radioactive waste management programme.</p>

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

DSRS	Disused Sealed Radioactive Sources
HEP	Hrvatska elektroprivreda d.d. (Croatian electricity company)
IAEA	International Atomic Energy Agency
IMROH	Institute for Medical Research and Occupational Health
IRRS	Integrated Regulatory Review Service
MoI	Ministry of the Interior
NEK	Nuklearna elektrarna Krško - a joint venture between the publically owned Slovenian and Croatian energy companies
The Fund	The Fund for financing the decommissioning of the Krško Nuclear Power Plant and the disposal of Krško NPP radioactive waste and spent nuclear fuel
RBI	Ruđer Bošković Institute for scientific research
RWMC	Radioactive Waste Management Center

## **APPENDIX E: IAEA REFERENCE MATERIAL USED FOR THE REVIEW**

- [1] EUROPEAN ATOMIC ENERGY COMMUNITY, FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANIZATION, INTERNATIONAL MARITIME ORGANIZATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, UNITED NATIONS ENVIRONMENT PROGRAMME, WORLD HEALTH ORGANIZATION, Fundamental Safety Principles, IAEA Safety Standards Series No. SF-1, IAEA, Vienna (2006).
- [2] INTERNATIONAL ATOMIC ENERGY AGENCY, Governmental, Legal and Regulatory Framework for Safety, IAEA Safety Standards Series No. GSR Part 1 (Rev. 1), Vienna (2016).
- [3] INTERNATIONAL ATOMIC ENERGY AGENCY, Leadership and Management for Safety, IAEA Safety Standards Series No. GSR Part 2, IAEA, Vienna (2016).
- [4] EUROPEAN COMMISSION, FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANIZATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, UNITED NATIONS ENVIRONMENT PROGRAMME, WORLD HEALTH ORGANIZATION, 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, Predisposal Management of Radioactive Waste, IAEA Safety Standards Series No. GSR Part 5, IAEA, Vienna (2009).
- [6] INTERNATIONAL ATOMIC ENERGY AGENCY, Disposal of Radioactive Waste, IAEA Safety Standards Series No. SSR-5, IAEA, Vienna (2011).
- [7] 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).
- [8] INTERNATIONAL ATOMIC ENERGY AGENCY, IAEA Nuclear Safety and Security Glossary 2022 (Interim) Edition, IAEA Non-serial Publications, IAEA, Vienna (2022).
- [9] 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).
- [10] INTERNATIONAL ATOMIC ENERGY AGENCY, Leadership, Management and Culture for Safety in Radioactive Waste Management, IAEA Safety Standards Series No. GSG-16, IAEA, Vienna (2022).
- [11] INTERNATIONAL ATOMIC ENERGY AGENCY, Classification of Radioactive Waste, IAEA Safety Standards Series No. GSG-1, IAEA, Vienna (2009).
- [12] INTERNATIONAL ATOMIC ENERGY AGENCY, Predisposal Management of Radioactive Waste from the Use of Radioactive Material in Medicine, Industry, Agriculture, Research and Education, IAEA Safety Standards Series No. SSG-45, IAEA, Vienna (2019).

## APPENDIX F: SITE VISIT

### Site visit to the Krško Nuclear Power Plant (NPP)

A site visit to the Krško NPP was organized for the ARTEMIS Review Team. The Republic of Croatia will be jointly responsible for the spent fuel arising from, and decommissioning of, the NPP as well as half of the operational waste arising from the NPP. The visit provided the opportunity to see the Krško NPP, hear about the management of low and intermediate level waste and learn about the new dry fuel store. The team was welcomed by Saša Medaković, a member of the NPP Management Board.

The first presentation was given by Matjaž Gričar (Project Manager), on the predisposal management of low and intermediate level waste in the Krško NPP. During operations of the NPP gaseous, liquid and solid radioactive wastes are generated. The gaseous wastes are processed to remove fission product gases before being transferred to a long-term storage tank. Liquid wastes are collected and sampled before either being released under controlled conditions or treated to reduce their volume. Solid wastes are segregated at source and wherever possible routed for volume reduction through treatment routes such as incineration, compaction or melting. The remaining wastes are placed into the appropriate packages and then stored in the radioactive waste storage building on site. There is currently 2358m<sup>3</sup> of solid radioactive waste in storage. The Intergovernmental Agreement between Croatia and Slovenia requires that each country takes possession of half of the operational waste generated up to 2023 (the original planned date of closure of the NPP), during the period 2023 to 2025. The NPP is ready to start the first phase of low and intermediate level waste handover.

The second presentation was given by Rok Bizjak, (Project Manager), on spent dry fuel storage at the Krško NPP. Since the beginning of power plant operations, used fuel has been stored in the reactor's storage pool. Originally, it had been planned that a dry store for the fuel would be developed sometime in the late 2040s. An outcome of the stress test reassessment conducted following events in 2011 was that implementation of the dry store should be accelerated, with construction taking place in the early 2020s. The dry store was completed in January 2023 and received its operating permit by the end of that month. The storage system comprises of fuel elements within a multi-purpose container, placed inside an overpack (a cask). The store has capacity for 60 casks, which is enough for the expected production of spent fuel over the extended lifetime of power plant operations to 2043, together with an allowance for contingency. The first campaign for fuel transfer to the store was underway at the time of the visit, with nine casks already emplaced. Up to two more fuel transfer campaigns are foreseen in the future.

The visit concluded with a tour of the NPP site lead by Andrej Kavčič (Head of Nuclear Fuel Management Department) which the ARTEMIS Review Team found very informative. The review team would like to thank Ida Novak Jerele (Public Relations) for arranging the visit.



*The ARTEMIS review team at the Krško NPP*