Pursuant to paragraph one of Article 124 of the Ionising Radiation Protection and Nuclear Safety Act (Official Gazette of the Republic of Slovenia) [*Uradni list RS*], Nos 76/17, 26/19 and 172/21) and Article 109 of the Rules of Procedure of the National Assembly (Official Gazette of the Republic of Slovenia) [*Uradni list RS*], Nos 92/07, 105/10, 80/13, 38/17, 46/20, 105/21 – Constitutional Court Decision and 111/21), the National Assembly of the Republic of Slovenia, at its session of 27 January 2023, adopted the

**RESOLUTION**

**on the National Programme for Radioactive Waste and Spent Fuel Management for the 2023–2032 Period (ReNPRROIG23–32)**

1. INTRODUCTION

Slovenia uses nuclear and radiation technologies in many economic and other fields, which results in the generation of radioactive waste that needs to be safely managed at every stage of radioactive waste management, from generation to disposal.

The main objective of the national programme for radioactive waste and spent fuel management (hereinafter: the national programme) is to ensure the safe and efficient management of radioactive waste and spent fuel in Slovenia in accordance with the principles of decision-making and actions based on the latest findings of domestic and foreign research, cutting-edge technologies and the best practices and operating experience, so as to ensure the safety of people and the environment at all times and provide long-term, technologically modern and economical infrastructure support to the users of nuclear and radiation technologies. For the purpose of this Resolution, the safe management of radioactive waste also includes the physical security thereof, and the safe management of spent fuel also includes the physical security thereof and all measures against nuclear proliferation.

The national programme is also the basis for ensuring compliance with Article 11 of 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 (OJ L 199, 2.8.2011, p. 48; hereinafter: Directive 2011/70/Euratom), which requires that each Member State ensure the implementation of its national programme covering all types of spent fuel and radioactive waste under its jurisdiction and all stages of spent fuel and radioactive waste management from generation to disposal.

The drafting and adoption of the national programme are carried out in accordance with Article 124 of the Ionising Radiation Protection and Nuclear Safety Act (Official Gazette of the Republic of Slovenia [*Uradni list RS*], Nos 76/17, 26/19 and 172/21; hereinafter: ZVISJV-1) [1]. The first national programme was adopted in 2006 by way of the Resolution on the National Programme for Radioactive Waste and Spent Nuclear Fuel Management for the 2006–2015 Period (Official Gazette of the Republic of Slovenia [*Uradni list RS*], No 15/06), which was amended in 2016 by the Resolution on the National Programme for Radioactive Waste and Spent Nuclear Fuel Management for the 2016–2025 Period (Official Gazette of the Republic of Slovenia [*Uradni list RS*], No 31/16; hereinafter: the ReNPRRO16–25). This resolution determined the national policy and strategy and the national programme for managing radioactive waste and spent fuel in accordance with Directive 2011/70/Euratom and the Ionising Radiation Protection and Nuclear Safety Act applicable at that time (Official Gazette of the Republic of Slovenia [*Uradni list RS*], Nos 102/04 – official consolidated version, 70/08 – ZVO-1B, 60/11 and 74/15).

The management of radioactive waste and spent fuel as set out in the Resolution on the National Programme for Radioactive Waste and Spent Fuel Management for the 2023–2032 Period (hereinafter: ReNPROIG23–32) is based on the current concept, as applied in the ReNPRRO16–25. No new or different facilities for managing radioactive waste and spent fuel are planned. In accordance with the requirements of the applicable legislation, the assessments of environmental impact in Slovenia and transboundary environmental impact have been carried out and, based on these assessments, relevant environmental approvals have been issued for the facilities discussed in the ReNPROIG23–32. The ReNPROIG23–32 has been drafted as a continuation and update of the ReNPRRO16–25 to remedy a few instances of non-compliance with Directive 2011/70/Euratom, pursuant to the new ZVISJV-1 adopted in 2017 and all the regulations adopted on its basis. The ReNPROIG23–32 should be adopted primarily due to the improved estimates of radioactive waste and spent fuel inventories for all facilities and practices throughout the period of validity. Since the adoption of the ReNPRRO16–25, the majority of key input documents estimating the quantities of radioactive waste and spent fuel during operation and decommissioning have been supplemented. The Decommissioning Programme for the Central Storage Facility for Radioactive Waste and the Decommissioning Programme for the TRIGA Mark II Nuclear Reactor were revised for the first time, and the Decommissioning Programme for the Krško Nuclear Power Plant and the Programme for the Disposal of Radioactive Waste and Spent Fuel from the Krško Nuclear Power Plant for the third time. These documents also changed the timeline for particular activities. All costs of radioactive waste and spent fuel management were re-evaluated for every facility and activity involved in radioactive waste and spent fuel management throughout the facilities’ service life. The Integrated National Energy and Climate Plan of the Republic of Slovenia and the Resolution on Slovenia's Long-Term Climate Strategy until 2050 have also been adopted since the adoption of the ReNPRRO16–25. Based on these documents, the research and development activities were redefined. The ReNPROIG23–32 also takes into account the results of the international review mission carried out by ARTEMIS (Integrated Review Service for Radioactive Waste and Spent Nuclear Fuel Management, Decommissioning and Remediation) organised by the International Atomic Energy Agency, which reviewed the draft ReNPROIG23–32. Key indicators for achieving the main objectives and strategies have been added to Chapter 4 of this Resolution to enable more effective monitoring of the progress and implementation of the planned measures. The content of the aforementioned documents interferes substantially with the currently applicable ReNPRRO16–25 in terms of both content and the presented timeline. Consequently, a new resolution for the next decade must be adopted before the expiry of the current resolution.

1.1 NUCLEAR AND RADIATION FACILITIES AND THE USE OF RADIATION SOURCES IN SLOVENIA

Slovenia's nuclear programme is relatively small in scale and the ownership of the largest nuclear facility is shared with neighbouring Croatia. The Slovenian nuclear programme comprises one operating nuclear power plant, one operating research reactor, one operating central facility for the storage of institutional radioactive waste generated in industry, research and medicine, and a repository of low- and intermediate-level radioactive waste (hereinafter: LILW repository), which is currently in the construction stage. There are also repositories for mining and hydrometallurgical tailings at the site of the closed uranium mine in Žirovski Vrh.

The largest and most important nuclear facility in the country is the Krško Nuclear Power Plant (hereinafter: Krško NPP), which is jointly owned by Slovenia and Croatia. The construction of the power plant, supplied by the US company Westinghouse, began in 1974. The first fuel loading took place in 1981 and in the same year the plant was synchronised with the power grid. The plant began operating commercially in 1983. In 2012 the Slovenian Nuclear Safety Administration (hereinafter: SNSA) issued a decision approving changes to the safety analysis report so as to allow the Krško NPP’s projected service life to be extended. In 2013, the Krško NPP began implementing a safety upgrade programme pursuant to the Post-Fukushima National Action Plan following the EU stress tests. The safety upgrade programme was completed in 2021, except the dry storage facility for spent fuel, which will be completed by the end of 2022. The Krško NPP started building a dry storage facility at the beginning of 2021. It is planned to be operational in 2023. The operation of the Krško NPP can be extended from the previously expected end of the basic service life in 2023 to 2043, provided that the outcome of the environmental impact assessment is favourable, the environmental approval for the extended operation is granted and the periodic safety reviews in 2023 and 2033 are successfully passed.

In July 2021, the Ministry of Infrastructure granted an energy permit to the investor, Gen energija, d.o.o., for the Krško Nuclear Power Plant 2 energy project (hereinafter: Krško NPP 2). [2]

The second nuclear facility in Slovenia is the TRIGA Mark II research reactor, which is operated by the Jožef Stefan Institute. It was built in 1966. In 1991, the facility was reconstructed, renovated and adapted for pulsed operation. It is used for research purposes. By way of decision of the SNSA No 3570-13/2014/15 of 24 December 2014 and the decision of the Scientific Council of the Jožef Stefan Institute of 18 June 2015, the operation of the reactor was extended at least until the conclusion of the next periodic safety review, i.e. until the end of 2024.

The Central Storage Facility for Radioactive Waste (hereinafter: CSF) is located in Brinje, in the immediate vicinity of the research reactor, and is intended for the storage of institutional low- and intermediate-level solid radioactive waste not originating from nuclear power generation facilities but from other activities. In April 2018, following the successfully passed periodic safety review of the facility, the operation of the CSF was extended until April 2028 by way of decision of the SNSA No 3570-5/2018/23. In view of the planned standby period of the LILW repository, when the facility will not accept and deposit any LILW or carry out other extensive works on the repository, and in view of the quantities of institutional radioactive waste expected to be generated in industry, research and medicine in Slovenia, it is essential that the CSF continue to operate after 2028.

The Žirovski Vrh Uranium Mine extracted uranium ore from 1982 until 1990. After the mine was closed, the processing plant and other mine facilities were decommissioned and the area remediated. Two repositories of mining and hydrometallurgical tailings still remain on the site of the closed mine, the Jazbec repository and the Boršt repository. After the remediation was concluded, the Jazbec repository of mining tailings was closed in 2015 and its management was transferred to the Radioactive Waste Management Agency (*Agencija za radioaktivne odpadke*, hereinafter: ARAO). In order to ensure radiation safety, the long-term monitoring and maintenance of the closed Jazbec repository, where the material with increased concentration of naturally occurring radionuclides was deposited, has been carried out since 2015 by ARAO as part of the mandatory national service of general economic interest of managing radioactive waste (hereinafter: the mandatory SGEI of radioactive waste management). To this end, the Decree on the method, subject and conditions for the provision of the mandatory national service of general economic interest of the long-term monitoring and maintenance of repositories of mining and hydrometallurgical tailings generated in the extraction and exploitation of nuclear minerals (Official Gazette of the Republic of Slovenia *[Uradni list RS]*, No 76/15) was adopted in October 2015.

Additional remediation measures were carried out at the Boršt repository of hydrometallurgical tailings in 2019 to ensure the long-term stability of the repository. The safety report for the repository was also revised. An approved expert in radiation and nuclear safety issued an expert opinion on the activities carried out and on the content of the safety report with regard to the repository's radiation safety and stability, which was required for a permit to close the repository. It is expected that in 2023 the required conditions will be ensured and all the necessary procedures carried out to close the repository, transfer its management and start its long-term monitoring and maintenance, which is carried out by ARAO as part of the SGEI of radioactive waste management.

No radiation protection measures for the population and workers are required in the area of the closed Jazbec and Boršt repositories, as the repositories are remediated and closed. The Boršt hydrometallurgical tailings repository is expected to be closed by the end of 2023.

In December 2009, the Decree on the national spatial plan for a low- and intermediate-level waste repository in Vrbina in the Municipality of Krško (Official Gazette of the Republic of Slovenia [*Uradni list RS*], Nos 114/09 and 50/12) was adopted [3], which approved the location and type of repository. In April 2019, following the examination and supplementation of the documents for the LILW repository, which included the environmental impact report, the draft safety report, the conceptual design, the design basis, the expert opinion of an approved expert in radiation and nuclear safety and other reference documents, the SNSA issued a draft prior consent with regard to nuclear and radiation safety. At the end of 2019, a transboundary environmental impact assessment procedure was initiated, which was carried out throughout 2020 and the first half of 2021 and successfully concluded in June 2021. Following the public display of documentation in 2020 and public debate, the LILW repository project was granted environmental approval by way of decision No 35402-29/2017-169 adopted by the Slovenian Environment Agency on 30 June 2021 and a supplementary decision on environmental approval, No 35402-29/2017-172 of 5 July 2021. In January 2022, the SNSA approved the safety analysis report for the Vrbina LILW repository, Krško (November 2021 [4]), by issuing opinion No 3510-3/2019/162 [5] on the construction of the LILW repository.

The building permit for the LILW repository nuclear facility, phase 1 and phase 2 repository facilities, permit No 35105-95/2021-2550/37, was issued on 27 July 2022. Construction is expected to start at the beginning of 2023, and to be completed in 2026. According to the repository timetable, trial operation is planned to start in the second half of 2026 and regular operation in the second half of 2027.

In addition to the above-listed nuclear and radiation facilities, Slovenia also uses sources of ionising radiation in many activities in industry, research and human and veterinary medicine.

1.2 RADIOACTIVE WASTE

The ZVISJV-1 [1] defines radioactive waste as radioactive materials in gaseous, liquid or solid form which are not expected or planned to be further used in accordance with the regulations governing ionising radiation protection and nuclear safety. A more detailed classification of radioactive waste with regard to its level and type of radioactivity and physical state is set out in the Rules on radioactive waste and spent fuel management (Official Gazette of the Republic of Slovenia [*Uradni list RS*], No 125/21) [6].

Under the Rules on radioactive waste and spent fuel management, radioactive waste in solid form is classified into the following categories, depending on the level and type of radioactivity: transient radioactive waste, very low-level radioactive waste, low- and intermediate-level radioactive waste (hereinafter: LILW), high-level radioactive waste (hereinafter: HLW), and radioactive waste containing naturally occurring radionuclides.

The Slovenian legislation defines spent fuel as "nuclear fuel [1] that has been irradiated in a reactor core and permanently removed from it". Spent fuel can be treated as useful material that can be reprocessed or radioactive waste that must be disposed of. By reprocessing spent fuel, processed uranium and plutonium are obtained, which can be used as raw material for new nuclear fuel. Radioactive waste generated in the reprocessing of spent fuel is classified as HLW containing radionuclides, the decay of which generates such heat that it must be taken into account in its management.

In addition to classifying radioactive waste, the Rules also govern the written procedures, radioactive waste and spent fuel management programmes, radioactive waste management plans, procedures for the sorting, processing, packaging, labelling, storage, decay-storage, movement, handover and acceptance of radioactive waste and spent fuel, the discharge and disposal of radioactive waste, the acceptance criteria for storage and disposal, the special requirements for managing waste from the extraction and processing of nuclear minerals and very low-level radioactive waste. An important part of the management governed by the Rules is related to reporting information on the generation and management of radioactive waste or spent fuel, and on the register of holders and the central register of radioactive waste and spent fuel.

1.3 APPLICABLE NATIONAL LEGISLATION AND INTERNATIONAL AGREEMENTS

The Constitution of the Republic of Slovenia (Article 72) [7] provides, among other things, that everyone has the right to a healthy living environment, which is to be ensured by the state. To this end, the conditions and manner in which economic and other activities are pursued are established by law. These provisions of the Constitution form the regulatory basis for nuclear and radiation safety. The Slovenian legislation regulating radioactive waste management is comprehensive and in line with international standards. In terms of practical application, the area is governed by the ZVISJV-1 and implementing regulations based thereon. Pursuant to this Act, six decrees have been adopted by the Government, ten sets of rules by the minister responsible for the environment, nine sets of rules by the minister responsible for health, and one set of rules and one decree by the minister responsible for internal affairs. Following more than fifteen years of application of the Act, several major amendments that changed or supplemented some key solutions and, in particular, the adoption of new EU directives on radiation protection and nuclear safety, more comprehensive regulation of nuclear and radiation safety was introduced in 2017 with the adoption of a new Ionising Radiation Protection and Nuclear Safety Act (Official Gazette of the Republic of Slovenia [*Uradni list RS*], No 76/17) and new implementing regulations. The Act was amended in 2019 and 2021. The amendments were mostly related to ensuring the physical security of nuclear facilities and nuclear and radioactive material and the security clearance process (2019) and to additional regulation of the mandatory SGEI of radioactive waste management and harmonisation with Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation. However, the main objectives, principles and proposed solutions, including the Act's structure and system, remained the same.

Slovenia has transposed into national law the fundamental safety standards of the International Atomic Energy Agency. During the EU accession negotiations, Slovenia aligned its legislation with that of the EU. Upon accession to the EU in 2004, there was no need to significantly amend the legislation governing nuclear and radiation safety, since the area had already been regulated in an exemplary manner. Slovenia also actively participated in the drafting of Council Directive 2009/71/Euratom establishing a Community framework for the nuclear safety of nuclear installations (OJ L 172, 2.7.2009, p. 18; hereinafter: Directive 2009/71/Euratom). In 2011, the European Commission adopted Directive 2011/70/Euratom, and Slovenia fully harmonised its national legislation with the Directive in January 2013. The adoption of the ZVISJV-1 and its amendments also transposed Council Directive 2013/59/Euratom of 5 December 2013 laying down the basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom (hereinafter: Directive 2013/59/Euratom) into the Slovenian legal system.

The European Commission adopted Commission Delegated Regulation (EU) 2022/1214 of 9 March 2022 amending Delegated Regulation (EU) 2021/2139 as regards economic activities in certain energy sectors and Delegated Regulation (EU) 2021/2178 as regards specific public disclosures for those economic activities (OJ L 188, 15.7.2022, hereinafter: Commission Delegated Regulation (EU) 2022/1214), which is applicable from 1 January 2023 and is binding in its entirety and directly applicable in all Member States. Among other things, this Delegated Regulation lays down technical criteria concerning the economic activity of electricity generation from nuclear energy in existing installations and the construction and safe operation of new nuclear power plants for the generation of electricity or heat, for an economic activity to qualify as contributing substantially to climate change mitigation or climate change adaptation and for determining whether this economic activity causes significant harm to any other environmental objective.

Since 2003, the joint ownership of the Krško NPP has been governed by the Agreement between the Government of the Republic of Slovenia and the Government of the Republic of Croatia on the Regulation of the Status and Other Legal Relations Regarding Investment in and the Exploitation and Decommissioning of the Krško Nuclear Power Plant (Official Gazette of the Republic of Slovenia – International Treaties [*Uradni list RS – MP*], No 5/03; hereinafter: the Slovenian-Croatian Agreement on the Krško NPP). This Agreement regulates the two countries' mutual relations concerning the status, exploitation and decommissioning of the Krško NPP and the management of its radioactive waste and spent fuel. Under this Agreement, the two contracting parties are equally responsible for ensuring all material conditions, whereas the supervision of nuclear and radiation safety is the sole responsibility of Slovenia. The contracting parties agreed on the common obligation to ensure an effective solution to the decommissioning and disposal of radioactive waste and spent fuel in terms of both the economic aspect and environmental protection. The Agreement also provides that the decommissioning of the Krško NPP and the disposal of radioactive waste and spent fuel from the power plant's operation and decommissioning are to be carried out in accordance with the disposal and decommissioning programmes, which are to be approved by the intergovernmental commission and revised at least every five years.The decommissioning programme must also be approved by the Slovenian administrative authority responsible for nuclear safety.

The ZVISJV-1 provides for the establishment of a mandatory national service of general economic interest to manage and dispose of radioactive waste, which must be provided by the state in accordance with the regulations governing services of general economic interest. To this end, the Decree on the method and conditions for providing the mandatory national public service of general economic interest of radioactive waste management (Official Gazette of the Republic of Slovenia [*Uradni list RS*], No 8/22) [8] and the Ordinance establishing the ARAO Public Utility Institute (Javni gospodarski zavod ARAO) – Radioactive Waste Management Agency (Official Gazette of the Republic of Slovenia [*Uradni list RS*], No 8/22; hereinafter: the Ordinance on the establishment of ARAO) [9] were adopted, which determine the method and conditions for providing the public service, its organisational form, financing and the price list for its services and activities, and other issues relevant to carrying out all organisational and physical activities related to radioactive waste and spent fuel management.

The following legislation regulates the wider area of nuclear and radiation safety: the Nuclear Damage Liability Act (Official Gazette of the Republic of Slovenia Gazette [*Uradni list RS*], No 77/10); the Control of the Export of Dual-Use Goods Act (Official Gazette of the Republic of Slovenia [*Uradni list RS*], Nos 37/04 and 8/10), which regulates the controls for dual-use goods (i.e. goods that could be used to make nuclear weapons); the Transport of Dangerous Goods Act (Official Gazette of the Republic of Slovenia [*Uradni list RS*], Nos 33/06 – official consolidated version, 41/09, 97/10 and 56/15); the Act Governing the Public Fund of the Republic of Slovenia for Financing the Decommissioning of the Krško Nuclear Power Plant and the Disposal of Radioactive Waste from the Krško Nuclear Power Plant (Official Gazette of the Republic of Slovenia [*Uradni list RS*], Nos 130/22; hereinafter: the Decommissioning Fund Act); the Act Governing the Permanent Cessation of Uranium Ore Exploitation and Prevention of the Effects of Mining at the Žirovski Vrh Uranium Mine (Official Gazette of the Republic of Slovenia [*Uradni list RS*], No 22/06 – official consolidated version); regulations governing physical security, regulations governing protection and rescue, etc. It is expected that the Boršt hydrometallurgical tailings repository will be closed by the end of 2023 and that the Act Governing the Permanent Cessation of the Exploitation of Uranium Ore and Prevention of the Effects of Mining at the Žirovski Vrh Uranium Mine, currently still applicable, will no longer apply in the period of validity of the ReNPROIG23–32.

Slovenia is bound by the following international conventions and treaties concerning radioactive waste and spent fuel management:

-        Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (Official Gazette of the Republic of Slovenia – International Treaties [*Uradni list RS – Mednarodne pogodbe*], No 3/99),

-        Treaty Establishing the European Atomic Energy Community (Euratom Treaty) (OJ C 203, 7.6.2016, p. 1),

-        Convention on Nuclear Safety (Official Gazette of the Republic of Slovenia – International Treaties [*Uradni list RS – Mednarodne pogodbe*], No 16/96),

-        Convention on Early Notification of a Nuclear Accident (Official Gazette of the Socialist Federal Republic of Yugoslavia – International Treaties, [*Uradni list SFRJ – Mednarodne pogodbe*], No 15/89),

-        Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (Official Gazette of the Socialist Federal Republic of Yugoslavia – International Treaties, [*Uradni list SFRJ – Mednarodne pogodbe*], No 4/91),

-        Convention on the Physical Protection of Nuclear Material (Official Gazette of the Socialist Federal Republic of Yugoslavia – International Treaties, [*Uradni list SFRJ – Mednarodne pogodbe*], No 9/85, and Official Gazette of the Republic of Slovenia – International Treaties [*Uradni list RS – Mednarodne pogodbe*], No 14/09),

-        Convention on Third Party Liability in the Field of Nuclear Energy of 29 July 1960, as amended by the Additional Protocol of 28 January 1964 and by the Protocol of 16 November 1982 (Official Gazette of the Republic of Slovenia – International Treaties [*Uradni list RS – Mednarodne pogodbe*], No 18/00; hereinafter: Paris Convention),

-        Protocol to Amend the Convention on Third Party Liability in the Field of Nuclear Energy of 29 July 1960, as amended by the Additional Protocol of 28 January 1964 and by the Protocol of 16 November 1982 (Official Gazette of the Republic of Slovenia – International Treaties [*Uradni list RS – Mednarodne pogodbe*], No 4/10; hereinafter: Protocol to the Paris Convention),

-        Convention of 31 January 1963 Supplementary to the Paris Convention of 29 July 1960, as amended by the Additional Protocol of 28 January 1964 and by the Protocol of 16 November 1982 (Official Gazette of the Republic of Slovenia – International Treaties [*Uradni list RS – Mednarodne pogodbe*], No 9/01),

-        Protocol to Amend the Convention of 31 January 1963 Supplementary to the Paris Convention of 29 July 1960 on Third Party Liability in the Field of Nuclear Energy, as Amended by the Additional Protocol of 28 January 1964 and by the Protocol of 16 November 1982 (Official Gazette of the Republic of Slovenia – International Treaties [*Uradni list RS – Mednarodne pogodbe*], No 4/10; hereinafter: Protocol to the Brussels Supplementary Convention),

-        Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention (Official Gazette of the Republic of Slovenia – International Treaties [*Uradni list RS – Mednarodne pogodbe*], No 22/94),

-        European Agreement Concerning the International Carriage of Dangerous Goods by Road (ADR) (Official Gazette of the Socialist Federal Republic of Yugoslavia – International Treaties, [*Uradni list SFRJ – Mednarodne pogodbe*], No 59/72) and the Act Notifying Succession (Official Gazette of the Republic of Slovenia – International Treaties [*Uradni list RS – Mednarodne pogodbe*], No 9/92), Annexes A and B form an integral part thereof,

-        Treaty on the Non-Proliferation of Nuclear Weapons (NPT) (Official Gazette of the Socialist Federal Republic of Yugoslavia – International Treaties, [*Uradni list SFRJ – Mednarodne pogodbe*], No 10/70) and the Act Notifying Succession (Official Gazette of the Republic of Slovenia – International Treaties [*Uradni list RS – Mednarodne pogodbe*], No 14/92 of 19 March 1992),

-        Act Ratifying the Agreement between the Republic of Slovenia and the International Atomic Energy Agency for the Application of Safeguards in connection with the Treaty on the Non-Proliferation of Nuclear Weapons (Official Gazette of the Republic of Slovenia – International Treaties [*Uradni list RS – Mednarodne pogodbe*], No 11/97),

-        Act Ratifying the Amendment to the Convention on the Physical Protection of Nuclear Material (Official Gazette of the Republic of Slovenia – International Treaties [*Uradni list RS – Mednarodne pogodbe*], No 14/09),

-        Act Ratifying the Protocol Additional to the Agreement between the Republic of Slovenia and the International Atomic Energy Agency for the Application of Safeguards in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons (Official Gazette of the Republic of Slovenia – International Treaties [*Uradni list RS – Mednarodne pogodbe*], No 18/00),

-        Act Ratifying the International Convention for the Suppression of Acts of Nuclear Terrorism (Official Gazette of the Republic of Slovenia – International Treaties [*Uradni list RS – Mednarodne pogodbe*], No 18/09).

2. RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT POLICY AND KEY MILESTONES

2.1 GENERAL OBJECTIVES OF RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT

Radioactive waste management enables the beneficial use of ionising radiation and nuclear technologies in different areas that enhance the quality and comfort of modern life. By modern, safe and economical management of radioactive waste it is ensured that the burdens that can be addressed today are not left to future generations. The provision of long-term, safe and cost-effective solutions regarding radioactive waste management entails infrastructural and professional support for the use of nuclear and radiation technologies in Slovenia. The objectives of radioactive waste and spent fuel management in Slovenia must follow the objectives of the Integrated National Energy and Climate Plan of the Republic of Slovenia adopted by the Slovenian Government in February 2020. [10] These include continuing to harness nuclear energy and maintaining the excellence of the operation of nuclear facilities in Slovenia, and comprehensively examining possibilities for the long-term use of nuclear energy.

The individual and collective protection of people and the environment against ionising radiation and contamination with radionuclides is the basic objective of radioactive waste and spent fuel management, which concerns all facilities and activities and all stages of the operation of a nuclear or radiation facility or radiation source, including planning, location selection, design, construction, operation, decommissioning and closure, and with regard to repositories also long-term monitoring and maintenance. It must also cover the transport of radioactive waste and spent fuel.

In order to achieve this basic objective, safe handling and storage of all radioactive waste and spent fuel are to be provided at every stage of their existence, which should be followed by appropriate permanent disposal solutions in accordance with the specified timetable. These operations must be carried out effectively, efficiently, transparently, and in accordance with the legislation and the principles of decision-making and actions based on the latest findings of domestic and foreign research, cutting-edge technologies and the best practices and operating experience. This is achievable through continuous education and awareness raising, and continuous research regarding the training of professional staff.

The general objectives of safe radioactive waste and spent fuel management are the following:

Objective 1: To protect people and the environment from unnecessary harmful effects of ionising radiation resulting from the management, storage and disposal of radioactive waste and spent fuel at every stage of their existence.

Objective 2: To support and facilitate the performance of radiation practices and the use of sources of ionising radiation for both generating energy and supporting and strengthening industry, research, medicine and other institutional activities in accordance with the principles of this Resolution, and within the framework of the applicable Slovenian legislation and international guidelines and standards.

Objective 3: To evaluate, verify and, so far as reasonably possible, continually improve the safety and efficiency of facilities or activities for radioactive waste and spent fuel management on a regular basis and in a systematic and verifiable manner, in accordance with the applicable national framework and under the prescribed control of the competent administrative authority.

Objective 4: To provide and maintain adequate financial and human resources necessary to fulfil the obligations related to safe radioactive waste and spent fuel management.

Objective 5: To prevent accidents with radiological consequences, and to mitigate such consequences should they occur, at every stage of radioactive waste and spent fuel management.

2.2 PRINCIPLES OF RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT

Slovenia has transposed into its legal order the modern fundamental nuclear and radiation safety principles of the international community, including the safe management of all types of radioactive material. The Resolution on Nuclear and Radiation Safety in the Republic of Slovenia for the 2013–2023 Period (Official Gazette of the Republic of Slovenia [*Uradni list RS*], No 56/13, hereinafter: the Nuclear and Radiation Safety Resolution) sets out the following principles:

-        the responsibility for safety,

-        the role of the state administration,

-        leadership and management for safety,

-        the justification of facilities and activities,

-        the optimisation of protection,

-        the limitation of risks to individuals,

-        the protection of present and future generations,

-        the prevention of accidents,

-        emergency preparedness and response,

-        protective measures to reduce existing or unregulated radiation risks.

In addition to these general principles of nuclear and radiation safety, radioactive waste and spent fuel management must be carried out in such a way so as to always ensure:

-        Protection of human health

Radioactive waste and spent fuel must be managed in such a way so as to continuously ensure an acceptable level of human health protection.

-        Environmental protection

Radioactive waste and spent fuel must be managed in such a way so as to continuously ensure an acceptable level of environmental protection.

-        Transboundary impact

Radioactive waste and spent fuel must be managed in such a way so as to ensure that potential effects on human health and the environment beyond national borders are also considered.

-        Protection of future generations

Radioactive waste and spent fuel must be managed in such a way so as to ensure that the expected impacts on the health of future generations do not exceed the impacts that are acceptable today.

-        Burdens on future generations

Radioactive waste and spent fuel must be managed in such a way so as not to transfer burdens to future generations.

-        National legal framework

Radioactive waste and spent fuel must be managed in accordance with national law, including the clear allocation of responsibilities among stakeholders. The national legal framework needs to be regularly adapted to the latest research findings, the development of technology, and best practices and experience.

-        Control of radioactive waste generation

The generation of radioactive waste and spent fuel must be kept to the lowest level that is reasonably practicable, in terms of both activity and volume, by means of various measures and planning procedures, e.g. the recovery and reuse of materials.

-        Interdependence of radioactive waste and spent fuel generation and management

The interdependence between different stages of spent fuel and radioactive waste management must be taken into account in their generation and management.

-        Safety of radioactive waste and spent fuel management facilities

In order to reduce the dependency on active safety functions, adequate long-term safety must be ensured by using passive safety functions in each stage of operation and during the entire lifetime of facilities for radioactive waste and spent fuel management.

-        Principle of transparency, information provision and public participation

Radioactive waste and spent fuel must be managed in a transparent manner, so that efficient public information is ensured and all relevant interested parties are aware of the possibility of participation. The interested parties must participate in making decisions that could affect public health, local communities or the environment.

-        Principle of the public nature of information

Information on radioactivity in the environment, the exposure of members of the public, and the procedures and activities of state authorities, providers of the mandatory SGEI and bearers of powers relating to radiation protection and nuclear safety is public.

-        Principle of professional competence

Decision-making and actions must be based on the latest findings of domestic and foreign research, cutting-edge technologies and the best practices and operating experience.

-        Polluter pays principle

The holder of a radiation practice licence is primarily responsible for the safety of radioactive waste and spent fuel management. The cost of the management of radioactive waste and spent fuel is borne by their producer or a holder that accepted or otherwise obtained them from the producer. If the radioactive waste and spent fuel producer is not known, the state shall assume the responsibility for and the cost of the radioactive waste or spent fuel management.

-        Principle of a graded approach

The measures to ensure the safety of radioactive waste and spent fuel management must be implemented in a graded manner. The documentation on the decision-making process related to safety must be commensurate with the levels of risk and must provide a basis for decisions on radioactive waste and spent fuel management.

-        Shipment to and from EU Member States, and the import and export of radioactive waste and spent fuel

Shipment to and from EU Member States, and import into and export from Slovenia are subject to the restrictions and requirements established by national and EU legislation, as well as international and bilateral agreements.

-        Research and the development of methods of radioactive waste and spent fuel management

In order to improve the safe management of spent fuel and radioactive waste, it is necessary to apply the results of scientific research and technological development. The research and development strategy of Slovenia regarding radioactive waste and spent fuel management should be directed towards new technological knowledge and cooperation with the international research community.

-        Principle of international cooperation

Slovenia is aware that it shares the responsibility and opportunity to safely and sustainably resolve issues related to radioactive waste and spent fuel management with other countries at the regional and international levels. In its actions, it must comply with the principles adopted in this policy and the principles of multilateral and bilateral agreements. National responsibility for radioactive waste and spent fuel management must be considered in parallel with active participation in international and regional efforts to make progress towards joint regional disposal programmes.

-        Principle of providing professional support and training for workers

Adequate human resources, including resources for education, research and development, must be provided to ensure safe radioactive waste and spent fuel management.

-        Principle of seeking a joint solution

Slovenia is aware of the responsibility for radioactive waste and spent fuel management and disposal and will strive, in accordance with the Slovenian-Croatian Agreement on the Krško NPP, for an effective joint solution to the decommissioning of the Krško NPP and the disposal of its radioactive waste and spent fuel.

2.3 DRAFTING OF THE PROGRAMME FOR DECOMMISSIONING THE KRŠKO NPP AND THE PROGRAMME FOR THE DISPOSAL OF RADIOACTIVE WASTE AND SPENT FUEL FROM THE KRŠKO NPP

In 2002, Slovenia and Croatia agreed on the ownership and operation of the Krško NPP and signed the Slovenian-Croatian Agreement on the Krško NPP, which entered into force in March 2003. Under this Agreement, both countries are responsible for the management of radioactive waste and spent fuel from the Krško NPP. The Agreement provides that the contracting parties will consensually seek solutions and finance them in equal shares. If the contracting parties fail to reach an agreement on a joint solution, they will individually, each at their own cost, provide for the final disposal of their part of the radioactive waste and spent fuel from the operation and decommissioning of the Krško NPP, either on their own territory or in third countries.

Slovenia is aware of the responsibility for radioactive waste and spent fuel management and disposal and will strive, in accordance with the Slovenian-Croatian Agreement on the Krško NPP, for an effective joint solution to the decommissioning of the Krško NPP and the disposal of its radioactive waste and spent fuel. Due to the small quantities of waste and the small scale of the nuclear programme, a joint solution would provide many safety, social and economic benefits to both countries.

Upon signing the Slovenian-Croatian Agreement on the Krško NPP, the contracting parties established an intergovernmental commission to monitor the implementation of the Agreement and perform other functions under this Agreement. Each contracting party has one chair and four members in the commission. The two contracting parties authorised the intergovernmental commission to, among other things, approve the programme for the decommissioning of the Krško NPP and the programme for the disposal of radioactive waste and spent nuclear fuel from the Krško NPP.

In accordance with this provision of the Slovenian-Croatian Agreement on the Krško NPP, the Programme for the Decommissioning of the Krško NPP and the Disposal of LILW and Spent Fuel [11] was drawn up in 2004, which the intergovernmental commission approved at its 7th session in 2005. Pursuant to this programme, which laid down the amount of the contributions for the decommissioning of the Krško NPP and the disposal of radioactive waste and spent fuel, and the then-applicable Act Governing the Fund for Financing the Decommissioning of the Krško NPP and the Disposal of Radioactive Waste from the Krško NPP, from April 2005 to 1 August 2020 ELES GEN, d.o.o. (or, since July 2006, GEN energija, d.o.o., as the legal successor of ELES GEN d.o.o.), as the entity liable for the calculation and payment of funds, was paying a contribution in the amount of EUR 3.00/MWh of electrical energy produced by the Krško NPP and sold in Slovenia to the Fund for Financing the Decommissioning of the Krško NPP and the Disposal of Radioactive Waste from the Krško NPP. From 1 August 2020, GEN energija, d.o.o., was paying a contribution of EUR 4.80/MWh to the Fund for Financing the Decommissioning of the Krško NPP and the Disposal of Radioactive Waste from the Krško NPP, in accordance with Decision of the Government of the Republic of Slovenia No 360-51/2020/5. Since 1 January 2022, GEN energija, d.o.o., has been paying a contribution of EUR 12/MWh to the Fund for Financing the Decommissioning of the Krško NPP and the Disposal of Radioactive Waste from the Krško NPP, in accordance with Decision of the Government of the Republic of Slovenia No 306-106/2021/5.

At its 11th session in November 2017, the intergovernmental commission tasked ARAO and Fond NEK with producing, in collaboration with the Krško NPP, the third revision of the Programme for the Disposal of Radioactive Waste and Spent Fuel from the Krško NPP. It also tasked the Krško NPP with producing, in collaboration with ARAO and Fond NEK, the third revision of the Programme for the Decommissioning of the Krško NPP (hereinafter: the Krško NPP Decommissioning Programme). [12]

At its 13th session in September 2019, the intergovernmental commission established, based on the report of the coordinating committee appointed to monitor the implementation of the third revisions of both programmes and study the options for the joint construction of an LILW repository, that a joint solution to the disposal of LILW would not be possible. This means that each country must provide for the disposal of its own portion of the radioactive waste. [13]

At its 14th session in July 2020, the intergovernmental commission for monitoring the implementation of the Agreement approved the third revisions of the Krško NPP Decommissioning Programme and the Programme for the Disposal of Radioactive Waste and Spent Fuel from the Krško NPP, in accordance with the Slovenian-Croatian Agreement on the Krško NPP. [14]

At its 15th session in October 2020, the intergovernmental commission appointed a coordinating committee to monitor the receipt of LILW from the Krško NPP by ARAO and Fond NEK in 2023–2025, to monitor the preparation of the fourth revisions of the Krško NPP Decommissioning Programme and the Programme for the Disposal of Radioactive Waste and Spent Fuel from the Krško NPP, and to carry out other activities related to the Krško NPP’s work. It also tasked the coordinating committee with coordinating the agreement concerning the servicing of the receipt of LILW at the Krško NPP site in a suitable form at the expense of one and/or both parties. [15]

At its 16th session in April 2022, the intergovernmental commission approved the terms of reference for the fourth revisions of the Krško NPP Decommissioning Programme and the Programme for the Disposal of Radioactive Waste and Spent Fuel from the Krško NPP. It tasked ARAO and Fond NEK with producing, in collaboration with the Krško NPP, the fourth revision of the Programme for the Disposal of Radioactive Waste and Spent Fuel from the Krško NPP by April 2024, and the Krško NPP with producing, in collaboration with ARAO and Fond NEK, the fourth revision of the Krško NPP Decommissioning Programme, by April 2024. [16] In addition, based on the report of the coordinating committee, the commission confirmed the need to review the study of the division and acceptance of LILW from the Krško NPP. It therefore tasked the coordination committee with continuing to monitor the implementation of the third revision of the Programme for the Disposal of Radioactive Waste and Spent Fuel from the Krško NPP and the preparation of the fourth revisions of both programmes.

2.4 PROCEDURES FOR THE REDUCTION OF RADIOACTIVE WASTE AND SPENT FUEL DURING OPERATION AND DECOMMISSIONING

According to the principle of radioactive waste control, the generation of radioactive waste and spent fuel must be kept to the lowest level that is reasonably practicable, in terms of both activity and volume, by means of various measures and planning procedures. The procedures and measures to minimise radioactive waste and spent fuel generation are planned at the source of generation, and during the operation and decommissioning of facilities. Normally, the procedures for the recovery and reuse of contaminated or only slightly contaminated materials are used to minimise the generation of radioactive waste during operation and decommissioning, in accordance with the prescribed criteria for the clearance of radioactive material from regulatory control.

In accordance with the requirements of the Rules on radioactive waste and spent fuel management, the holders of radioactive waste or spent fuel that are the operators of radiation or nuclear facilities must include in their radioactive waste or spent fuel management programme measures planned to minimise the generation of radioactive waste or spent fuel. They must monitor the effectiveness of these measures through pre-determined key indicators and propose amendments to the programme if the targets are not met.

2.5 SHIPMENT TO/FROM EU MEMBER STATES, THE EXPORT/IMPORT AND TRANSIT OF RADIOACTIVE WASTE AND SPENT FUEL

In the EU, shipment from and to EU Member States, and the import, export and transit of radioactive waste and spent fuel are governed by Council Directive 2006/117/Euratom of 20 November 2006 on the supervision and control of shipments of radioactive waste and spent fuel (OJ L 337, 5.12.2006, p. 21, and OJ L 200M, 1.8.2007, p. 254; hereinafter: Council Directive 2006/117/Euratom), while the Convention on the Physical Protection of Nuclear Material and Nuclear Facilities applies to the physical protection of nuclear material (e.g. spent fuel) during shipment from and to EU Member States, export, import or transit, and conventions governing third-party liability apply to liability for nuclear damage.

In Slovenia, this field is regulated by the ZVISJV-1, the Nuclear Damage Liability Act (Official Gazette of the Republic of Slovenia [*Uradni list RS*], No 77/10), and the Rules on transboundary shipments of radioactive waste and spent fuel (Official Gazette of the Republic of Slovenia [*Uradni list RS*], Nos 22/09 and 76/17 – ZVISJV-1), which transposed Council Directive 2006/117/Euratom into Slovenian legislation. The aforementioned Rules apply to transboundary shipments of radioactive waste or spent fuel whenever Slovenia is the country of origin, the country of destination or the country of transit and the quantities and concentration of the shipment exceed the levels laid down in Table 1 of the Annex to the Decree on radiation practices (Official Gazette of the Republic of Slovenia, [*Uradni list RS*], No 19/18).

2.6 PROVISION OF HUMAN AND FINANCIAL RESOURCES

The reliability and safety of the overall management of radioactive waste and spent fuel at every stage of their existence and the feasibility of the set objectives are ensured through stable financing, and the adequate staff structure and qualifications of all those involved in radioactive waste and spent fuel management.

The basic prerequisite for ensuring a high level of nuclear and radiation safety in the country is to ensure the competent professional support of qualified personnel, which should not be left solely to the play of market forces. Stakeholders must, in accordance with the national framework, provide their staff with appropriate education and training with a view to obtaining, maintaining and further developing the necessary expertise and skills. In order to implement the prescribed radiation or nuclear safety measures, the operator of a radiation or nuclear facility must be provided funding at every stage of operation. The necessary financial resources must be provided by the owners of the facility.

Radioactive waste and spent fuel management activities are funded in accordance with the polluter pays principle. The funds originate directly from own resources and the added value of producers or holders of radioactive waste and spent fuel, which they obtain from the sale of electricity, from providing radiation practice services or from other industrial processes generating radioactive waste. Since safe radioactive waste and spent fuel management reduces the environmental risk and is thus in the wider social interest, additional public funding should be provided when this is justified (the producer is unknown, the producer carries out non-commercial activities, e.g. healthcare, science and research) through the line ministry that finances the activities and services of ARAO.

The funds deposited in the Public Fund of the Republic of Slovenia for Financing the Decommissioning of the Krško Nuclear Power Plant and the Disposal of Radioactive Waste from the Krško Nuclear Power Plant (hereafter: the Krško NPP Decommissioning Fund) are used pursuant to the Decommissioning Fund Act to finance the functions and services of the mandatory SGEI of radioactive waste and spent fuel management and other functions under the Decommissioning Fund Act and the functions laid down in the ZVISJV-1, to finance the development and implementation of the project for the safe decommissioning of the Krško NPP, and to pay compensation for restricted use of land to local communities in accordance with the Decree on the criteria for determining the amount of compensation for restricted land use and the planning of intervention measures in the area of a nuclear facility (Official Gazette of the Republic of Slovenia [*Uradni list RS*], Nos 92/14, 46/15, 76/17 – ZVISJV-1 and 8/20; hereinafter: the Compensation Decree).

ARAO was established in 1991 as a public corporation by the Ordinance on the establishment of a public corporation for radioactive waste management (Official Gazette of the Republic of Slovenia [*Uradni list RS*], No 5/91). In 1996, it was converted into a public utility institute by the Ordinance on the conversion of the public corporation Agencija za radioaktivne odpadke p.o., Hajdrihova 2, Ljubljana, into a public utility institute (Official Gazette of the Republic of Slovenia [*Uradni list RS*], No 45/96). In 2022, a new Ordinance on the establishment of ARAO was adopted, which regulates, pursuant to the ZVISJV-1, the organisation, activities, bodies and their competences, and other basic matters relating to the provider of the mandatory SGEI of radioactive waste management. [9]

ARAO is the provider of the mandatory SGEI of radioactive waste management for all radioactive waste generated in the territory of Slovenia. Pursuant to the Decree on the method and conditions for providing the mandatory national public service of general economic interest of radioactive waste management, ARAO accepts, transports, processes and stores radioactive waste generated in medicine, research and industry, and carries out activities and services related to the preparations for the construction of repositories and to the construction thereof itself. [8] ARAO is authorised to and responsible for managing and carrying out the long-term monitoring and maintenance of closed repositories of mining and hydrometallurgical tailings and repositories of radioactive waste. By planning and providing long-term, safe and cost-effective solutions for radioactive waste and spent fuel management, including the construction of the LILW repository, ARAO provides infrastructural and professional support regarding the use of nuclear and radiation technologies in Slovenia. As the provider of the mandatory SGEI of radioactive waste management, ARAO will, when the infrastructure conditions are met, also carry out the final disposal of the radioactive waste and spent fuel generated during the operation and decommissioning of the nuclear power plant and radioactive waste from other activities.

As the provider of the mandatory SGEI of radioactive waste management, ARAO draws up its long-term programmes of work pursuant to the Ordinance on the establishment of the ARAO public utility institute [9]. A long-term programme of work must include the ARAO staffing plan. The plan should reflect the needs regarding specialist staff whose employment will enable the safest and smoothest radioactive waste and spent fuel management, and the operation, planning and supervision of nuclear and radiation facilities (including those that have already been closed). The current number of employees must be increased, as ARAO will have to perform additional functions as part of the mandatory SGEI of radioactive waste management during the period of validity of ReNPROIG23–32. The recruitment of new staff is required mostly due to the construction and operation of the LILW repository, the implementation of the long-term monitoring and maintenance of the closed Jazbec and Boršt repositories, the implementation of measures for the planning and maintenance of the high-level radioactive waste repository, and other functions set out in this Resolution.

In order to carry out the administrative functions related to the supervision of nuclear safety, nuclear and radiation facilities, and ionising radiation sources in the country and to carry out specialist administrative and development functions in the field of nuclear and radiation safety, which includes radioactive waste and spent fuel management, additional staff must be recruited at the SNSA to meet the requirements of the new administrative functions and the supervision of new facilities for the storage, preparation for disposal and disposal of radioactive waste and spent fuel.

2.7 FINANCING OF RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT IN SLOVENIA

Activities related to radioactive waste and spent fuel management in Slovenia are financed from three main resources:

1.      the Krško NPP Decommissioning Fund, which is fed by contributions paid by GEN energija, d.o.o., as the Slovenian owner of the Krško NPP, pursuant to the Krško NPP Decommissioning Programme, the Programme for the Disposal of Radioactive Waste and Spent Fuel from the Krško NPP and the Act Governing the Public Fund of the Republic of Slovenia for Financing the Decommissioning of the Krško Nuclear Power Plant and the Disposal of Radioactive Waste from the Krško Nuclear Power Plant (Official Gazette of the Republic of Slovenia [*Uradni list RS*], No 130/22),

2.      payments made by holders of institutional radioactive waste for services provided within the mandatory SGEI of radioactive waste management in accordance with the price list,

3.      the state budget.

The disposal of radioactive waste and spent fuel from the Krško NPP is financed exclusively from the fund established for this purpose. ARAO's cost of providing the public service of managing institutional radioactive waste is partly covered by radioactive waste producers and holders in accordance with the price list for the public service of radioactive waste management. The remainder of the costs are covered by state budget funds, which are disbursed pursuant to a contract on the provision of the public service of radioactive waste management.

ARAO's cost of carrying out the preparations for the construction, constructing, operating and closing the LILW repository is covered from the Krško NPP Decommissioning Fund and the Slovenian state budget. The distribution of costs between the two financing resources is based on the volume share of the waste from the Krško NPP and from other sources.

The cost of planning and implementing the final solution for the management of the HLW and spent fuel from the Krško NPP and of planning and implementing the Krško NPP decommissioning is covered from the Krško NPP Decommissioning Fund. ARAO's labour costs and material costs of operation are financed partly from the Slovenian state budget and partly, in a share proportionate to the expected quantity of LILW from the Krško NPP, from the Krško NPP Decommissioning Fund.

In accordance with the ZVISJV-1, the state provides funds to finance the management of radioactive waste and spent fuel generated by unknown producers and funds to provide the mandatory SGEI of radioactive waste management in the part not covered by the users of radiation sources and with regard to services whose users are unidentifiable or whose use is unmeasurable. The state also provides funds for the performance of the mandatory national SGEI of the management, long-term monitoring and maintenance of closed repositories of radioactive waste and repositories of mining and hydrometallurgical tailings.

Research in radioactive waste and spent fuel management is financed from the state budget and from the Krško NPP Decommissioning Fund, depending on the purpose of the activity and the origin of the radioactive waste and spent fuel. The funds from the state budget are provided through the line ministry that finances the activities and services of ARAO.

2.8 KEY PROGRAMME MILESTONES FOR THE 2023–2032 PERIOD

The programme for radioactive waste and spent fuel management provides for the safe and efficient management of radioactive waste and spent fuel in Slovenia by ensuring the safety of people and the environment at all times. Radiation practices and the use of nuclear technologies are directed through various strategies and national programmes. For example, the use of nuclear and radioactive material is provided for in the Integrated National Energy and Climate Plan of the Republic of Slovenia (NEPN) [10], the Nuclear and Radiation Safety Resolution and other documents. The NEPN envisages the continuation of nuclear energy exploitation and the maintenance of excellence in the operation of nuclear facilities in Slovenia. Possibilities for the long-term use of nuclear energy will be examined, including all economic and other specialist analyses and activities to provide the basis for a decision on the construction of a new nuclear power plant to be made by 2027 at the latest.

Continued use of nuclear energy is also envisaged in the Resolution on Slovenia’s Long-Term Climate Strategy until 2050 [17]. The long-term use of nuclear energy is among the key objectives of the strategy, which provides for the relevant administrative procedures to be carried out and documents needed for investment decisions to be prepared. The strategy also envisages the priority implementation of all measures to ensure the long-term operation of the existing nuclear power plant, which significantly contributes to the low-carbon production of electricity. If, based on the energy permit [2] and other procedures, it is decided to invest in and construct the Krško NPP 2, the investor will have to, in accordance with the regulations governing radioactive waste management, draw up a programme for the management of radioactive waste and spent fuel during the operation of the facility and design a project for decommissioning and radioactive waste and spent fuel management and disposal after the facility is shut down.

In determining the milestones, it has been taken into account that if a decision is made to invest in the Krško NPP 2 and the siting and construction are successfully carried out, the operation of the facility will probably generate its first radioactive waste after the expiry of this programme, considering international experience and the time needed to launch the operation of the Krško NPP 2. Thus, the Krško NPP 2 project is not included among the milestones of this programme.

The technical screening criteria for a project for the generation of electricity from nuclear energy laid down in Annex I of Commission Delegated Regulation (EU) 2022/1214 include that the EU Member State has operational final disposal facilities for all very low-, low- and intermediate-level radioactive waste and a documented plan with detailed steps to have in operation a disposal facility for high-level radioactive waste by 2050, which for existing facilities applies to projects approved after 2025. Chapter 4.4 of this Resolution sets out the LILW disposal strategies and the steps to be taken to achieve the objectives of these strategies. The construction of a repository for the disposal of LILW from the Krško NPP is planned for the beginning of 2023, and its operation for 2027. Chapters 4.5 and 5 of the Resolution also envisage several measures and funds to ensure that HLW and spent fuel from the Krško NPP are disposed of. If Slovenia adopts an appropriate decision on the investment in the Krško NPP 2, regardless of the plan to request funds from the financial mechanism determined by Commission Delegated Regulation (EU) 2022/1214 to implement the investment, the plans for ensuring the disposal of HLW and spent fuel will be supplemented accordingly.

In any event, according to the aforementioned plans and strategies, it is expected that waste will continue to be generated in the existing or planned power plants, including radioactive waste from the Krško NPP.

These documents naturally evolve and change over time, so this programme is also adjusted in response to the aforementioned challenges. The basic way to ensure the required flexibility is to establish conditions for the storage of radioactive waste and spent fuel, which is later followed by planned disposal. This phase-based approach in which a long phase of storage is followed by a shorter phase of disposal is internationally accepted and recognised. Since the quantities of radioactive waste and spent fuel in Slovenia are relatively small, such manner of optimised operation, which includes various possibilities of cooperation in radioactive waste and spent fuel management, also increases performance. The described phase-based approach is illustrated in the figure below.



Figure 1: The alignment of ReNPROIG23–32 with national programmes and strategies concerning the business, research and energy sectors

The key milestones, which arise from "external" strategies and programmes and directly affect the implementation milestones of the national programme for radioactive waste and spent fuel management, are the end of the operation of and, consequently, the end of electricity generation by the Krško NPP, and the end of research at and the operation of the TRIGA Mark II research reactor at the Jožef Stefan Institute.

Specialist documents serving as a reference for the present strategy are based on the assumption that the nuclear power plant will still operate after 2023. Pursuant to the decision issued by the Slovenian Environment Agency in 2020, the Krško NPP must carry out an environmental impact assessment and obtain an environmental approval in order to extend the lifetime of the power plant until 2043. The Krško NPP is implementing an approved ageing management programme, which fulfils one of the conditions for extending the operation of the NPP until 2043, in addition to successfully passing periodic safety reviews in 2023 and 2033. By the end of 2022, the Krško NPP will carry out an extensive safety upgrade programme, which will further contribute to the plant's safe operation until 2043.

The set milestones are based on the expectation that the TRIGA Mark II research reactor will be in operation at least until 2024 [18] with the possibility of extension. In 2014, the reactor underwent its first periodic safety review, which must be conducted every 10 years of reactor operation. The operation of the reactor was thus extended for 10 years, i.e. until 2024.

If the state as the owner and the Jožef Stefan Institute as the operator wished to further extend the operation of the reactor, they will have to adopt a decision to continue the operation and carry out another periodic safety review and any necessary improvements identified in the review by 2024.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Key milestones | Radioactive waste management activities carried out in 2022 or envisaged in the future | Estimated duration of activity | Responsible entity | Notes |
| Management of LILW from the operation of the Krško NPP | Storage at the Krško NPP | The Krško NPP storage facility will operate until at least the beginning of the second phase of disposal of its waste at the Vrbina LILW repository, Krško (2050). | Krško NPP | The storage capacity of the Krško NPP will be freed in the first phase of the LILW repository's operation. |
| Disposal at the Vrbina LILW repository, Krško | The first phase of the disposal of Slovenia’s half of the stored waste from the Krško NPP will run from the second half of 2027 to the end of 2029. Another disposal phase following the standby period is planned to run from 2050 to 2058. | ARAO |  |
| LILW from the Krško NPP decommissioning | Disposal at the Vrbina LILW repository, Krško | Disposal to start in 2050 and planned to run until 2058. | ARAO |  |
| Vrbina LILW repository, Krško  | In the stage of construction and preparations for the trial and regular operation | The building permit for the LILW repository buildings was granted in July 2022. Construction will take place between 2023 and 2026. The repository will start trial operation in the second half of 2026. | ARAO | According to the analysis of the needs for further disposal, the operation of the repository may continue after 2058. |
| Wet storage of spent fuel at the Krško NPP | In operation | Until 2048 (5 years after the shutdown of the Krško NPP in 2043).  | Krško NPP |  |
| Dry storage of spent fuel at the Krško NPP | In the construction stage | Construction will be completed by the end of 2022. The start of spent fuel transfer from the spent fuel pool to the dry storage facility at the Krško NPP site – the first campaign to transfer 592 fuel elements is planned for 2023. The second transfer campaign is planned for 2028, involving approximately 592 fuel elements, and the third for 2038, involving approximately 444 fuel elements. The last transfer of the remaining fuel elements from the pool to the dry storage facility is envisaged to take place no later than 5 years after the shutdown of the Krško NPP. It is planned that the storage facility will operate for 60 years after the Krško NPP has ceased to operate (2103). The fuel may be transferred and the pool shut down even earlier if this proves to increase safety and economic efficiency. | Krško NPP  | Four campaigns are planned for the transfer of spent fuel from the pool to the dry storage facility. |
| Spent fuel and HLW management |  | Keeping abreast of international developments in spent fuel disposal, carrying out research, development and demonstration activities for the construction of the national repository and seeking solutions for the reprocessing or export of spent fuel and disposal in the regional or multinational repository Continuous activity | ARAO |  |
| Spent fuel and the HLW repository | In 2019, Slovenia and Croatia formulated a supplemented reference scenario of disposal in solid rock.  | Comparative studies, preliminary designs and the preparation of qualified staff are to be carried out by 2045. Location search in 2045–2055 An appropriate and socially acceptable location to be approved in 2055 Construction in 2055–2065 The start of operation of the spent fuel repository in 2065 The closure of the repository and the start of the long-term monitoring and maintenance of the repository after 2075 | ARAO | There is a possibility of a different solution being agreed on within the intergovernmental commission (the commitment to seek a joint solution) and/or an international solution for the permanent disposal of spent fuel and HLW. |
| Operation of the Central Radioactive Waste Storage Facility in Brinje  | In operation  | The disposal of 60% of radioactive waste from the storage facility at the LILW repository in 2028 and 2029, and of the remaining 40% after 2050  | ARAO | The time of decommissioning and the closure of the facility is to be adjusted with regard to the need for radioactive waste storage. |
| Operation and decommissioning of the TRIGA research reactor | In operation | The research reactor is to operate at least until the conclusion of the next periodic safety review (2024) with the possibility of another extension. The decision on whether the reactor will continue to operate, be renovated or be decommissioned will be adopted during the next periodic safety reviews.  | Jožef Stefan Institute |  |
| Closed Jazbec repository of mining tailings  | Long-term monitoring and maintenance of the repository  | The Jazbec repository of mining tailings was closed in 2015. ARAO manages the repository and carries out the long-term monitoring and maintenance of the repository in accordance with the amended safety report – continuous activity. | ARAO |  |
| Closed Boršt repository of hydrometallurgical tailings | Long-term monitoring and maintenance of the repository  | The Boršt repository of hydrometallurgical tailings is expected to be closed in 2023. ARAO will then start the permanent management and long-term monitoring and maintenance of the repository. |  ARAO  |   |

Table 1: Key milestones in the implementation of the national programme for radioactive waste and spent fuel management

3. ANALYSIS OF THE SITUATION IN RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT

3.1 LILW MANAGEMENT

Slovenia generates approximately 40 m3 of processed LILW per year. Nine-tenths of this waste is generated at the Krško NPP, which is responsible for storing all its LILW at the location of the plant. The remaining ten percent of the LILW is institutional radioactive waste generated in medicine, industry and research and educational institutions, including the research reactor. All LILW generated at the Krško NPP is currently stored in the storage facility at the power plant site, while the institutional radioactive waste is stored at the Central Storage Facility for Radioactive Waste (CSF) in Brinje near Ljubljana.

In the past, radioactive waste containing natural radionuclides was also generated during the excavation and processing of uranium ore at the Žirovski Vrh Mine in the form of mining and hydrometallurgical tailings. This waste has already been deposited in the Jazbec mining tailings repository and the Boršt hydrometallurgical tailings repository at the site of the closed mine.

3.1.1 Krško NPP

Quantity to date

In the last ten years, the Krško NPP has generated up to 40 m3 of waste annually, which has then been treated to reduce the volume. In recent years, the volume of LILW generated by the Krško NPP has been reduced by using volume-reduction methods, such as compression, supercompaction, drying, incineration and melting. Figure 2 shows the cumulative quantity of stored LILW by the end of 2021. In total, 2,333 m3 of solid LILW with a total gamma activity of 18.5 TBq and a total alpha activity of 0.027 TBq was stored. Radioactive waste intended for incineration and melting is separated and, due to the lack of space, temporarily transferred to the decontamination building, where, as of the end of 2021, 53 packages of dried spent ion exchange resins from the secondary circuit and 371 packages of compressible waste were temporarily stored awaiting further treatment. In 2021, a further 167 packages of compressible waste and 96 packages of other waste were stored in the building for the manipulation of equipment and shipments of radioactive cargo.

At the end of 2021, the storage room for old steam generators additionally held almost 1,000 m3 of contaminated equipment (including two old steam generators). Most of the material was generated during the replacement of steam generators in 2000, while the remainder is the contaminated material generated in the following years during the Krško NPP outages and the waste returned from Sweden, where it had been sent for processing. The waste in the storage facility mainly contains the following short-lived radioactive isotopes: Co-60, Fe-55, Sr-90, Cs-134 and Cs-137.



Figure 2: Cumulative amount of LILW in the Krško NPP storage facility at the end of 2021 in m3

| **Type of waste** | **Code** | **Number of packages** | **Gamma activity [Bq]** | **Alpha activity [Bq]** | **Volume [m3]** |
| --- | --- | --- | --- | --- | --- |
| Incineration products | A | 100 | 5.68∙109 | 1.15∙108 | 20.8 |
| Dried spent ion-exchange resins from the secondary circuit | BR | 1 | 8.54∙108 | 1.32∙106 | 0.2 |
| Compressible waste | CW | 7 | 1.65∙108 | 3.29∙105 | 1.5 |
| Dried sludge  | DS | 1 | 3.39∙107 | 6.30∙103 | 0.2 |
| Evaporator concentrate | EB | 2 | 2.23∙108 | 1.17∙105 | 0.4 |
| Spent filters | F | 105 | 8.85∙1010 | 4.01∙107 | 21.8 |
| Other waste | O | 7 | 3.20∙108 | 1.26∙106 | 1.5 |
| Dried spent ion-exchange resins from the primary circuit | PR | 3 | 1.41∙1011 | 1.22∙108 | 0.45 |
| Compressed waste from 1988 and 1989 | SC | 617 | 1.25∙1010 | 2.07∙108 | 197.4 |
| Spent ion exchange resins | SR | 689 | 1.82∙1012 | 3.72∙109 | 143.3 |
| Tube Type Containers containing compressed waste generated in 1994 and 1995, and pellets from the regular supercompaction in 2006, 2007, 2008, 2010, 2011, 2012, 2013 and 2014.  | ST | 1853 | 5.19∙1011 | 6.65∙108 | 1601.0 |
| Tube Type Containers containing standard uncompressed drums  | TI | 396 | 1.59∙1013 | 2.20∙1010 | 344.1 |
| Total |  | 3,781 | 1.85∙1013 | 2.69·1010 | 2,332.7 |

Table 2: Inventory of the LILW storage facility at the Krško NPP as of 31 December 2021

Waste management

During its operation, the Krško NPP generates solid, liquid and gaseous radioactive waste, which is managed in accordance with the approved safety report, management programme and other procedures at the Krško NPP. It is appropriately treated and conditioned using the existing technology systems to bring it to a form that ensures safe storage. The technologies for the treatment and conditioning of all forms of LILW in place in the production process are comparable to technologies established around the world. The existing treatment procedures reduce volume, extract radionuclides, change the composition of waste and minimise the discharge of radioactive substances into the environment. Emissions from the technological processes of radioactive material management are purified and checked by measurements. They are strictly controlled and carried out in accordance with the issued operating licence and the approved operational limits and conditions.

In 2013, the Krško NPP started planning a facility for the manipulation of equipment and shipments of radioactive cargo (the waste manipulation building – WMB). The new building, which was built in 2018, alleviated the storage problem caused by the delay in the construction of the LILW repository, as it enabled the removal of measuring equipment and the supercompactor from the manipulation area of the storage facility. Packages intended for storage or incineration are also prepared in the new building.

The gas mixture that is discharged from the primary cooling system and contains radionuclides of noble gases and other elements in the form of vapour and aerosols is retained in the gas decay tank until their activity falls below the prescribed limits due to natural decay. Most of the condensation components are removed from the gas mixture, while the remains of the noble gases are discharged into the atmosphere in controlled releases from the ventilation system through highly efficient filters.

Radioactive liquids are classified into two categories according to their generation and chemical properties, i.e. the liquids that have a sufficiently high degree of chemical purity and can be reused in the reactor, and the liquids that are not sufficiently chemically pure and are therefore considered liquid radioactive waste.

Liquid radioactive waste is treated and conditioned to reduce its volume. Various procedures and treatment methods are used for this purpose, such as evaporation, ion exchange, filtration and in-drum drying. The selection of the method depends on the quantity and physical and chemical properties of the radioactive waste. Two separate products are produced by processing: a concentrate with an increased concentration of radionuclides and a decontaminated liquid.

The concentrate with an increased concentration of radionuclides is further conditioned, i.e. brought into a form suitable for storage. The evaporator concentrate is conditioned using the in-drum drying technique.

As liquid waste flows through the ion exchange apparatus, radioactive substances bind to the surface of the ion exchange resins. After a long period of use, resins become ineffective and have to be replaced and stored as radioactive waste. Spent ion exchange resins from primary systems and from the steam generator sludge management system are dried and packed in stainless steel drums. Those from the primary systems are packed in heavy drums with a net volume of 150 l, made of stainless steel and with biological shielding on the inside of the drum.

After saturation and replacement, spent filter cartridges of liquid systems are packed in standard 208 l drums. Further volume reduction of spent ion exchange resins can be achieved by the thermal treatment (pyrolysis or incineration) of the dried ion exchange resins from the secondary circuit.

The drums containing products from the drying system are inserted into tube type containers.

A boric acid recycling system for collecting and processing excess borated water from the primary system and other sources, which contains tritium and is radioactive, is also used in the management of liquid radioactive waste.

|  |  |  |
| --- | --- | --- |
| Process | Applicability | Form of radioactive waste for immobilisation |
| Evaporation in an evaporator | Liquids | Sludge after evaporation (concentrate) |
| Ion exchange | Water with contaminants in ion form | Spent ion exchange resins (dried) |
| Filtration | All liquids | Filter cartridges |

Table 3: Processes used for the treatment of liquid radioactive waste at the Krško NPP

Solid waste is mainly generated in the treatment of gaseous and liquid, some of it also arises directly from maintenance and cleaning. It is divided into five groups (waste streams): evaporator concentrate conditioned by the in-drum drying technique, spent ion exchange resins, spent filters, compressible waste and other waste.

Radioactive waste in solid form is classified according to the level and type of radioactivity pursuant to the Rules on radioactive waste and spent fuel management. The most represented category in terms of quantity, which consequently occupies the most storage space, is short-lived LILW.

In addition to classification according to the physical state and categories of radioactive waste, waste is also grouped by its origin, properties and subsequent management.

Waste is inserted into different types of packaging according to its classification: 208 l standard drums, 320 l overpacks and 869 l tubular overpacks. The principal methods of processing solid waste in order to reduce its volume are sorting, decontamination, compression, supercompaction, incineration, pyrolysis and melting.

Waste is sorted and separated, e.g. non-contaminated from potentially radioactive waste, combustible from non-combustible waste, compressible from incompressible waste. Non-combustible and incompressible waste is separated from the rest.

Combustible waste is promptly prepared and grouped into shipments in the waste manipulation building. When a sufficient quantity is gathered, it is sent for incineration to further reduce its volume. Incineration campaigns are carried out by an external contractor at its site.

Seven radioactive waste incineration campaigns had been carried out by the end of 2021, as shown in Figure 2. Ash and filter residues from the incineration of combustible waste are returned to the holder in 100 l drums embedded in concrete in 208 l drums.

Dry compressible radioactive waste is packed in standard 208 l drums. For volume reduction, a hydraulic press and high-pressure compactors (hereinafter: a supercompactor) are used. Pellets are placed in tubular overpacks. In 2006, a supercompactor was permanently installed. It was used for the immediate supercompaction of suitable packages until 2015. In 2015, supercompaction was suspended due to the construction of the waste manipulation building (WMB). It will resume when the supercompactor is moved to this building. Incompressible waste is broken down and packed in standard drums. Metallic waste suitable for melting is mostly surface-contaminated waste or activated waste from the containment vessel, which is successfully decontaminated (approximately 70%) using available decontamination procedures so that it meets the criteria for clearance. The remainder of the waste is suitable for melting in one of the available melting plants abroad. The melting products are ingots, slag and dust.

|  |  |  |
| --- | --- | --- |
| Process | Material | Reduction factor |
| Low pressure in-drum compaction | Fabric, plastic, sheet metal, cables, small equipment | Up to 4 |
| Supercompaction of drums | Fabric, plastic, paper, sheet metal, small metallic parts  | Up to 10 |
| Incineration | All combustibles | Up to 30 |
| Pyrolysis | Combustible materials, ion exchange resins from the secondary circuit | Up to 60 |
| Melting | Metals | Up to 10 |
| Shredding, grinding | All materials | Up to 2 |

Table 4: Processes used to reduce the volume of solid radioactive waste

The above-described types of radioactive waste result from the current treatment and conditioning technology. The storage facility also contains radioactive waste arising from technologies and processes that were used in the past. For example: evaporator concentrate solidified with cement vermiculite mixture, solidified spent ion exchange resins, compressed radioactive waste from the first supercompaction campaign in 320 l drums.

The Krško NPP has always striven to reduce and control the generation of radioactive waste at every management stage. To this end, a five-year development plan was drawn up in accordance with the ZVISJV-1. The plan provides guidelines for reducing the quantity of radioactive waste through consistent control and by stopping coolant leaks, decontaminating and reusing tools and materials, preventing contamination, consistently separating contaminated materials from clean ones and using volume-reduction techniques. In accordance with the internal management procedures, the main volume-reduction techniques are decontamination, supercompaction, thermal treatment and melting. The option of the clearance of radioactive materials is also regularly considered.

Storage capacity and expected quantity of waste

Radioactive waste management at the Krško NPP will not be much different in the future than it has been to date and annual quantities are also not expected to change substantially. The long-term operational objective of the Krško NPP is to maintain the quantity of generated LILW under 35 m3 per year. All treated, conditioned and packaged solid radioactive waste from the Krško NPP is stored in the LILW storage facility at the Krško NPP. The storage facility is an anti-seismic, reinforced concrete building with an area of 1,470 m2 and a useful volume of approximately 2,000 m3, which is divided by partition walls into six separate compartments. Under the location permit from 1978, the original administrative capacity of the LILW storage facility at the Krško NPP was limited to 5,000 standard-size drums. The new location permit issued in 1988 relaxed the administrative capacity limits up to the existing building dimensions under the condition that an equivalent dose of 0.2 mSv/year as measured at the plant boundary fence is not exceeded.

The storage space of the radioactive waste storage facility was optimised with the construction of a steel structure for a more rational use of the height of the storage space – tubular containers are now arranged in two tiers. The capacity of the storage space was increased to 11,200 standard drums (2,350 m3) or 3,000 tubular containers.

In 1999, an earthquake-proof reinforced-concrete decontamination building was built, prior to the replacement of the old steam generators. There is an area in the building for storing old steam generators, several transport containers of contaminated waste (pieces of piping, other metal waste) generated during the replacement of the steam generators, a heat exchanger, a replaced reactor vessel head with equipment, and other contaminated bulk material.

Several improvements have been made so far in the radioactive waste management system and in the temporary LILW storage facility with a view to improving the safety of handling radioactive waste, reducing its volume and optimising the storage space. The modernised procedures introduced with these improvements use new packing methods which makes them safer for long-term storage, as well as for workers, as they reduce radiation exposure.

At the end of 2021, around 96% of the declared storage capacity of the LILW storage facility at the Krško NPP was filled. Currently, there is available space in the partially occupied areas A and B of the storage facility. No larger manipulation operations or the movement of existing packages are planned. The annual quantities of radioactive waste generated are predictable. One of the fundamental principles of radioactive waste management is to reduce the generation of new radioactive waste and the volume of existing radioactive waste.

The Krško NPP estimates that additional storage space is available in the former manipulation areas of the storage facility and in the manipulation area in the waste manipulation building. The waste manipulation building provides space for handling radioactive waste, e.g. sorting, treatment, decay-storage, measurements and other procedures.

All the established procedures for reducing the generation of solid waste must continue, the treatment of borated water must be optimised and the volume of the already generated waste further reduced. The decontamination building can also be used as additional storage space, provided that the old steam generators and other larger components stored there are disassembled, shredded and melted down.

3.1.2 TRIGA MARK II RESEARCH REACTOR

Quantity to date

Radioactive waste is generated during the operation and maintenance of the reactor, during work in the hot cell and in the controlled area of the Department of Environmental Sciences. The waste generated is mainly LILW, such as spent ionic resins, activated or contaminated experimental equipment, samples, protective equipment and aluminium irradiation containers. Radioactive waste is treated separately according to its physical state. Solid waste is separated into incompressible (contaminated tools and other objects, e.g. laboratory glassware) and compressible material (e.g. gloves, shoe covers, protective clothing, contaminated or activated samples, test tubes, pipettes made of plastic, foils, etc.). One to two standard 208 l drums of solid waste (<0.5 m3) is generated annually.

Occasionally, work with activated samples at the laboratory also produces liquid radioactive waste, which is stored for decay in a special 20 m3 tank and, after reaching clearance levels, released into the Sava River in accordance with the prescribed requirements. Radioactive liquids are collected in glass or plastic containers and appropriately solidified before being handed over to the Central Storage Facility for Radioactive Waste (CSF).

Waste management

Solid radioactive waste generated in the use of radioactive material and the operation of the research reactor is temporarily stored in a hot cell facility, which is an integral part of the reactor. The material is stored in drums, while larger contaminated metal pieces are stored as special waste. During the operation of the reactor, gaseous and liquid radioactive discharges are also generated. The estimated dose received from these discharges by a reference person 100 m from the reactor was approximately 0.02 µSv in 2021 (at the fence of the reactor centre, with a reference time of 65 hours). The annual effective dose at a distance of 500 m is approximately 0.6 µSv, which is below the prescribed limit referred to in the safety report and is due to air emissions of inert gas Ar-41 with an annual activity of 1.1 TBq and liquid discharges in which Na-22 with activity at the detection limit was determined.

The basic measure to reduce the amount of radioactive waste generated is the optimisation of operating procedures and the careful separation of non-radioactive and radioactive spent material at the point of generation. In addition, radioactive material that fulfils the regulatory conditions for clearance is also aged and removed from the radiologically controlled area. Sorting and separation into compressible and incompressible waste and the use of a press ensure the additional reduction of the generated waste.

Storage capacity and expected quantity of waste

The quantity of LILW generated during the operation of the research reactor and laboratory work is not significant and can be temporarily stored in the hot cell facility and then handed over to the public service provider. The capacity of the hot cell facility for processing and storing radioactive waste suffices for a much greater quantity than is generated. The storage capacity is approximately 5 m3. During normal operation, less than 10% of the available capacity is used. The anticipated quantity of generated radioactive waste should remain below 0.5 m³ per year. The only exception would be large worn-out reactor components.

3.1.3 INSTITUTIONAL RADIOACTIVE WASTE

Quantity to date

Radiation practice operators, other than operators of nuclear and radiation facilities, mainly use sealed radiation sources, which they return to the supplier after use, if such option exists. If the sources are still usable, they can also hand them over to another holder of a radiation practice licence, although they rarely use this option. Most often, the radioactive waste for which clearance is not planned is handed over to the provider of the mandatory SGEI of radioactive waste management. Institutional radioactive waste is divided into three main groups: solid radioactive waste (Group I), spent sealed sources (Group II) and other radioactive waste (Group III). ARAO also accepts radioactive waste from a found source of an unknown producer or holder or from an accident involving radioactive material. The Central Storage Facility for Radioactive Waste (CSF) has a space reserved for the storage of 7.5 m3 of any radioactive waste generated in the event of a radiological accident.

In Slovenia, unsealed radiation sources (radiopharmaceuticals) for diagnostics and therapeutic purposes are used by seven organisational units for nuclear medicine, i.e.: the Department of Nuclear Medicine at the University Medical Centre Ljubljana, several departments and laboratories of the Institute of Oncology Ljubljana, the University Medical Centre Maribor and general hospitals in Celje, Slovenj Gradec, Izola, and Šempeter pri Gorici. Sealed radiation sources for therapeutic purposes are used at the Institute of Oncology in Ljubljana and at the Department of Ophthalmology of the University Medical Centre Ljubljana, while the Blood Transfusion Centre of Slovenia has been using an x-ray device for the irradiation of blood components instead of a sealed source since 2020. Radioactive waste resulting from the use of unsealed radiation sources is mostly short-lived transient radioactive waste that is not problematic in terms of management, because the producers of such waste provide suitable premises where the waste is temporarily stored or decay stored until its activity is reduced to the extent that it may be cleared in accordance with the applicable regulations.

In the last five years, the public service provider accepted on average 750 kg (2.7 m3) of institutional radioactive waste per year. These are gross quantities including the packaging.

The use of radioactive sources in industry and research has been falling, as the technologies are being replaced by those that do not need radiation sources. The greatest portion of unprocessed radioactive waste accepted is waste ionisation smoke alarms.

With regard to the area of origin of accepted radioactive waste and the average mass over the past three years, radioactive waste is generated in research and education (10%, including research for medical purposes), healthcare (5%) and industry (85%, including ionisation smoke alarms and the historical waste owned by the Slovenian Armed Forces).

At the end of 2021, 88.4 m³ of radioactive waste (total mass 49.5 t, total activity 3.2 TBq) was stored at the CSF, which amounts to approximately 80% of its capacity.

Sealed radiation sources represent most of the activity stored at the CSF. Table 5 shows that sealed sources accounted for approximately 96% of the activity of radioactive waste stored at the end of 2021. The remaining activity came from solid radioactive waste types T1, T2, T3, and T4. As much as 59% of the waste stored as of the end of 2021 contained short-lived radionuclides (Co-60, Cs-137, Sr-90, etc.), while other waste contained long-lived radionuclides (Ra-226, Am-241, Th-232, etc.).

In terms of volume, the largest share of radioactive waste stored at the CSF in 2021 was from Group I. Solid waste account for approximately 91% of the stored radioactive waste volume, the remainder are sealed radiation sources. Of solid radioactive waste, 29.9% is combustible waste (compressible and incompressible), one half (50.4%) is also compressible (combustible and non-combustible), while 33.4% is incompressible and non-combustible waste, waste in special form or large bulk waste (T4) whose further processing is not reasonable. Although sealed sources contribute substantially to the activity, they only occupy 9.1% of the volume of the storage facility. Radioactive waste from Group III – other radioactive waste (liquid and mixed waste) is rarely delivered. Before it is accepted in the storage facility, it is treated and solidified. It represents only a small share of waste in the storage facility.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Groups | Radioactive waste type |  | Number of packages | Radionuclides | Activity (Bq) | Activity share of the subgroup (%) | Activity share | Volume of the subgroup (m3) | Volume share of the subgroup | Volume share of the group |
| Subgroups |  |  | Solid radioactive waste |  |  |
|  | T1 (solid, compressible, combustible) |  | 104 | 226Ra, 60Co, 241Am, 109Cd, 108Ag, 238U, 57Co, 232Th, 3H | 6.70E+08 | 0.02 | 4.02 | 20.2 | 22.8 | 90.9 |
| T2 (solid, compressible, non-combustible) |  | 125 | 226Ra, 60Co, 241Am, 109Cd, 108Ag, 238U, 3H, 238U, 14C, 228Th, 106Ru, 210Pb | 1.68E+10 | 0.52 | 24.4 | 27.6 |
| T3 (solid, incompressible, combustible) |  | 29 | 226Ra, 60Co, 232Th, 137Cs, 152Eu, 22Na, 133Ba | 3.41E+09 | 0.11 | 6.3 | 7.1 |
| T4 (solid, incompressible, non-combustible) |  | 175 | 226Ra, 60Co, 109Cd, 137Cs, 108Ag, 238U, 14C, 232Th, 133Ba, 95Nb, 152Eu, 241Am, 85Sr | 1.08E+11 | 3.37 | 29.5 | 33.4 |
| Sealed sources | ZV0 (smoke alarms) |  | 76 | 241Am, 226Ra | 1.88E+10 | 0.59 | 95.98 | 3.1 | 3.5 |  |
| ZV1 (spent sealed sources with A ≤ 3.7 GBq) |  | 118 | 226Ra, 60Co, 241Am/Be, 238U, 232Th, 63Ni, 55Fe, 90Sr, 106Ru, 3H, 152Eu, 137Cs, 85Kr, 238U | 6.86E+11 | 21.40 | 1.8 | 2.0 | 9.1 |
| ZV2 (spent sealed sources with 3.7 GBq < A ≤ 37 GBq) |  | 35 | 226Ra, 152Eu, 154Eu, 60Co, 137Cs, 85Kr, 90Sr, 241Am/Be, 133Ba, 3H, 137Cs, 210Pb, 55Fe | 7.54E+11 | 23.52 | 1.3 | 1.4 |
| ZV3 (spent sealed sources with 37 GBq < A ≤ 370 GBq) |  | 8 | 152Eu, 241Am, 60Co, 137Cs, 133Ba, 90Sr, 241Am/Be, 3H, 85Kr, 90Sr | 4.38E+11 | 13.66 | 1.5 | 1.7 |
| ZV4 (spent sealed sources with A > 370 GBq) |  | 3 | 60Co, 137Cs | 1.18E+12 | 36.81 | 0.4 | 0.5 |
|  | Total number of packages |  | 673 |  | 3.21E+12 | 100.00 | 100.00 | 88.4 | 100.0 | 100.0 |
|  | Total volume |  | 88.4 m3 |  |  |  |  |  |  |  |
|  | Total mass |  | 49.5 t |  |  |  |  |  |  |  |

Table 5: The types of radioactive waste and the number of packages at the CSF on 31 December 2021

Radioactive waste management

A radioactive waste package consists of the packaging with internal barriers or absorption material and radioactive waste. The packaging for radioactive waste storage is selected according to the type, properties and quantity of waste, and must meet the acceptance criteria for storage. A standard 208 l drum is the outer packaging of most radioactive waste stored at the CSF. The drums are put into pallet frames and stacked three tiers high. Smaller bulky units are stored in bags, small metal containers or plastic containers inserted into metal cage pallets. After treatment and conditioning, bulk radioactive waste is also stored in drums.

As part of the provision of the public service, ARAO informs the holders of radioactive waste of other radioactive waste management options and encourages them to hand radiation sources over to other radiation practice licence holders, if the sources are still usable, or to return spent sources to the suppliers or producers. Based on the information on radioactive waste held by holders, ARAO also provides advice on the clearance of radioactive materials while they are still held by the holder and on the possibility of export, if appropriate. ARAO reduces the quantity of operational radioactive waste by consistently following the procedures for the acceptance and storage of radioactive waste, thus ensuring that the possibility of contamination upon acceptance and in storage is kept to a minimum.

In order to reduce the volume of radioactive waste stored at the CSF, the waste is sorted, separated and packed, which facilitates the more efficient and safer handling of packages. The volume and mass of radioactive waste in storage is additionally reduced in treatment and conditioning procedures, such as decontamination, the disassembly of devices that have contained sealed radiation sources, the cutting of large contaminated parts into smaller pieces and compression. These treatment and conditioning procedures are sufficient for the current needs. ARAO carries them out independently as a regular activity. More complex procedures are rarely required, so it would be reasonable to consider the possibility of such procedures, when needed, being carried out abroad or in mobile units that can be obtained for temporary use.

In order to reduce the volume of radioactive waste at the CSF and to provide sufficient storage space, in recent years ARAO has transported several shipments of ionisation smoke alarms abroad for recycling, where they will remain. It also transported and handed over for recycling 100 kg of depleted uranium.

Storage capacity and expected quantity of waste

The CSF consists of staff rooms, an area for storing radioactive waste, an engine room for the ventilation device and built-in systems. The facility measures 10.6 m × 25.7 m, and is 3.6 m high. The storage area is divided into ten compartments with the compartment that is farthest from the cargo door deepened below the storage floor level. The transport route runs along the middle of the storage area.



Figure 3: Expected radioactive waste quantities at the CSF over the next few years, taking into account the reduction of volume due to treatment, reuse and clearance

Given the current storage arrangement, the administrative storage capacity is 115 m3 of radioactive waste, of which 107.5 m3 is intended for regular storage and 7.5 m3 for the emergency acceptance of waste in the event of a radiological accident. Should the waste from accidents exceed this volume, the issue would be addressed on a case-by-case basis. It is possible to increase the storage capacity (up to 17 m3) by introducing technology for storage in the deepened compartment and by using parts of the transport route area.

Based on years of experience in accepting radioactive waste and trends in the use of radioactive sources in industry, healthcare and research and education, the expected annual input of radioactive waste at the CSF in the next few years is 3 m3, except in the event of the acceptance of a large quantity of worn-out components from the TRIGA research reactor. If waste treatment and conditioning were not carried out in the hot cell facility and given the expected intake trend, the radioactive waste storage facility will be administratively at full capacity in 2027. However, in the case of sealed radiation sources, where the entire device is accepted and in the process of further treatment non-radioactive parts are removed and only the radioactive radiation source is retained in the storage facility, the volume is reduced by more than 90% in the majority of cases where this process is possible. The volume of solid radioactive waste can also be reduced efficiently by incinerating combustible waste abroad and supercompacting the already compressed waste. However, this process is expensive and will only be possible when all other volume-reducing options are exhausted. ARAO will continue to transport radioactive waste abroad for recycling, as long as this option exists and is economically justified.

If the current practice of radioactive waste management continues, the storage capacity will suffice until the LILW repository starts regular operation planned for 2027.

When the Vrbina LILW repository, Krško, is built, the LILW from the CSF that meets the acceptance criteria for disposal will be deposited there. The issue of any remaining LILW will be resolved along with the issues relating to the management of spent fuel and HLW.

3.2 SPENT FUEL MANAGEMENT

In Slovenia, spent nuclear fuel is only generated by the Krško NPP and the TRIGA Mark II research reactor. The current quantity of spent nuclear fuel is small (approximately 550 t of uranium and 6.8 t of plutonium). These quantities are exceptionally small compared to other nuclear states and will remain so even after both reactors are shut down. Currently, only the Krško NPP has any spent fuel, since all the spent fuel from the TRIGA Mark II research reactor was returned to the United States of America (hereinafter: USA) in 1999.

The operator of a nuclear facility in operation is competent and responsible for managing spent fuel at the site of the facility. This means that the Krško NPP is responsible for the storage of spent fuel from the NPP, while the Jožef Stefan Institute is responsible for the storage of spent fuel from the research reactor (of which there was none as of 2021). After the storage, ARAO, as the provider of the SGEI of managing radioactive waste, will be responsible for any processing of spent fuel before disposal, preparations for the construction of a repository, the construction of a repository, and the packaging and disposal of spent fuel. When the repository is built, ARAO will also be responsible for its operation and management, and for long-term monitoring and maintenance after its closure.

3.2.1 Krško NPP

Quantity to date

The reactor core of the Krško NPP comprises 121 fuel elements with external dimensions of 20 cm x 20 cm x 376 cm. A fuel element consists of 235 fuel rods filled with ceramic tablets of uranium dioxide and dressed in zirconium alloy cladding. Uranium enrichment is on the order of a few percent (between 2% and 5%). One fuel element contains approximately 406 kg of uranium.

In 2004, the Krško NPP introduced a longer fuel cycle in which fuel elements are changed once every 18 months, as shown in Figure 4. On average, 56 fuel elements are replaced during each outage. At the end of 2021, there were 1,379 spent fuel elements stored in the pool for spent nuclear fuel at the Krško NPP site, taking into account two containers of fuel rods from the fuel reconstitution.

Figure 4: The total number of fuel elements at the end of 2021 and the number of annually replaced fuel elements in the Krško NPP pool

Storage capacity and the expected spent fuel quantity

The total number of storage places in the spent fuel pool since its modification in 2003 is 1,709, of which 26 are inaccessible. Since space for the entire reactor core must be ensured in the pool at any given moment, 121 places must always be reserved for the emergency evacuation of the core. The remaining places are physically available for the storage of spent fuel elements. Due to the increased safety reserves, only 1383 places are actually available for storage. Following the stress tests conducted after 2011, the safety reserves were increased and stricter criteria for the placement of fuel elements in the storage racks were introduced. The number of available storage places for spent fuel before spent fuel is transferred is estimated to be sufficient until 2023. When phases 1 and 2 of the spent fuel transfer are carried out, the number of places will suffice for five years after the end of the extended lifetime of the Krško NPP.

In 2011, the SNSA issued a decision requiring the Krško NPP to update safety measures for the prevention of major accidents and the mitigation of their consequences. The decision, among other things, required the Krško NPP to assess the possibility of reducing the risk associated with spent fuel management by amending the long-term strategy. To this end, in 2012 the Krško NPP drafted a document entitled Evaluation of Spent Nuclear Fuel Storage Options. In the document, the Krško NPP notes that it is essential, for several reasons, that the spent fuel management strategy in the NPP is updated and that the most suitable solution would be to build a dry storage facility. Considering the accident scenario, which exceeds the design basis, the current storage capacity of the spent fuel pool does not suffice for normal operation after 2023 and the number of fuel elements in the pool must be reduced.

The main purpose of the construction and operation of a dry storage facility is to modernise the technology of temporary spent fuel storage. Dry storage is a safer method of storing spent fuel, as it uses a passive cooling system. This technology also improves radiation safety and increases the robustness of the system. With dry storage, a new, technologically safer method of spent fuel storage is being introduced, which will gradually reduce the number of spent fuel elements in the pool, thus substantially increasing the level of radiation safety and physical protection.

3.2.2 TRIGA MARK II RESEARCH REACTOR

Quantity to date

The core of the TRIGA Mark II research reactor has 91 locations that can be filled with either fuel elements or other core components (control rods, dummy elements, irradiation channels, etc.). In 2021, the reactor core had a total of 63 fuel elements, of which three were control rods with fuel followers. The remaining 28 locations were filled with the fourth control rod, irradiation channels or a neutron source or were left empty. The fuel elements of the TRIGA Mark II research reactor have a cylindrical shape and measure 72 cm in length and 3.75 cm in diameter. The stainless-steel cladding contains a metal fuel mixture of uranium and zirconium hydride. One fuel element contains approximately 0.3 kg of uranium enriched to 20%.

The TRIGA Mark II research reactor currently does not hold any spent fuel because in 1999 the Jožef Stefan Institute, as the operator of the research reactor, returned all stored spent fuel (219 spent elements) to the fuel’s country of origin, i.e. the USA, as part of a special programme for repatriating spent nuclear fuel from research reactors.

3.2.2.1 Storage capacity and expected waste quantity

Following the repatriation of the spent fuel to the USA, the inventory at the TRIGA Mark II research reactor comprises 63 fuel elements in the reactor and 21 fresh fuel elements kept in the fresh fuel storage area. The pool for spent fuel, with a capacity of 630 fuel elements, is available in case there is a need for the temporary storage of spent fuel. This is more than enough for the storage of the total fuel inventory planned until the shutdown.

The future quantities of spent fuel depend on the decision of the operator and the owner of the research reactor on the operation of the reactor after 2024. The TRIGA Mark II research reactor has been in operation since 1966. In 1991, it was thoroughly inspected and reconstructed.

In 2015, a long-term strategy for the operation of the TRIGA reactor [15] was drawn up, which considers various scenarios of spent fuel management, i.e.:

-        transportation to the USA,

-        transportation to other countries,

-        transfer to a different location,

-        transfer to ARAO.

For this purpose, a preliminary cost analysis for the management of spent fuel from the research reactor was conducted. It was established that even if Slovenia used the option of repatriating the spent fuel from the research reactor to the USA, such repatriation would no longer be free of charge for Slovenia under the USA’s fee policy concerning countries with high-income economies.[19] [20] Furthermore, the basic fuel repatriation programme expired in May 2019. In 2019, the programme was extended until 12 May 2029, but fuel may only be repatriated under certain conditions, i.e. that the research reactor is shut down or modified to enable operation with low-enriched uranium, that there is a clear statement of reasons for nuclear non-proliferation, including the removal of a large quantity of uranium and/or separated plutonium from the nuclear facility, or that the facility met the acceptance criteria before the expiry in 2019 but the spent fuel transport campaign has not been concluded due to reasons beyond the control of the facility operator.[21] Considering these conditions and the characteristics of the fuel and operation of the TRIGA Mark II reactor, the return of spent fuel is currently not possible.

3.3 DECOMMISSIONING OF NUCLEAR AND RADIATION FACILITIES

The decommissioning of a nuclear or radiation facility encompasses all the measures required to achieve clearance from regulatory control under the Act governing ionising radiation protection and nuclear safety. The decommissioning includes decontamination and dismantling procedures and the removal of all radioactive waste and spent fuel from the facility. When the decommissioning process is completed, the facility and location can be exempted from administrative control and the location can be used for other purposes without radiological restrictions. Globally, there are two established approaches to decommissioning, i.e. immediate and delayed decommissioning. Apart from the decision of the facility owners, the selection of the decommissioning approach technically depends primarily on the national long-term overall strategy for radioactive waste and spent fuel management.

Under the Slovenian legislation and internationally recognised standards, the owner or the operator of the facility is the one responsible for the decommissioning of a nuclear or radiation facility. The responsibility for decommissioning is laid down in the ZVISJV-1 and implementing regulations, which stipulate that, after the start-up of a facility, the operator must adopt and apply a programme of measures and procedures that provide for the possibility of the permanent shutdown of the facility in accordance with the prescribed protection against ionising radiation. In accordance with the legislation, the operator or the owner is also obliged to ensure an adequate decommissioning programme for the facility.

In Slovenia, there are three operating nuclear facilities (the Krško NPP, the TRIGA Mark II research reactor and the CSF) and a new facility under construction – the repository of LILW in Vrbina, Krško. None of the facilities is being decommissioned.

3.3.1 DECOMMISSIONING OF THE KRŠKO NPP

After the Krško NPP is shut down, it will be decommissioned. After decommissioning, its status as a nuclear facility will also cease. The holder of the operating licence, i.e. the Krško NPP, has the primary responsibility for designing technical decommissioning procedures. Both owners of the Krško NPP, i.e. Slovenia and Croatia, jointly bear the final responsibility for the power plant decommissioning, as laid down in the Slovenian-Croatian Agreement on the Krško NPP.

In accordance with Article 10 of the Slovenian-Croatian Agreement on the Krško NPP, the owners are obliged to review and update the decommissioning programme every five years. The owners (the two countries) authorised an intergovernmental commission to fulfil this obligation.

Pursuant to the requirements of Article 10 of the Slovenian-Croatian Agreement on the Krško NPP, the Programme for the Decommissioning of the Krško NPP and the Disposal of LILW and Spent Nuclear Fuel was approved in 2005.[11] The programme was based on the scenario of the immediate decommissioning of the reactor after the facility is shut down. When the decommissioning programme was approved in 2005, the shutdown was scheduled for 2023. At present, the shutdown of the NPP is envisaged for 2043, provided that the environmental impact assessment and periodic safety reviews in 2023 and 2033 are concluded successfully.

Pursuant to the decision adopted at the 11th session of the intergovernmental commission in November 2017 [12], NEK, d.o.o., in cooperation with ARAO and Fond NEK, produced the third revision of the Krško NPP Decommissioning Programme [22].

The third revision of the Krško NPP Decommissioning Programme [22], approved by the intergovernmental commission at its 14th session in July 2020 [14], is based on the strategy of immediate decommissioning with the removal of all components, systems and structures after the power plant is permanently shut down in 2043. The third revision of the programme also covers the operation of the dry storage facility for spent fuel and its decommissioning and the gradual conventional demolition of the remaining buildings. Two scenarios are considered. The basic scenario envisages the operation of the dry storage facility until 2103, while the alternative scenario envisages operation until 2075.

According to the third revision of the Krško NPP Decommissioning Programme, 50% of LILW, which represents Slovenia's share of the LILW from the Krško NPP decommissioning, will be put into N2d disposal containers, while the remaining 50%, which represents Croatia's share of the LILW from the Krško NPP decommissioning, will be put into reinforced concrete containers. The revised programme also examines the option of all LILW being placed either into N2d disposal containers or into reinforced concrete containers and presents the results.

The decommissioning itself is divided into several stages. Under the strategy of immediate decommissioning and dismantling, which takes into account that the wet storage facility for spent fuel must continue to operate for five years after the cessation of the operation of the Krško NPP and that the last spent fuel transfer campaign will start in 2048, disassembly activities will start five years after the reactor is shut down.

Decommissioning begins with the preparation of plans and all necessary data and documents before the lifetime of the power plant ends. Immediately after the shutdown of the power plant, the post-operation period is to begin, in which the plant is prepared for disassembly, the systems and components are cooled, and the activity of the irradiated components is gradually reduced (see Table 6). In this period, all the activities planned for after the shutdown of the power plant are carried out, the preparations for and the implementation of the last campaign of transferring spent fuel from the storage pool to the existing dry storage facility at the plant site, the preparation of documents required for dismantling permits, the removal of various radiation sources, the removal and disassembly of old replaced steam generators, the decontamination of the primary circuit and the processing of the generated radioactive waste.

It is planned that all the permits required for decontamination and disassembly activities will be obtained during the dismantling stage. To this end, the monitored and controlled areas of the power plant will be decontaminated, the activated components and structures will be disassembled and radioactive materials will be decontaminated and cleared from regulatory control. The next key project is the dismantling, cutting up and packaging of the reactor vessel.

|  |  |  |
| --- | --- | --- |
|  | Basic scenario | Alternative scenario |
| Launch of the decommissioning project (pre-decommissioning activities) | 07/2040 |
| Permanent shutdown of the Krško NPP/approval of decommissioning and dismantling works | 12/2043 |
| Removal and disassembly of old replaced steam generators  | 12/2045 |
| Completion of works – primary circuit | 07/2047 |
| Completion of works – the interior of the reactor pressure vessel | 06/2049 |
| Completion of works – reactor pressure vessel | 03/2051 |
| Completion of works – biological shield | 10/2052 |
| Removal of buildings – brownfield state | 02/2058 |
| End of operation of the dry storage facility | 01/2103 | 01/2075 |
| Greenfield status | 07/2107 | 07/2079 |

Table 6: Main milestones of the Krško NPP decommissioning

The aim of the next stage, which starts when the reactor vessel is dismantled, is to conclude the works by removing the biological shield. Outside the dismantling area, the biological shield will be cut into blocks, which will be further segmented into pieces suitable for packaging and disposal or for clearance.

The remaining systems and infrastructure in the controlled area will be dismantled by disassembling the systems and components. Components and equipment, such as steel structures, hoisting equipment, cables and cable trays and ventilation ducts, will be removed. The final dismantling of the infrastructure includes the removal of tools, scaffolding, steel supports and other parts that are no longer needed.

The last project of power plant decommissioning to brownfield status, when the buildings (other than the dry storage facility, which will continue to operate) will be cleared from regulatory control, is the decontamination of building structures in the controlled area and the removal of buildings in the controlled and monitored areas. During this stage, a comprehensive radiological characterisation and the measurements necessary to clear radioactive material from regulatory control will be carried out.

The complete removal of all systems and structures and the restoration of the site to its original state will be carried out in 2103, after the dry storage facility ceases to operate. As soon as the demolition works are finished and the building pits are filled with demolition rubble, the restoration and other works will start to bring the area to greenfield status, when all facilities will be cleared from regulatory control.

During the decommissioning and dismantling of the Krško NPP, many components, systems and structures with very different physical, chemical and radiological properties will have to be treated, conditioned and packaged. The aim of all decommissioning activities, including decontamination and treatment, is the clearance of radioactive materials and the preparation of non-radioactive waste for conventional disposal and the packaging of radioactive waste for final disposal in Slovenia and Croatia.

In the scenario of immediate Krško NPP decommissioning in 2043 and the subsequent decommissioning of the dry storage facility, 466.4 thousand tonnes of material are expected to be generated, which can be classified in five main categories, as presented in Table 7.

|  |  |
| --- | --- |
| Decommissioning materials | Mass (t) |
| Ordinary waste (no treatment) | 444,497 |
| Materials meeting the clearance criteria (prior to treatment)  | 15,632 |
| Hazardous non-radioactive material (prior to treatment) | 115.0 |
| HLW (no treatment) | 82.1 |
| LILW (prior to treatment) | 6,115.6 |

Table 7: A breakdown of decommissioning materials, summarised from the third revision of the Krško NPP Decommissioning Programme [22]

Most of the waste from decommissioning will not be radioactive. The radioactive waste from decommissioning can be classified into three categories:

-        activated components from within the reactor, reactor vessel and biological shield (main radionuclides: Co-60 and Eu-152),

-        contaminated components due to internal contamination from contact with radioactive materials (main radionuclides: Co-60 and Cs-137),

-        contaminated components in the radiologically controlled area and building structures due to the dispersion of radioactive particles and dust.

The management of the materials generated in the decommissioning will comprise the clearance of radioactive materials from regulatory control and the disposal of non-radioactive materials with the possibility of reuse, and preparation for disposal at landfills for municipal and construction waste. Prior to disposal, radioactive waste will have to be conditioned to form appropriate disposal units in accordance with the acceptance criteria for disposal. The treatment, conditioning and packaging of radioactive waste will include various procedures for reducing the volume of and solidifying the waste, e.g. additional cutting, the disassembly of components, decontamination, compression, evaporation and immobilisation, in accordance with the acceptance criteria for disposal.

Part of the activated components of the internal parts of the reactor and the reactor vessel with HLW and long-lived LILW will be packed into Holtec HI-SAFE containers and stored long term together with the spent fuel. The remainder of the radioactive waste from the reactor and the reactor vessel will be packed first in standard 208 l drums or cylindrical containers and then in concrete containers, or directly in concrete containers, and disposed of as LILW at repositories in Slovenia and Croatia.

If the operation of the Krško NPP is extended until 2043 and the envisaged scenario of the immediate decommissioning of the Krško NPP (2043–2058) and the decommissioning of the dry storage facility for spent fuel and HLW is realised, approximately 6,116 t of untreated LILW will be produced (Table 7).

Treatment involving the evaporation of the contaminated water and the water from decontamination procedures is expected to reduce the mass of the LILW to 3,252 t, with a total activity of 5.6 TBq, which will have to be disposed of at appropriate disposal facilities in accordance with the acceptance criteria. This estimate includes all primary and secondary LILW but not the radioactive components from the reactor interior and parts of the reactor vessel, as these will be placed in seven Holtec HI-SAFE containers and first stored together with the spent fuel and then deposited in the repository for HLW and spent fuel. However, the estimate includes the LILW produced in the treatment of already replaced old and new steam generators. The total quantity of LILW from the Krško NPP decommissioning to be disposed of at LILW repositories in Slovenia and Croatia is estimated at 2,860 t in mass, 2,842 m3 in volume, and 4.93 TBq in activity.

According to the third revision of the Krško NPP Decommissioning Programme [22], 410 N2d containers of LILW will have to be deposited in repositories in Slovenia and Croatia. Slovenia's share amounts to 205 N2d containers, of which 177 will be deposited in the Vrbina LILW repository, Krško. The remainder (28 N2d containers or 550 t) of LILW, which will be generated in the decommissioning of the dry storage facility, will be deposited in a geological repository together with the spent fuel and HLW, as the Slovenian LILW repository is expected to be closed by then.

In July 2020, the intergovernmental commission on monitoring the implementation of the Slovenian-Croatian Agreement on the Krško NPP tasked the specialist organisations in Slovenia and Croatia (NEK, d.o.o., ARAO, Fond NEK) with preparing the terms of reference required for the fourth revision of the Krško NPP Decommissioning Programme and with drawing up the fourth revision of the programme. [14] At its 16th session in April 2022, the intergovernmental commission approved the terms of reference for the fourth revision of the Programme for the Decommissioning of the Krško NPP and tasked the Krško NPP with producing, in collaboration with ARAO and Fond NEK, the fourth revision of the Programme for the Decommissioning of the Krško NPP, by April 2024. [16]

The new revised Krško NPP Decommissioning Programme, as envisaged in the Slovenian-Croatian Agreement on the Krško NPP, will provide new and improved estimates of the quantities of material generated in decommissioning and in the treatment and conditioning of those materials, and of the funds required for decommissioning.

3.3.2 DECOMMISSIONING OF THE TRIGA RESEARCH REACTOR

The long-term operational strategy for the TRIGA reactor [16] noted that the scenario under which the reactor would operate until May 2016 and the spent fuel would be transported to the USA by May 2019 was not realistic considering the time and financial investment required in the short period of time. Therefore, the TRIGA reactor has continued to operate during the aforementioned period and the spent fuel has not been repatriated to the USA. In recent years, Slovenia has invested significant funds in the renovation of some systems (ventilation, fire safety, instruments, etc.). The first periodic safety review was concluded in 2014 and the next is already underway.

In 2007, the Jožef Stefan Institute produced the first edition of the Programme for the Decommissioning of the TRIGA Mark II Research Reactor [20], which was based on the offer of the USA[23] [24] to accept the spent fuel from the research reactor. The programme included an option in which the research reactor would operate until 2016, the spent fuel would be transported to the USA by 2019 and the reactor would be immediately decommissioned. In 2021, the Jožef Stefan Institute prepared the fourth edition of the Programme for the Decommissioning of the TRIGA Mark II Research Reactor [18], which takes into account the need for the reactor to continue to operate, the results of the most recent periodic safety review and management options for the radioactive waste and spent fuel.

The basic timetable for the decommissioning of the TRIGA Mark II reactor envisages the operation and shutdown of the reactor by the end of 2034, with the possibility of extension until 2043, the transportation of spent fuel to the USA, if possible, or its storage until final disposal, which the basic scenario envisages to be carried out together with the disposal of the spent fuel from the Krško NPP. There is also an option of depositing spent fuel in deep geological boreholes. The basic strategy for the decommissioning and dismantling of the reactor envisages immediate decommissioning three years after the end of operation.

The existing decommissioning programme based on the scenario of the immediate decommissioning of the reactor estimates that approximately 105.2 t of LILW in the form of construction and other waste will be generated, which will be deposited in the LILW repository in Vrbina, Krško, after the decommissioning is completed.

As it has been decided that the TRIGA Mark II research reactor is to operate at least until the conclusion of the next periodic safety review, i.e. until 2034, with the possibility of extension until 2043, an updated decommissioning programme will be drawn up in the 10-year period covered by the present Resolution.

3.3.3 DECOMMISSIONING OF THE CENTRAL STORAGE FACILITY FOR RADIOACTIVE WASTE IN BRINJE

As a public national infrastructure for the storage of institutional radioactive waste, the Central Storage Facility for Radioactive Waste (CSF) provides a safe storage space for radioactive waste for as long as it is generated by different activities in the country and for as long as there is a need for its storage. There are no nuclear reactions that could cause neutron activation taking place in the Central Storage Facility for Radioactive Waste, and no contamination of the facility and the immediate surroundings is expected in its service life. The results of contamination control to date show that no contamination of partition walls, floors and ceilings, metal pallets, the surface of radioactive waste packages, movable and electro-mechanical equipment, and underground wastewater tank and piping is to be expected.

In 2012, a preliminary decommissioning programme was drawn up for the CSF [25], under which the decommissioning of the facility was planned after the shutdown without the removal of the building, according to two scenarios with differences at the start of the decommissioning.

In January 2021, ARAO prepared a revised decommissioning programme for the CSF [26]. The programme was supplemented to take into account the status of the LILW repository project and the start of repository operation, the possibilities for the storage of institutional radioactive waste at the LILW repository site, the generation of institutional radioactive waste in Slovenia, the requirements of the valid operating licence for the CSF and the justification and need for its continued operation.

In view of the project documents for the Vrbina LILW repository, Krško, the approved national spatial plan for the LILW repository, the programme for the decommissioning of the TRIGA research reactor and the quantities of the institutional radioactive waste expected to be generated in industry, research and healthcare in Slovenia, it is essential that the CSF continues to operate.

When all Slovenian LILW meeting the acceptance criteria for disposal is deposited in the LILW repository, a standby period is planned (until 2050), when the repository will be brought to a state corresponding to a long period of inactivity and during which LILW will not be accepted and deposited and no major works will be carried out at the repository. During the LILW repository standby period, institutional radioactive waste will still be generated in Slovenia, due to radiation practices in industry, research and healthcare and the operation of the TRIGA research reactor. Furthermore, the project documents for the LILW repository envisage that by 2029 all the LILW generated by that time will be deposited in the repository, which represents 60% of the estimated total quantity of waste stored at the CSF by 2058. The disposal of the remaining LILW is planned for after the repository standby period, when the acceptance and deposition of LILW will resume.

In order to ensure safe and efficient radioactive waste management, which is the main objective of the national programme for radioactive waste and spent fuel management, and in accordance with the overall objectives of safe radioactive waste and spent fuel management, the following scenario is planned for the decommissioning of the CSF after it is shut down:

When the LILW repository is available for waste disposal, all the LILW from the CSF that meets the acceptance criteria for disposal will be transported to and deposited in the repository. The CSF will remain in operation as a central storage facility for institutional radioactive waste during the standby period of the LILW repository and at least until the shutdown of the LILW repository, which is planned for 2058. According to this scenario, the CSF will be decommissioned and put into unrestricted use after the permit to conclude the decommissioning of the facility is granted. The scenario does not envisage the removal of the facility. The justifiability, adequacy and timetable of the facility’s operation should be regularly verified in the procedures for extending the operating licence and when drawing up and adopting the national programme for radioactive waste and spent fuel management.

It is established that the CSF will be decommissioned according to the aforementioned scenario and the timetable dictated by the needs for storage at the facility. In accordance with the decommissioning strategy, radioactive waste and all mobile equipment will be removed from the facility and the facility cleaned, regardless of when the decommissioning will start. The ventilation system will be dismantled, as it is possible that some parts are contaminated. All other installed systems will remain in place and the works will not interfere with the structure of the building. The building will not be removed and will be available for industrial use after the decommissioning is concluded.

The amount of radioactive and non-radioactive waste generated in the decommissioning will be relatively small. There will be some municipal waste, waste metal and protective equipment and potentially some radioactive waste. Municipal waste, waste metal and protective equipment will be managed in accordance with the established procedures and the applicable decree on waste. It is possible that a small amount of solid radioactive waste will be generated in the decommissioning as a result of the dismantling of the ventilation system and the decontamination of contaminated parts of the system. Materials generated in the decontamination will be packed together with the contaminated ventilation system filters and contaminated personal protective equipment, and finally deposited in the LILW repository. The quantity of contaminated materials is estimated at 2 t.

The CSF is expected to be decommissioned in 2058. The process will take approximately four months or, together with the procedure for obtaining the permit to conclude decommissioning, no more than one year. Thus, the facility could be released to unrestricted use in 2059, unless it has to continue to operate after 2059 due to further use of radioactive materials.

3.4 RADIOACTIVE WASTE CONTAINING NATURALLY OCCURRING RADIONUCLIDES AT THE SITE OF THE FORMER ŽIROVSKI VRH MINE

The obligations of Rudnik Žirovski Vrh, d.o.o., during the closure process are laid down by the Act Governing the Permanent Cessation of Uranium Ore Exploitation and Prevention of the Effects of Mining at the Žirovski Vrh Uranium Mine. A public company (Javno podjetje za zapiranje rudnika urana, d.o.o.) was established by way of a decree [27] adopted in 2001. In November 2006, the Slovenian Government adopted the amended programme for the permanent cessation of the exploitation of uranium ore and the prevention of the effects of mining at the Žirovski Vrh Uranium Mine in the period from 2006 to 2010, which was the basis for carrying out the works related to the closure and prevention of the consequences of mining operations.

The mining and hydrometallurgical tailings and other waste generated during the decommissioning of ore processing and other facilities at the Žirovski Vrh Uranium Mine were deposited in the Jazbec and Boršt repositories. At the Jazbec mining tailings repository, 1,910,425 t of mining tailings are permanently deposited, with an average content of 53 g U3O8/t (or 7.7 kBq of U-238/kg), and a total deposited activity of 21.7 TBq. The repository is covered with a 1.95-m-thick final layer and has a drainage system in place. The area is fenced and under constant radiological surveillance.

The Boršt hydrometallurgical tailings repository is covered with a 2.05-m-thick final layer. In total, 730,450 t of waste is deposited in the repository, i.e. 610,000 t of hydrometallurgical tailings, 111,000 t of mining tailings and 9,450 t of contaminated materials from the decontamination of the repository environment (mining tailings, contaminated soil, construction waste). The total activity of the deposited materials is 48.8 TBq.

A five-year transitional period following the final arrangement of the Jazbec repository in 2008 ended at the end of 2013. During the transitional period the monitoring of radioactivity and the environment was conducted, which confirmed the effectiveness of the remediation measures. By the decision of the SNSA, in 2013 the Jazbec repository of mining tailings became an element of the state infrastructure. In November 2015, following the conclusion of the closure procedure, ARAO began to carry out the long-term monitoring and maintenance of the repository as a service of general economic interest. In September 2019, the SNSA issued a decision to ARAO approving an amendment to the safety report for the Jazbec repository of mining tailings in the part concerning long-term post-closure monitoring. The safety report was amended, changing the programme of radioactivity monitoring and adjusting its scope. It approved new limit values for the emissions from the closed Jazbec repository and the mine effluent during the long-term monitoring period.

Due to the reactivation of the landslide in the area of the Boršt repository in 2008, additional remediation works were needed. The first stage of the Boršt repository remediation was concluded in 2010. However, it was found that the rock and soil mass was still moving and the repository could not be closed yet. In order to reduce landslide movements and ensure control of the long-term stability of the repository, additional intervention measures were carried out in 2016 and 2017 to further lower the groundwater level in the repository. In 2019, nine new piezometers were installed in the wider area around the repository.

All administrative procedures for the closure of the Boršt repository under the ZVISJV-1 and the Mining Act (Official Gazette of the Republic of Slovenia [*Uradni list RS*], Nos 14/14 – official consolidated version, 61/17 – GZ and 54/22) should be concluded in 2023. The repository will be closed and ARAO will start the long-term monitoring and maintenance of the repository.

3.5 TECHNOLOGICALLY ENHANCED NATURALLY OCCURRING RADIOACTIVE MATERIALS

Technologically enhanced naturally occurring radioactive materials are waste or materials that are usually not treated as radioactive but contain naturally occurring radionuclides to such an extent that they may cause radiation exposure to workers or members of the public. In the technological process, the concentration of radionuclides increases due to accumulation. Waste with technologically enhanced natural radioactivity may also contain other hazardous ingredients such as chemicals, hydrocarbons and heavy metals. This waste can be subject to different administrative controls, each with its own legal requirements. In order to be cleared from regulatory control, it must meet all the conditions of the applicable legislation. The holder of the operating licence for the industrial activity is responsible for managing the waste.

The most effective way of managing waste with technologically enhanced naturally occurring radioactivity is to pragmatically address each case individually. The waste is first treated as the materials in the appropriate technological process, taking into account the management principles that apply to low-level radioactive waste. In accordance with the ZVISJV-1, radioactive materials may be mixed with non-radioactive materials during normal operation in activities where materials are mixed. However, they may not be mixed due to their radioactivity in a technological process for the purpose of reuse or recycling. Pursuant to the ZVISJV-1, the Decree on the reduction of exposure due to natural radionuclides and past or existing activities or events (Official Gazette of the Republic of Slovenia [*Uradni list RS*], No 38/18) [28] was adopted in 2018, which lays down the programme for ensuring protection against the increased exposure of workers and members of the public due to radioactive contamination of the environment as a result of remaining radioactive material or activities involving materials containing naturally occurring radionuclides.

3.6 RESEARCH, DEVELOPMENT AND DEMONSTRATION ACTIVITIES

Research in radioactive waste management has been financed with public funds via public calls issued by the Slovenian Research Agency and pursuant to the common legal rules for financing research projects and programmes, young researchers, infrastructure programmes and cooperation with the French Alternative Energies and Atomic Energy Commission (CEA) laid down in the Research and Development Act (Official Gazette of the Republic of Slovenia [*Uradni list RS*] Nos 22/06 – official consolidated version, 61/06 – ZDru-1, 112/07, 9/11, 57/12 – ZPOP-1A, 21/18 – ZNOrg, 9/19 and 186/21 – ZZrID). Funding provided by the Slovenian Research Agency is mainly based on projects (2–6-year periods). Preference is given to those project proposals that the evaluation system recognises as scientifically the most far-reaching. This system neither encourages nor ensures the long-term existence and development of individual research fields that although being less scientifically ground-breaking can nevertheless make a significant contribution to addressing social challenges. Dedicated public funds have not been activated to an extent sufficient to ensure the long-term existence and development of research in radioactive waste management. As a result, in the past, research, development and demonstration activities in radioactive waste management have only occasionally been financed from public funds that were not obtained under the polluter pays principle.

In accordance with Council Directive 2011/70/Euratom, Slovenia must set up a long-term programme of research, development and demonstration activities concerning radioactive waste and spent fuel management. In addition to ensuring progress in the management of radioactive waste and spent fuel in Slovenia, the stable long-term funding of this programme from national sources is one of the key conditions for the successful participation of Slovenian researchers in European projects and technological platforms and for obtaining the support of national stakeholders in implementing the principle of decision-making and actions based on the latest findings of domestic and foreign research, cutting-edge technologies and the best practices and operating experience.

With an adequate share of domestic co-financing, the Slovenian organisations operating in the field of radioactive waste and safe fuel management play an active role in the EURAD project, which is designed to support the implementation of Council Directive 2011/70/Euratom in Member States, taking into account the various stages of radioactive waste and safe fuel management and Member States' progress in implementing their national programmes. By participating in other EU projects concerning radioactive waste and spent fuel management, Slovenian organisations ensure that knowledge is transferred and exchanged internationally and take part in joint research, development and demonstration activities that directly benefit projects in Slovenia while enabling Slovenian researches to contribute to European progress in this field.

Research, development and demonstration activities related to the management of radioactive waste and spent fuel are carried out through ARAO, as part of the SGEI of radioactive waste management, in the organisations that, as the operators of nuclear facilities or holders of radioactive waste, are responsible for radioactive waste and spent fuel management, in the administrative authorities responsible for nuclear and radiation safety, in research institutions and in organisations providing technical support.

Research, development and demonstration activities include the research and development tasks to be carried out for all stages of radioactive waste and spent fuel management, from generation, processing and storage to disposal, and for the long-term monitoring and maintenance of closed repositories. They support the management of radioactive waste and spent fuel, with an emphasis on ensuring the safety of the existing facilities and activities, and the planned storage and disposal of radioactive waste and spent fuel, as well as various challenges of radioactive waste management carried out by holders thereof. The majority of ARAO’s research, development and demonstration activities are currently focused on supporting the construction and operation of the LILW repository. To this end, various projects have been carried out to characterise radioactive waste, plan the activities for the treatment and conditioning of radioactive waste before disposal, develop acceptance criteria for disposal, research basic materials, develop and certify disposal containers, research and develop concrete mixtures and backfill materials, and ensure the long-term safety of the LILW repository. Approximately EUR 4.6 million had been spent on these activities by the end of 2021.

At present, ARAO spends approximately EUR 150,000 per year for research and development and for planning activities related to the management of HLW and spent fuel after storage at the Krško NPP site is concluded. Pursuant to the approved third revision of the Programme for the Disposal of Radioactive Waste and Spent Fuel from the Krško NPP [29], ARAO and the Croatian Fond NEK are planning to increase the funds for this purpose and to jointly prepare further improvements of the disposal programme to include more detailed technical solutions and reliable cost estimates, including a more detailed programme of geological research and for gathering information on potential geological locations suitable for deep geological disposal in Slovenia and Croatia.

In 2013, Slovenia adopted the Nuclear and Radiation Safety Resolution, which also touches upon ensuring the competency of professional support for the entire area of nuclear and radiation safety. The strategy pursues objectives related to the co-financing of the participation of Slovenian scientific and research organisations in international research projects and programmes, of basic research in nuclear and radiation safety, and of applicable research to help address any challenges in nuclear and radiation safety as they occur. Both resolutions are closely linked and should be followed simultaneously.

In Strategy 12 referred to below, research and development are crucial for the provision of the mandatory SGEI of radioactive waste management and is a condition for its effectiveness. It is planned that research, development and demonstration activities supporting the provision of the SGEI of radioactive waste management will be commissioned directly by ARAO based on the approved long-term programme for the provision of the mandatory SGEI of radioactive waste management. Funds for the provision of this service must be provided by the state within ARAO's financial plan in accordance with the financing sources for the SGEI of radioactive waste management, as laid down by the Decree on the method and conditions for providing the mandatory national public service of general economic interest of radioactive waste management [6].

3.7 ANALYSIS OF RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT FUNDING

In Slovenia, radioactive waste and spent fuel management is based on the polluter pays principle, under which radioactive waste producers or holders, if they accepted waste from the producer, pay for the provision of the SGEI of radioactive waste management. In the case of radioactive waste and spent fuel from the Krško NPP, funds are collected in the Krško NPP Decommissioning Fund.

In accordance with the ZVISJV-1, the provision of the mandatory national service of general economic interest regarding the long-term monitoring and maintenance of closed repositories of mining and hydrometallurgical tailings produced in the exploitation of nuclear minerals (described in detail in Chapters 2.7 and 5 on the estimated cost of the implementation of the national programme for radioactive waste and spent fuel management) are financed in full from the state budget.

Due to the small quantities of institutional radioactive waste and the specifics of its management, the cost of the management of such waste is high. Therefore, the price for the service paid by producers and holders upon handover is not based solely on the market economy.

If during the period of validity of this Resolution a decision is made to invest in and build the Krško NPP 2, the financing of radioactive waste and spent fuel management will be based on the polluter pays principle. The cost of the decommissioning and the disposal of radioactive waste and spent fuel from the Krško NPP 2 will be covered exclusively from the fund dedicated to this purpose, into which the facility owner will pay funds earned from the sale of electricity. The amount of funds required for its decommissioning and for the disposal of radioactive waste and spent fuel should be determined before the facility starts to operate based on the preliminary decommissioning programme produced during the stage of obtaining a building permit for the new nuclear power plant and on the programme for radioactive waste and spent fuel management.

Pursuant to the ZVISJV-1 and the Decree on the method and conditions for providing the mandatory national public service of general economic interest of radioactive waste management, the Slovenian Government will adopt a new price list for the SGEI of radioactive waste management. The price list must take into account the costs of the provider of the SGEI of radioactive waste management, and break down the price of services by the type of radioactive waste in terms of its activity, the half-life of the radionuclides, the volume of the waste, and the scope of treatment and conditioning required prior to storage or disposal.

The prices of services are thus based on the optimum level for achieving the main purpose of the ZVISJV-1, i.e. to minimise the detriment to the health of people due to exposure to ionising radiation and the radioactive contamination of the living environment, while enabling the development, production and use of radiation sources and the performance of radiation practices where necessary. The public service price list can only be adjusted to the real economic value of all procedures, i.e. the acceptance, treatment, storage and final disposal of waste, once the final repository has been in operation and the actual cost of disposal is known.

Based on the third revision of the Krško NPP Decommissioning Programme [22] and the third revision of the Programme for the Disposal of Radioactive Waste and Spent Fuel from the Krško NPP [29], the Slovenian Government established that the payments to the Krško NPP Decommissioning Fund under the Programme for the Decommissioning of the Krško NPP and the Disposal of Radioactive Waste and Spent Fuel [11] would not suffice to cover the costs of all the activities envisaged in the two programmes, and on 16 July 2020 it adopted Decision No 360-51/2020/5 increasing the contribution from EUR 3.00/MWH to EUR 4.80/MWh, and in January 2022 Decision No 306-106/2021/5, further increasing the contribution to EUR 12.00/MWh as of 1 January 2022.

In 2003, the Compensation Decree determining the compensation for restricted land use in the area of nuclear facilities was adopted. It was amended in 2008, 2015 and 2020. The 2020 amendment of the Decree takes into account that the sum of all compensations, allowing for the reduced basis and the revaluation of the basis exceeding 1.5% of the annual inflation rate in EU Member States, is within the financial framework of the third revision of the Krško NPP Decommissioning Programme and the Programme for the Disposal of Radioactive Waste and Spent Fuel from the Krško NPP, which ensures the long-term financial sustainability of the Krško NPP Decommissioning Fund as a priority. Taking into account the inflation rate in the years from 2015 to 2019, the amendment slightly increased the basis for calculating the compensation. It harmonised the factors used to calculate the amounts of compensation and charges with regard to a more precise determination of the status of the nuclear facility. It also specified the liable persons and the duration of payment of compensation and charges.

The TRIGA Mark II research reactor is state owned and its operation is financed from the budget of the ministry responsible for science. As the owner, the state will also have to provide the resources for its decommissioning and the management of the radioactive waste and spent fuel, once the reactor is shut down, in accordance with Article 91 of the ZVISJV-1. In 2021, the resources for this purpose were not collected in an appropriate and sustainable manner, despite an estimate of the amount required being provided. In accordance with the ZVISJV-1 and the investment documents for the LILW repository, the funds necessary for the disposal of the LILW generated in the decommissioning of the TRIGA reactor and disposed of at the Vrbina LILW repository, Krško, will be provided from the Slovenian state budget.

4. STRATEGIES AND PROGRAMMES FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT

Slovenia's strategies for radioactive waste and spent fuel management are based on the continuous supervision of all radioactive sources at every stage of their lifecycle, from use and storage to disposal, so that the use of radiation sources and nuclear technologies does not adversely affect human health and has no additional negative impact on the environment. They are based on safe and economical storage, followed by appropriate processing and packaging, and disposal of all waste not envisaged for reuse.

The key points of the programme are the following: the management of LILW from the Krško NPP, the management of highly radioactive waste and waste from the decommissioning of the Krško NPP and the management of spent fuel from the Krško NPP. Any other radioactive waste management has been adapted to this programme in terms of the timetable and technology.

The strategies are based on the assumption that the Krško NPP will operate until 2043 and on the Slovenian-Croatian Agreement on the Krško NPP. To this end, they take into account the third revisions of the Krško NPP Decommissioning Programme [22] and the Programme for the Disposal of Radioactive Waste and Spent Fuel from the Krško NPP [29], which were made in 2019 and approved by the intergovernmental commission on monitoring the implementation of the Slovenian-Croatian Agreement on the Krško NPP at its 14th session in July 2020 [14]. The strategies are adapted to the needs of existing and planned radioactive waste and spent fuel management projects and their development, which include changes that have taken place since the adoption of the previous national programme (ReNPRRO16–25) until now.

The basic scenario in drafting the programme of radioactive waste and spent fuel management for Slovenia envisages the construction of the LILW repository and the completion of the construction and operation of the dry storage facility for spent fuel at the Krško NPP. The Investment Programme for the Vrbina LILW Repository, Krško, Revision E [30] [31], approved in 2021, envisages the construction of the LILW repository to fulfil the requirements for the disposal of Slovenia’s share of LILW generated in the operation and decommissioning of the Krško NPP, and the disposal of all other Slovenian institutional LILW generated in Slovenia. Notwithstanding the decision made by the intergovernmental commission at its 13the session that a joint solution to the disposal of LILW is not possible [13], the LILW repository project paves the way for the technical design and enables the expansion of the disposal capacity with the construction of additional silos since the approval of the Decree on the national spatial plan for a low- and intermediate-level waste repository in Vrbina in the Municipality of Krško [3]. It is possible to expand the capacity to allow the disposal of all LILW from the Krško NPP should an appropriate agreement be reached with Croatia on a joint solution to this issue, pursuant to the Slovenian-Croatian Agreement on the Krško NPP, or should the need arise for additional disposal capacities as a result of the construction of new electricity-generating nuclear facilities.

Pursuant to the applicable Slovenian-Croatian Agreement on the Krško NPP and the decisions made by the intergovernmental commission at its 10th session in July 2015 [32], the dry storage facility for Slovenia's and Croatia's shares of the spent fuel can only operate within the NPP at the Krško NPP's site until the end of the extended lifetime of the Krško NPP, i.e. until 2043. The joint continued operation of the storage facility at the Krško NPP site requires an agreement between the two Parties.

The decommissioning programme for a radiation or nuclear facility drawn up by the facility operator must describe the decommissioning strategy, including all possible versions, decommissioning activities, the timeline and waste management, provide an estimate of the decommissioning costs and specify the sources of financing, foresee the final status of the facility after decommissioning, and provide other content laid down in the Rules on radiation and nuclear safety factors [33].

In selecting the strategy, priority should be given to the strategy of immediate decommissioning, provided the grounds for this choice exist and are described. If, based on all relevant factors, the selected version does not include immediate decommissioning and it is assessed that such is impractical, this must be specifically justified. In such case, the decommissioning programme must demonstrate that the selected strategy will be carried out safely and that sufficient financial resources will be available for the safe maintenance of the facility during the standby period and for subsequent decommissioning [34].

4.1 RADIOACTIVE WASTE MANAGEMENT DURING THE OPERATION OF NUCLEAR AND RADIATION FACILITIES

The strategy for radioactive waste management during the operation of nuclear and radiation facilities is based on the principle of using the processes, technologies and methods that generate the least amount of operational radioactive waste, and on further radioactive waste management in order to reduce the space this waste takes up in the radioactive waste storage facilities and at its final disposal sites. The strategy promotes the use of such processes, technologies and methods that reduce the quantity of generated radioactive waste, reduce the quantity and volume of radioactive waste already generated and stored through appropriate procedures and methods, and meet the acceptance criteria for final disposal, where they exist.

Radioactive waste and spent fuel generated in nuclear and radiation facilities are to be managed in accordance with the approved safety reports for the operation of the specific nuclear facilities.

Strategy 1: The responsibility for radioactive waste and spent fuel in nuclear and radiation facilities rests with the holders of the operating licences. Radioactive waste and spent fuel are managed in accordance with the approved safety reports for the operation of the specific nuclear facilities. Storage is carried out for the purpose of efficient and secure phased disposal at the LILW repository. In radioactive waste management, the concept of the clearance of radioactive materials from regulatory control in accordance with the prescribed criteria is promoted in order to avoid unnecessary generation of radioactive waste.

The measures to achieve the objectives of the strategy:

M1/1 The Krško NPP is to store radioactive waste in the existing storage facility by using already established methods of storage and storage acceptance criteria, modified procedures for optimising radioactive waste management and procedures for reducing the volume of already generated waste, and also by using the space for manipulating equipment and shipments of radioactive shipments between the auxiliary building and the interim LILW storage facility and the decontamination building – continuously until the removal of all LILW from the site. For the purposes of this Resolution, "continuously" means "during the implementation of this Resolution".

-        Key Indicator (hereinafter: KI) KI1/1.1 The Krško NPP maintains an average annual volume of stored LILW below 35 m3 through established treatment methods.

M1/2 The Krško NPP is to store spent fuel in the existing spent fuel pool and arrange for the relocation of spent fuel in 2023 and 2028 and its storage in a dry spent fuel storage facility at the NPP Krško site.

-        KI1/2.1 The relocation of 592 fuel elements in 2023 and 592 fuel elements in 2028.

M1/3 The operator of the TRIGA Mark II research reactor is to manage the radioactive materials generated during the operation of the research reactor in accordance with the established practice of collecting, sorting, separating, clearing from regulatory control and temporarily storing radioactive material in the hot cell facility and handing it over to the provider of the mandatory SGEI of radioactive waste management for storage at the CSF and final disposal – continuously.

-        KI1/3.1 The operator of the TRIGA Mark II research reactor continues its current practice of managing radioactive material in such a way that the annual volume of generated solid radioactive waste does not exceed 0.5 m3 on average.

M1/4 ARAO is to ensure regular and uninterrupted acceptance of radioactive waste and its storage. In doing so, it should, to the extent possible, carry out activities for the reuse, processing or removal of radiation sources stored as radioactive waste at the CSF.

-        KI1/4.1 ARAO keeps the annual volume increase of stored radioactive waste at the CSF below 1.5 m3 on average by using procedures for treating and conditioning radioactive waste, reducing its volume, clearing it from regulatory control, and reusing or removing certain radioactive waste.

Radioactive waste and spent fuel management is financed as part of the operating costs of the individual nuclear or radiation facility. The disposal of LILW is financed from the resources of the Krško NPP Decommissioning Fund and the state budget in proportion to the volume share of LILW from the Krško NPP and other sources. For the Slovenian part of the inventory, the storage of HLW and spent fuel at the Krško NPP site after the end of the Krško NPP operation and the disposal of HLW and spent fuel from the Krško NPP are financed from the Krško NPP Decommissioning Fund.

4.2 MANAGEMENT OF RADIOACTIVE WASTE GENERATED IN INDUSTRY AND RESEARCH

The institutional radioactive waste generated in the use of radiation sources in industry and research is to be managed in accordance with current practice. The holders of radiation sources endeavour to ensure that radioactive waste is not produced in greater quantities than is required for their activities.

In activities where radioactive substances/radionuclides can be replaced by other methods, the use of such methods is encouraged.

Disused radiation sources and radioactive waste are to be handed over to the provider of the mandatory SGEI of radioactive waste management. With a view to preventing radiation sources no longer used for various reasons but still active from ending up as waste, it is recommended that they be handed over to another holder of a radiation practice licence. The recycling or return of radiation sources to suppliers or producers of devices or sources, or their removal without return to Slovenia, is also encouraged, even when the radiation source is already stored at the CSF.

Sealed radiation sources should preferably be obtained from suppliers prepared to take the spent sources back after use. The producers or holders of radioactive waste provide financial resources for the payment of the waste acceptance services at the CSF according to the applicable price list.

Strategy 2: After radioactive material is no longer in use, its users must return it to the supplier/producer or hand it over to another radiation practice operator, or, if this is not possible, hand it over to the provider of the mandatory SGEI of radioactive waste management. Radioactive material can be recovered or reused even if it is already stored at the CSF. The use of alternative methods in activities, where this is possible, is encouraged.

The measures to achieve the objectives of the strategy:

M2/1 Sealed radiation sources are primarily to be returned to suppliers or producers. If this is not possible, they are to be handed over to the provider of the mandatory SGEI of radioactive waste management for appropriate treatment, conditioning and storage in the CSF – continuously.

-        KI2/1.1: Before handing a sealed radiation source over to the provider of the mandatory SGEI of radioactive waste management, its user must check the possibility of returning the source to the producer or supplier. Newer sealed radiation sources should be returned to the supplier or producer in at least 75% of cases.

M2/2 The operator of the CSF is to arrange for a periodic safety review and the renewal and extension of the operating licence of the CSF for another 10 years – until the end of 2028.

-        KI2/2.1 ARAO, as the operator of the CSF, must draw up and submit an application for the approval of the content, scope, methodology and timetable of the next periodic safety review by the end of 2024 at the latest, and draw up a programme for the content, scope and timetable of the review by June 2025.

M2/3 The state is to ensure conditions for the regular provision of the mandatory SGEI of radioactive waste management from take over and transport to treatment, storage and disposal – continuously.

-        KI2/3.1 Every three years, ARAO draws up a long-term programme of work for a period of five years, which serves as the basis for determining the time-dependent financial resources and the financing of activities. The Slovenian Government adopts the long-term work programme of the public service of radioactive waste management based on a reasoned opinion of ARAO's Management Board and on the proposal of the minister responsible for waste. ARAO reports on the implementation of the long-term programme to the Slovenian Government every year as part of the annual report on the implementation of the business plan of the public service of radioactive waste management.

The management of disused radiation sources is financed by service users. The Jožef Stefan Institute is exempt from the payment of services for the radioactive waste generated in the performance of activities as part of its public service or public authority, in accordance with paragraph three of Article 21 of the Decree on the method and conditions for providing the mandatory national public service of general economic interest of radioactive waste management. If radioactive waste is handed over to the provider of the mandatory SGEI of radioactive waste management, the costs are covered from the payment made for the service by service users or holders of radioactive waste according to the price list. The cost of the periodic safety review of the CSF is part of the operating costs of the facility and is to be financed from the state budget and from the contributions paid by service users to the provider of the mandatory SGEI of radioactive waste management for accepting radioactive waste at the CSF.

4.3 MANAGEMENT OF RADIOACTIVE WASTE GENERATED IN HEALTHCARE

Transient radioactive waste generated in activities using unsealed short-lived radiation sources is stored in suitable storage rooms until it decays to clearance levels. Afterwards, such waste is managed in accordance with the regulations on waste management. If clearance from regulatory control in accordance with the regulation governing radiation practices cannot be achieved, solid radioactive waste generated in healthcare is handed over to the provider of the mandatory SGEI of radioactive waste management and stored at the CSF until it can be disposed of at the LILW repository.

Transient liquid radioactive waste arising from the treatment of patients is managed by the continuous dilution and discharge of active waste into the sewerage system. [35] Such direct discharges of radioactive effluent into the sewerage system must be in accordance with the approved emission limit values.

Sealed radiation sources used in human and veterinary healthcare are regularly checked by approved radiation protection experts. When they are no longer in use, they are returned to the producers or suppliers, or, if this is not possible, handed over to the provider of the mandatory SGEI of radioactive waste management and stored at the CSF until they can be disposed of at the LILW repository.

Strategy 3: As a rule, users of sealed radiation sources return disused devices containing sealed radiation sources to the supplier/producer. Failing that, sealed radiation sources are handed over to the provider of the mandatory SGEI of radioactive waste management and stored at the CSF. The clearance of radioactive material from regulatory control in accordance with the regulation governing radiation practices is promoted in order to reduce the quantity of radioactive waste. Transient liquid radioactive waste is to be managed by diluting it and discharging it into the sewerage system in accordance with the approved emission limit values.

The measures to achieve the objectives of the strategy:

M3/1 Sealed radiation sources are to be primarily returned to suppliers or producers. If this is not possible, they are to be handed over to the provider of the mandatory SGEI of radioactive waste management and stored at the CSF – continuously.

-        KI3/1.1 Before handing a radiation source over to the provider of the mandatory SGEI of radioactive waste management, its user must check the possibility of returning the source to the producer or supplier. Radiation sources should be returned to the supplier or producer in at least 75% of cases.

M3/2 Solid radioactive waste is to be primarily stored in storage rooms until it can be cleared in accordance with the regulation governing radiation practices. If this is not possible, it is to be handed over to the provider of the mandatory SGEI of radioactive waste management and stored at the CSF – continuously.

-        KI3/2.1 The storage room may not be filled to more than 80% of its capacity. Radiation practice operators that hold radioactive waste and store it until it is handed over to the provider of the public service of radioactive waste management or until clearance from regulatory control must keep annual records of radioactive waste storage, including the occupancy of the storage room, the generation and the quantity of waste, and the expected clearance from regulatory control, and report thereon to the authority responsible for nuclear safety.

M3/3 Transient liquid radioactive waste is to be diluted and dispersed, then discharged into the sewerage system, in accordance with the approved emission limit values – continuously. Where this is feasible and in accordance with the optimisation of radiation protection, decay-storage should be given priority over dilution and dispersion in managing transient liquid radioactive waste.

-        KI3/3.1 Discharges should be below 90% of the approved emission limit values.

The management of radioactive waste generated in healthcare is financed by the user of the radiation source. If radioactive waste is handed over to the provider of the mandatory SGEI, the costs are paid by the producer in accordance with the price list of the mandatory SGEI of radioactive waste management.

4.4 CONSTRUCTION AND OPERATION OF THE LILW REPOSITORY

The Decree on the national spatial plan for a low- and intermediate-level waste repository [3] approved the location and type of repository. The selected type of repository envisages the disposal of LILW by packing it in appropriate containers and depositing it in near-surface disposal units – silos. The location and design of the repository allow for further expansion with the construction of additional silos. A silo is basically designed as a cylindrical reinforced-concrete structure with an inside diameter of 27.3 m, a height of 55 m (depth) and a useful depth of 33 m. The disposal concept combines the properties of surface repositories (surface deposition) and those of underground repositories (depositing disposal units in poorly permeable water-saturated geological formations).

The concept of the Vrbina Krško LILW repository is based on a system of several successive natural and engineered barriers and a system in which individual repository components perform multiple safety functions. The basic concept of LILW disposal at the Vrbina site involves the deposition of suitably conditioned and packed radioactive waste that meets the acceptance criteria for disposal in disposal units located below the groundwater level on site. Deposition is carried out from the surface.

The LILW in containers will be loaded into the silo from the top by using a gantry crane. Each silo has capacity for 990 N2d disposal containers, 10 deposition layers of 99 containers each. The disposal containers will be placed alongside and on top of each other. It is assumed that a gap of 20 cm will occur between the walls of the containers. After every second deposition layer, the gaps between the containers will be filled in and a levelling layer constructed.

The Investment Programme for the Vrbina LILW Repository, Krško, Rev. C [32], approved in July 2014, provides for two scenarios: the basic scenario envisaging the disposal of half of the LILW, and the extended scenario envisaging, in accordance with the Slovenian-Croatian Agreement on the Krško NPP, the disposal of all LILW waste from the Krško NPP.

In July 2021, an investment feasibility study [36] was produced as part of the required investment documentation. The study is tailored to the specificities of the investment project and contains an inventory of all the necessary activities with a timetable and the organisational and other solutions for implementing the investment. In 2021, an amendment to the investment programme, Revision E, was drawn up and approved. [30] [31] The revision of the document constitutes an amendment to the investment programme, Revision C, required under Strategy 4 of the ReNPRRO16–25 and the Decree on the uniform methodology for the preparation and consideration of investment documentation in public finance (Official Gazette of the Republic of Slovenia [*Uradni list RS*], Nos 60/06, 54/10 and 27/16). The amendment to the investment programme takes into account the amendments to the Compensation Decree that came into force in February 2020, the findings of the reasonable assurance report by an independent auditor regarding the review of the data for the LILW repository investment and the use of ARAO funds, the new estimates of the inventory and management of LILW from the Krško NPP based on the third revisions of the Krško NPP Decommissioning Programme and the Programme for the Disposal of Radioactive Waste and Spent Nuclear Fuel from the Krško NPP that were approved in July 2020, the changed dynamics of the implementation of the investment, the investor's orientations, and the other modifications to the project of LILW disposal.

In accordance with Decision AD 3.2 adopted at its 13th session [13], the intergovernmental commission concluded that a joint solution with Croatia regarding the disposal of LILW was not possible. Pursuant to this decision, the investment documentation only considers the scenario that envisages the disposal of only half of the waste generated in the Krško NPP and the remaining Slovenian LILW, while the option to dispose of all LILW generated in the Krško NPP if Croatia joins the project, which in previous editions of the investment programme was considered in the sensitivity analysis, has been removed.

At its 16th session in April 2022 (Decision AD 3.1), the intergovernmental commission adopted the coordinating committee’s report containing proposals and guidelines for accepting LILW from the Krško NPP, and a timetable for accepting and depositing LILW from the Krško NPP. It was also decided that the costs of servicing the handover of LILW at the Krško NPP site and its transport are to be borne by ARAO and the Croatian Fond NEK. [16] To this end, in February 2022 ARAO signed the Agreement on the Performance of ARAO’s Obligations regarding the Conditioning of LILW for Handover and Transport from the Krško NPP Site. Under this agreement, the Krško NPP will carry out all functionally related activities for LILW conditioning to suitable forms and packaging, while ARAO will provide all the funds required for this so that LILW can be handed over and transported from the Krško NPP site in accordance with the intergovernmental agreement.

Half of the LILW from the Krško NPP and all other Slovenian LILW that meets the acceptance criteria for disposal will be deposited in the LILW repository. The construction of the repository (one disposal silo, all technological and other facilities, and the auxiliary infrastructure) will take place from 2023 to 2026. In the second half of 2026, the repository will start a trial operation of no more than 12 months, when pre-operational tests of the delivery, acceptance, registration and disposal of containers will be conducted. At the end of the first part of the trial operation, when the conditions necessary for radioactive waste acceptance are met and the operational tests completed, further tests and the disposal of the containers with HLW will be carried out.

At the end of the trial operation period, a use permit will be obtained in the first half of 2027, and based on this, a licence for regular operation in the second half of 2027. All "Slovenian" operational waste will be deposited by the end of 2029. In 2030 the repository will enter standby mode, which is to last until 2050, when the acceptance and disposal of LILW will resume. The purpose of the standby phase of the repository is to optimise its operation and is an intermediate phase between the operation and the closure or restart of the repository.

When the acceptance and disposal of LILW resumes, the remaining "Slovenian" operational waste generated in the Krško NPP and the waste generated in the decommissioning of the Krško NPP until 2058 will be deposited in the repository. After the disposal of all the waste and the decommissioning of the repository in 2058, the silo and the entire repository can be closed in 2059 and the long-term monitoring and maintenance of the repository can commence. If, due to the quantity of radioactive waste generated, there is a need to continue the operation of the repository beyond 2059, the dynamics of the decommissioning and closure of the repository will be adjusted accordingly.

The Vrbina LILW repository, Krško, is equipped with technological systems and devices that are technically necessary for the disposal of waste conditioned in disposal containers. Waste will be conditioned for disposal at the Krško NPP site or any other suitable location. Disposal containers that are suitably certified and allow relatively easy transport and handling are to be used in conditioning for disposal. The optimised design of the repository enables an expansion of the repository, in terms of both disposal capacity and the capacity of the technological systems and devices. The repository will be built gradually by a modular construction method to allow adjustment to the necessary disposal capacity, the resumption of the acceptance and disposal of LILW after a standby period, and the adjustment to factors that may affect the construction, capacity and operation of the repository, such as new methods and techniques of waste disposal and improved estimates of LILW quantities from the decommissioning.

The Vrbina repository will thus accommodate half of the LILW from the Krško NPP (i.e. LILW generated during the operation and decommissioning of the Krško NPP and also other LILW, such as replaced or removed equipment). In addition, the repository will also accommodate LILW from the CSF in Brinje, LILW from the decommissioning of the CSF and the TRIGA Mark II reactor, as well as LILW generated during the operation, decommissioning and closure of the repository.

The repository is designed for the disposal of any kind of LILW generated in Slovenia. Accordingly, criteria for the acceptance and disposal of LILW at the repository have been drawn up, which set the maximum specific activity of alpha emitters in a radioactive waste package, in a disposal unit (silo) and in the repository as a whole, in accordance with the applicable Slovenian regulations, and are included in the safety report for the repository [4] [5]. The only exception are small quantities of long-lived or other radioactive waste that would require disproportionately complicated and costly conditioning for disposal to comply with the disposal acceptance criteria. Another exemption is LILW that will be generated by the decommissioning of the dry storage facility at the Krško NPP. A solution for the disposal thereof will be sought when HLW and spent fuel is to be disposed of.

According to the investment programme for the LILW repository [30], the total volume of LILW to be disposed of is estimated at 4,468 m3 prior to conditioning for disposal, or 853 N2d disposal containers after conditioning for disposal, which amounts to 10,475 m3 of disposal volume.

This includes 773 N2d containers for the disposal of Slovenia's share (50%) of the waste from the Krško NPP, which accounts for as much as 90.62% of all LILW to be disposed of, and 80 N2d disposal containers for the disposal of institutional radioactive waste, or 9.38% of all LILW. The remaining 28 N2d containers of LILW that will be generated by the decommissioning of the dry storage facility for spent fuel will be deposited in a geological repository, together with the spent fuel and HLW.

The data on the quantities of waste from the operation and decommissioning of the Krško NPP, which are used in the repository investment programme, are taken from the third revisions of the Krško NPP Decommissioning Programme and the Programme for the Disposal of Radioactive Waste and Spent Fuel. The data on institutional waste are a conservative estimate summarised from the radioactive waste inventory report, produced for the purpose of drawing up the disposal acceptance criteria. These are the envisaged quantities of radioactive waste, which may change in the actual project. The timetable for the implementation of the project is properly aligned with realistic development scenarios – minor deviations in the necessary storage capacity are possible, but such discrepancies will be eliminated with an improved assessment in the subsequent versions of the decommissioning programmes for specific facilities.

Strategy 4: The aim is to build the LILW repository, successfully conclude trial operation and obtain an operating licence, and deposit the existing LILW in the repository as soon as possible. After all Slovenian operational LILW is disposed of, the repository will go into standby mode. After the shutdown and during the decommissioning of the Krško NPP, the acceptance and disposal activities of the repository will resume, all LILW will be deposited in the repository and the repository will be decommissioned (the non-disposal part of the repository) and closed. LILW will be conditioned for disposal at the Krško NPP site or any other suitable location.

Joint measures to achieve the objectives under the basic scenario are as follows:

M4/1 The Slovenian Government is to fulfil the conditions for the regular operation of the intergovernmental commission as a body to monitor the implementation of the Slovenian-Croatian Agreement on the Krško NPP, with a view to seeking safe, effective and economical joint solutions – continuously.

-        KI4/1.1 The intergovernmental commission meets at least once a year to address the issue of the management of LILW from the Krško NPP.

M4/2 The acceptance criteria for disposal are to be supplemented.

-        KI4/2.1 The disposal acceptance criteria approved by the authority responsible for nuclear safety in its opinion on the construction of the repository are supplemented by the provider of the mandatory SGEI of radioactive waste management at least when approving the trial operation and in the operating licence of the repository.

M4/3 The construction of the repository is to be carried out between 2023 and 2026.

-        KI4/3.1 After the construction of the disposal part of the repository and the technological and administrative service facility is completed, the provider of the mandatory SGEI of radioactive waste management successfully performs a trial lowering and deposition of an N2d container without LILW in the disposal silo – no later than 50 months after the construction contractor starts work.

M4/4 During the construction of the repository, the provider of the mandatory SGEI of radioactive waste management is to draw up a progress report on the implementation of the project once a year, so that any deviations from the planned implementation are identified in time and measures to remedy these deviations are taken.

-        KI4/4.1 The identified deviations from the planned investment costs in the project implementation report must not exceed 20% of the estimated project value or the implementation timetable must not be extended by more than one year.

M4/5 Trial operation of the repository is to be carried out in the second half of 2026.

-        KI4/5.1 During the trial operation, the provider of the mandatory SGEI of radioactive waste management tests the operation of the repository for up to 10 N2d containers without LILW.

-        KI4/5.2 During the trial operation, the provider of the mandatory SGEI of radioactive waste management begins to deposit containers with LILW, while ensuring that a maximum of 198 deposited N2d containers with LILW (2 layers of containers) can be removed from the repository and the repository restored to its original state.

M4/6 The repository is to operate regularly from 2027 to 2029, disposing of one half of all operational LILW from the Krško NPP and the waste from the CSF.

-        KI4/6.1 By the end of 2029, approximately 500 N2d containers or 80% of Slovenia's share of operational LILW from the Krško NPP should be disposed of, as well as 24 N2d containers or 60% of the envisaged waste from the CSF and one N2d container with LILW generated during conditioning for disposal.

M4/7 The standby phase of the repository is to take place from 2030 to 2050; during standby, the operational storage of LILW is to be carried out, as necessary, at the Krško NPP and the CSF.

-        KI4/7.1 During the repository's standby phase, the provider of the mandatory SGEI of radioactive waste management performs all planned and necessary activities, as specified in the approved safety report and activity plan for the repository's standby phase.

-        KI4/7.2 During the repository's standby phase, the Krško NPP stores radioactive waste generated during operation and decommissioning in the radioactive waste storage facility; the occupancy of the storage facility should not exceed 95% of the available storage capacity. After the start of the decommissioning of the Krško NPP in 2043 and until the operation of the LILW repository resumes, the Krško NPP may also temporarily store contaminated materials from decommissioning in other facilities at the Krško NPP, if necessary.

-        KI4/7.3 ARAO, as the operator of the CSF, stores radioactive waste not originating from the nuclear power generation facilities during the standby phase of the repository; the occupancy of the storage facility should not exceed 80% of the administrative storage capacity of the facility, which is 115 m3 of radioactive waste.

M4/8 In 2050, the repository is to be prepared to again accept and dispose of LILW, i.e. the remaining LILW from the operation and decommissioning of the Krško NPP, the remaining institutional radioactive waste from the CSF and its decommissioning, the decommissioning of the TRIGA Mark II research reactor and waste from the operation, decommissioning and closure of the repository.

-        KI4/8.1 The remaining LILW is disposed of by the end of 2058 – approximately 294 N2d containers or 20% of Slovenia's remaining share of operational LILW from the Krško NPP, Slovenia's entire share of LILW from the decommissioning of the Krško NPP generated up to that time (177 N2d containers), 16 N2d containers or 40% of the expected waste from the CSF and 14 N2d containers with LILW to be generated during conditioning for disposal, and 36 N2d containers with LILW generated during the decommissioning of the TRIGA Mark II research reactor.

M4/9 The repository is to operate until 2058, when its decommissioning is to begin.

-        KI4/9.1 The provider of the mandatory SGEI of radioactive waste management supplements the decommissioning programme for the non-disposal part of the repository by the beginning of the trial operation of the repository and subsequently in the periodic safety review procedures for the LILW repository. The programme should also be adjusted if there are any changes in significant milestones in the construction and operation of the repository, or in the plans for radioactive waste management in the technological facilities and in the use of the technological equipment.

M4/10 Depending on the analysis of the need for continued disposal, the repository is to continue operation after 2059 or is to be closed in 2059 and long-term monitoring and maintenance are to begin.

-        KI4/10.1 The provider of the mandatory SGEI of radioactive waste management supplements the repository closure programme and the plan for long-term monitoring and maintenance after the closure of the repository by the beginning of the trial operation of the repository and subsequently in the periodic safety review procedures for the LILW repository. The programme and plan should also be adjusted if there are any changes in significant milestones in the construction and operation of the repository, or in the plans for radioactive waste management in the technological facilities and in the use of the technological equipment.



Figure 5: A schematic presentation of the main milestones of Strategy 4

4.5 STORAGE AND DISPOSAL OF SPENT FUEL AND HLW

Spent fuel from the Krško NPP is first stored in the spent fuel pool, which is installed, together with the active cooling systems, in the building for spent fuel. It is planned to be transferred to a dry storage facility at the NPP site, which is already under construction. The storage of spent fuel in the dry storage facility will improve nuclear safety through the use of passive storage functions and by reducing the number of fuel elements in the spent fuel pool, which will remain in service until the final phase of spent fuel transfer, planned for 2048.

The construction and operation of the storage facility until 2043 will be financed from the Krško NPP's funds. The construction of a dry storage facility for spent fuel was also discussed by the intergovernmental commission on monitoring the implementation of the Slovenian-Croatian Agreement on the Krško NPP at its 10th session in July 2015 [32]. The commission decided that the construction of a dry storage facility at the Krško NPP site until the shut-down of the NPP was part of a joint solution for spent fuel disposal in accordance with point seven of Article 10 of the Slovenian-Croatian Agreement on the Krško NPP.

The third revision of the Krško NPP Decommissioning Programme [22] assumes that, in addition to the spent fuel, the Krško NPP dry storage facility will store HLW generated during the decommissioning of the Krško NPP and that the dry storage facility will continue to operate for at least 60 years after the shutdown of the Krško NPP. Further operation of the repository at the Krško NPP site following the extended operation of the NPP until 2043 is subject to additional agreement between the contracting parties.

After the period of dry storage, spent fuel or HLW generated in spent fuel processing is further treated, packaged and disposed of. A deep geological repository is required for both spent fuel and HLW generated in the processing of spent fuel to ensure adequate temporal isolation of the waste from the environment. The operation of a dry storage facility is a prerequisite for the Krško NPP lifetime extension until 2043.

Many countries (e.g. the USA, the Netherlands, Spain, Switzerland, Hungary) are introducing long-term storage of spent fuel for a period of up to 100 years, in order to follow international developments in the safe and efficient management of spent fuel, and to use advanced methods for reprocessing spent fuel and take advantage of the benefits of radioactive decay and the reduction of the residual heat of the fuel. During long-term storage, the accumulation and appreciation of financial resources in the Krško NPP Decommissioning Fund will continue and the development of a multinational or regional deep geological repository will be monitored.

Fuel reprocessing is an industrial practice in France, Germany, the UK, Spain and several other countries. In reprocessing, substances suitable for further use are extracted from spent fuel (uranium and plutonium – up to 96% of the original fuel mass) and only 4% of HLW (minor actinides, fission products, structural materials) remains. New options are also arising, for example, after reprocessing, useful substances could be offered to interested buyers for reuse and not returned to the country of origin. Only HLW with reduced volume and radiotoxicity that is no longer defined as nuclear material and is easier and cheaper to store and dispose of would be returned to the country of origin.

All these options require a final solution involving the deep geological disposal of spent fuel and HLW. Reprocessing radically reduces the volume and radiotoxicity of waste for final disposal.

Disposal of HLW and spent fuel in a deep geological repository (national, regional or multinational) or any of the other disposal options (e.g. disposal in deep boreholes) is an urgent and necessary solution regardless of the selected option of storage, processing and other forms of spent fuel and HLW management prior to disposal.

The dry storage facility for spent fuel at the Krško NPP will serve for the storage of all HLW and spent fuel generated at the NPP until a deep geological repository is set up. A reference scenario for Slovenia’s own repository in suitable solid rock has been proposed. [37] The location of the repository is still generic at this stage, with the assumption that it will be somewhere on the territory of Slovenia or Croatia. The disposal concept for HLW and spent fuel follows the Swedish SKB KBS-3V model of disposal and envisages all the assemblies of components, systems and structures needed at the site for the repository to operate as an independent nuclear facility. Fuel elements will be inserted and sealed into massive copper containers in the encapsulation facility that is planned for the repository site. The main function of these containers is to isolate spent fuel elements from the environment. The repository will also accommodate HLW generated in the Krško NPP decommissioning and long-lived LILW generated in the operation and decommissioning of the dry storage facility and repository facilities. The underground part of the repository is planned at a depth of 500 m below the ground surface. Alternatively, a depth of 800 m is also being considered.

The basic scenario for HLW and spent fuel disposal envisages the operation of the Krško NPP until 2043, while the start of operation of the repository is based on the duration of dry storage after the Krško NPP shutdown. In this scenario, the disposal of HLW and spent fuel is to start in 2093.

During the period of validity of this programme, research, development and demonstration activities to support the planning of and preparations for the construction of the repository will be carried out as specified in the measures in Strategy 5, and thereafter until the activation of the geological programme in 2053. In 2055, the location search and repository siting will start, until a location is finally approved in 2086.

An underground laboratory is planned to be constructed in 2079, which is to operate until the start of the five-year construction of the repository in 2087. Trial operation is planned to start in 2092 and regular operation in 2093, which is expected to last for 10 years. The shutdown in 2103 will be followed by the decommissioning of the repository facilities and the repository's final closure in 2110.

The list of initial areas to be considered for the location of the HLW and spent fuel repository will be drawn up based on the results of the expert evaluation of the land in terms of suitability for disposal, and on the criteria determining the safety of the repository. In accordance with international guidelines, the assessment of alternative locations within the initial areas will be made by assessing and evaluating variant solutions in terms of the impact on the population and the environment and on regional and urban development, the economy, functional and technical suitability, and social acceptability. The selection of the location is expected to be carried out in a combined procedure that includes professional/expert assessment and the acquisition of bids from interested local communities, and ensures transparency and a high degree of public participation.

Slovenia, together with Croatia, is planning to deposit HLW and spent fuel in a deep geological repository in the territory of one of the two countries. However, there is still a possibility of agreeing on a wider regional repository in Europe or the possibility of disposal in a multinational repository outside Europe under the conditions set out in Council Directive 2011/70/Euratom. Slovenia is a member of ERDO Association, which brings together organisations from European countries that carry out joint research and development projects for disposal, work together to address common challenges for the safe management of long-lived radioactive waste, explore and plan for the possibility of joint disposal, and lay the foundations for the establishment of one or more operational multinational solutions for radioactive waste management. The main reason for cooperation and integration in this field is the exchange and transfer of knowledge from the international environment to Slovenia, the implementation of joint projects and the joint planning of certain activities. Slovenia has an extremely small-scale nuclear programme, which is why it can achieve significant positive economic effects by participating in joint projects and programmes.

Strategy 5: Spent fuel from the Krško NPP is stored in the spent fuel pool and spent fuel dry storage facility at the location of the power plant. The holder of the spent fuel examines the possibility of spent fuel reprocessing. The provider of the mandatory SGEI of radioactive waste management follows and actively participates in international and, in particular, European developments regarding the treatment, reprocessing and final disposal of spent fuel or HLW arising from spent fuel reprocessing, implements activities for the construction of its own spent fuel and HLW repository, and participates in and analyses activities for the disposal of spent fuel in a regional or multinational repository.

The measures to achieve the objectives of the strategy:

M5/1 The Slovenian Government is to fulfil the conditions for regular operation of the intergovernmental commission as a body monitoring the implementation of the Slovenian-Croatian Agreement on the Krško NPP, with a view to seeking safe, effective and economical joint solutions for safe fuel and HLW disposal – continuously.

-        KI5/1.1 The intergovernmental commission meets at least once a year to address the issue of the management of HLW and spent fuel from the Krško NPP.

M5/2 The Krško NPP is to build a dry storage facility for spent fuel at the Krško NPP site with a service life of 60 years after the planned end of the extended operation of the Krško NPP. The operation and relocation of spent fuel are to start in 2023.

-        KI5/2.1 The relocation of 592 fuel elements in 2023 and the relocation of 592 fuel elements in 2028. The Krško NPP ensures that the capacity of the pool and dry storage facility for spent fuel is sufficient for the operation of the power plant until the end of its expected extended lifetime in 2043.

M5/3 The Krško NPP as the holder of spent fuel is to carry out an analysis of the options, safety and economic viability of spent fuel reprocessing.

-        KI5/3.1 By 2030, the Krško NPP, in cooperation with the provider of the mandatory SGEI of radioactive waste management, produces a report with an analysis of the options for spent fuel reprocessing, examining all the advantages and disadvantages of such a solution, with a focus on storage and final disposal.

M5/4 The provider of the mandatory SGEI of radioactive waste management, research institutions and authorised experts in radiation and nuclear safety are to monitor and actively participate in the international development of spent fuel and HLW management and disposal – continuously.

-        KI5/4.1 The provider of the mandatory SGEI of radioactive waste management carries out within its work plan at least two major activities for this purpose per year (drawing up specific studies, analyses, participation in conferences, participation in joint projects of the IAEA, IGD-TP, ERDO, etc.).

-        KI5/4.2 The provider of the mandatory SGEI of radioactive waste management, research institutions and authorised experts in radiation and nuclear safety participate in at least three (total number) international projects on spent fuel and HLW management.

The provider of the mandatory SGEI of radioactive waste management carries out planning, research, development and demonstration activities for the continuation of dry storage after the shutdown of the Krško NPP, and the preparations for construction and the construction of the repository to ensure the permanent direct disposal of the spent fuel and HLW from the Krško NPP and the reprocessed spent fuel and HLW from the TRIGA Mark II research reactor in a national, regional or multinational repository. In this respect, progress made in the development, construction and operation of national repositories in other countries and progress in international and regional efforts to achieve a joint regional disposal programme should be taken into account. The construction of a national repository that will accommodate half of the spent fuel from the Krško NPP is a last resort in the event that an agreement cannot be reached with Croatia on the construction of a joint spent fuel repository.

M5/5 Within the five-year long-term programme for the provision of the mandatory SGEI of radioactive waste management and the revisions of the Programme for the Disposal of Radioactive Waste and Spent Fuel from the Krško NPP, and until the activation of the geological programme for the construction of a national repository, the provider of this mandatory SGEI is to carry out planning and development activities to ensure the continuation of dry storage after the Krško NPP is shut down and the permanent direct disposal of spent fuel and HLW.

-        KI5/5.1 In the period of validity of the programme, the provider of the mandatory SGEI of radioactive waste management carries out, either alone or jointly with partners from Croatia, at least three of the activities under this measure every five years, such as:

-  regularly revising the concept of HLW and spent fuel disposal in solid rock,

-  developing and updating the safety analyses and acceptance criteria for disposal,

-  developing the criteria and the programme for siting the repository,

-  drafting field surveys and pre-operational monitoring,

-  analysing the impact of spent fuel reprocessing on final disposal,

-  participating in international associations and projects for regional or international disposal,

-  analysing and developing disposal options in other geological environments,

-  analysing alternative disposal concepts,

-  other.

M5/6 The location search is to start in 2045, along with the procedure for the siting of the repository, the national spatial plan determining the location of the repository for spent fuel and HLW is to be drawn up and adopted by 2055 and the location is to be finally approved in 2055. The construction of the spent fuel and HLW repository is to be carried out between 2055 and 2065, with the repository becoming operational in 2065. The repository is to operate for 10 years, then it is to be decommissioned and closed after 2075, when the long-term monitoring and maintenance of the repository is to start. There is a possibility of a different solution being agreed on within the intergovernmental commission (the commitment to seek a joint solution) and/or an international solution for the permanent disposal of spent fuel and HLW.

-        KI5/6.1 Every five years during the period of validity of the programme, the provider of the mandatory SGEI of radioactive waste management draws up a summary report on the status and progress of the HLW and spent fuel disposal programme and, based on this report, proposes to the Slovenian Government additional measures and activities to ensure the final disposal of HLW and spent fuel.

M5/7 The provider of the mandatory SGEI of radioactive waste management is to actively participate and engage in activities fostering regional or multinational cooperation to ensure joint disposal and periodically reviews the comparison of the concept, costs and administrative requirements for the preparations for construction and the construction of a national, regional or multinational repository, and the disposal of HWL and spent fuel at such a repository. In addition to the concept of disposal in solid rock, the option of the disposal of HLW and spent fuel in deep geological boreholes or other suitable options should also be examined.

-        KI5/7.1 Every five years during the period of validity of the programme, the provider of the mandatory SGEI of radioactive waste management produces an analysis of the alternatives and feasibility, a timetable, a disposal concept and a cost estimate for the disposal of HLW and spent fuel in a national, regional or multinational repository.

If the lifetime of the dry storage facility at the Krško NPP is changed or a decision made to build new nuclear power generation capacities, the activities for the start of the operation of the spent fuel and HLW repository are adjusted accordingly.

The financing of the construction of a dry storage facility for spent fuel and its operation until the end of the extended lifetime of the Krško NPP are part of the Krško NPP operating costs. The operating costs of the dry storage of spent fuel and HLW after 2043 and the cost of the decommissioning of the dry storage facility are costs of managing radioactive waste and spent fuel from the Krško NPP, which are financed from the Krško NPP Decommissioning Fund. The activities of the provider of the mandatory SGEI of radioactive waste management are financed from the Krško NPP Decommissioning Fund, except for activities for the management of spent fuel from the TRIGA Mark II research reactor, which are financed from the state budget. The activities of research institutions and approved radiation and nuclear safety experts related to monitoring and participating in the international development of spent fuel management and the disposal of spent fuel and HLW are financed by channelling the funds available for research activities, or from other sources, or from funds that ARAO may use to perform activities and services under the approved financial plans.



Figure 6: A schematic presentation of the main milestones of Strategy 5

4.6 DECOMMISSIONING OF THE KRŠKO NPP

The Krško NPP Decommissioning Programme addresses the strategy of immediate decommissioning with the removal of all components, systems and structures after the permanent shutdown of the power plant in 2043. The third revision of the decommissioning programme [22] also covers the operation of the dry storage facility for spent fuel and its decommissioning, and the gradual conventional demolition of the remaining buildings on the site.

Decommissioning will start with the preparation of plans and all the necessary documents three years before the end of the extended lifetime (i.e. in 2040). It is expected to be completed within 15 years after the shutdown of the reactor. After the plant is shut down, preparatory decommissioning work starts, which is followed by the dismantling of the primary loop, the internal parts of the reactor, the reactor vessel, the biological shield and other systems. Most of the disassembled components will be deposited in the LILW repository, while smaller parts, such as the control rods and the cut up reactor vessel, which is contaminated with long-lived radionuclides, is first stored in separate Holtec HI-SAFE containers in the storage facility for spent fuel and subsequently, together with the radioactive waste generated in the decommissioning of the dry storage, deposited in the repository for HLW and spent fuel (according to the basic scenario between 2093 and 2103), as the LILW repositories in Slovenia and Croatia will already be closed by then.

Although the basic approach to the decommissioning of the power plant remains unchanged, the Krško NPP Decommissioning Programme needs to be updated, in particular to ensure proper planning, the estimation of the quantities of radioactive waste and spent fuel from decommissioning, the cost estimation and the provision of financial resources. To this end, new and improved methods of decommissioning and decontamination should be taken into consideration, priority should be given to immediate dismantling and other knowledge and good practices gained from completed or ongoing decommissioning projects around the world.

At its 16th session in April 2022, the intergovernmental commission approved the terms of reference for the fourth revision of the Krško NPP Decommissioning Programme and tasked the Krško NPP with producing, in collaboration with ARAO and Fond NEK, the fourth revision of the Krško NPP Decommissioning Programme, by April 2024. [16]

Strategy 6: The Krško NPP Decommissioning Programme is regularly reviewed in accordance with the Slovenian-Croatian Agreement on the Krško NPP. Priority is given to the strategy of immediate decommissioning. If a different strategy is chosen, the operator of the facility must justify this in detail.

The measures to achieve the objectives of the strategy:

M6/1 During the period of validity of this document, the Krško NPP Decommissioning Programme is to be updated at least every five years – it is planned to be approved by the intergovernmental commission at the end of 2025 and at the end of 2030 at the latest.

-        KI6/1.1 Under the terms of reference approved at the 16th session of the intergovernmental commission, the Krško NPP, in cooperation with ARAO and an authorised expert organisation from Croatia, prepares the fourth revision of the decommissioning programme by the end of 2024 at the latest, which is to be approved by the intergovernmental commission.

-        KI6/1.2 The Krško NPP, in collaboration with ARAO and an authorised expert organisation from Croatia, prepares the terms of reference for the fifth revision of the Krško NPP Decommissioning Programme. The terms of reference must be ready for approval by the intergovernmental commission and coordinated by the end of 2027 at the latest.

-        KI6/1.3 After the approval of the terms of reference, the Krško NPP, in cooperation with ARAO and an authorised expert organisation from Croatia, prepares the fourth revision of the decommissioning programme by the end of 2029 at the latest, which is to be approved by the intergovernmental commission.

M6/2 In drawing up the Krško NPP Decommissioning Programme, it is necessary to take into consideration new and changed facts, the introduction and application of new and improved methods of disassembly/dismantling and decontamination.

-        KI6/2.1 The requirement under this measure must be duly included in the terms of reference for the fifth revision of the decommissioning programme and the fourth and fifth revisions of the Krško NPP Decommissioning Programme.

M6/3 The ministry responsible for energy is to ensure that payments to the Krško NPP Decommissioning Fund are regulated in a sustainable manner, that the funds are collected on time, by examining all relevant aspects, and that the payments to the Krško NPP Decommissioning Fund can be amended before the approval of the new revisions of the Krško NPP Decommissioning Programme and the Programme for the Disposal of Radioactive Waste and Spent Nuclear Fuel, if necessary.

-        KI6/3.1 An amended or new Act regulating the operation of the Krško NPP Decommissioning Fund is adopted by the end of 2023 or by the approval of the next Krško NPP Decommissioning Programme and the Programme for the Disposal of Radioactive Waste and Spent Nuclear Fuel.

The participation of the Krško NPP in the drawing up of the Krško NPP Decommissioning Programme is financed from the funds of the Krško NPP's operator, while ARAO's participation is financed from the funds in the Krško NPP Decommissioning Fund.



Figure 7: A Schematic presentation of the main milestones of Strategy 6

4.7 DECOMMISSIONING OF THE TRIGA MARK II RESEARCH REACTOR

In 2015, the Jožef Stefan Institute, as the operator of the TRIGA Mark II research reactor, decided to extend the operation of the reactor at least until the conclusion of the next periodic safety review in 2024. [19] In view of the decision on the continued operation of the research reactor, the option to return spent fuel to the USA [23] [24], according to which the fuel should have been removed from the reactor by May 2016 and spent fuel handed over by May 2019, was abandoned.

Given that the operator of the research reactor decided to continue operation and analysed various options for spent fuel management, it is proposed that, after the shutdown, which is planned for 2043 at the latest, the spent fuel is permanently disposed of together with the spent fuel from the Krško NPP. This means a relatively long storage of the spent fuel (about 50 years) until its final disposal. Regardless of what is decided in this respect, it should be monitored how other countries return spent fuel to the USA, and an agreement should be sought on the repatriation of fuel to the USA on acceptable terms by the time the research reactor is shut down.

If no agreement on the repatriation of the fuel to the USA can be reached, a detailed programme for spent fuel management after the shutdown of the reactor should be drawn up by the beginning of the next periodic safety review in 2030 at the latest, which should be incorporated into future revisions of the TRIGA research reactor decommissioning programme and the radioactive waste and spent fuel management programme.

After the spent fuel has been removed from the reactor and a cooling period of five years has passed, the reactor must be removed/dismantled, for which there are two options: immediate dismantling or conservation and deferred dismantling.

In 2007, a draft Programme for the Decommissioning of the TRIGA Mark II Research Reactor was drawn up [20], which was upgraded in 2021 with the current operation and decommissioning plans for the reactor [18].

All LILW resulting from the immediate decommissioning of the TRIGA Mark II research reactor will be disposed of at the Vrbina LILW repository, Krško.

Strategy 7: All LILW resulting from the immediate decommissioning of the TRIGA Mark II research reactor will be disposed of at the Vrbina LILW repository, Krško. The spent fuel from the TRIGA Mark II research reactor will be repatriated to the state of origin, if possible, or first stored and then disposed of together with the spent fuel from the Krško NPP.

The measures to achieve the objectives of the strategy:

M7/1 The operator and the owner of the TRIGA Mark II research reactor are to explore the option of returning the spent fuel to the USA, the country of origin.

-        KI7/1.1 No later than during the preparations for the next periodic safety review (by the end of 2026), the operator and the owner of the research reactor are to compile a report on the activities performed to repatriate spent fuel, including an analysis of the administrative, cost, strategic and other aspects that affect the possibility of and decision on repatriation.

M7/2 If the repatriation is necessary and feasible, the spent fuel from the TRIGA Mark II research reactor is to be returned to the USA under the terms of spent fuel return and according to the adopted timeline of the reactor's shutdown.

-        KI7/2.1 The operator and the owner of the research reactor are to draw up a plan for returning the spent fuel to the USA. Time limit: the end of 2028.

M7/3 If the return of spent fuel to the USA is not feasible under acceptable terms, the operator and the owner of the TRIGA Mark II research reactor, together with the provider of the mandatory SGEI of radioactive waste management, are to prepare an analysis of solutions for the storage and disposal of spent fuel from the research reactor after its shutdown.

-        KI7/3.1 By the end of 2030, a joint report is to be produced by the operator of the research reactor and the provider of the mandatory SGEI of radioactive waste management, which will serve as the basis for a decision on the future management of spent fuel. The report is to present an analysis of solutions for the storage and disposal of spent fuel from the research reactor after its shutdown.

M7/4 The operator of the TRIGA Mark II research reactor is to draw up an updated decommissioning programme for the reactor, which should give priority to the strategy of immediate decommissioning, include an updated safety assessment, and a programme of maintenance, testing and inspection of the components, systems and structures for the period of the reactor's decommissioning.

-        KI7/4.1 The decommissioning programme for the TRIGA Mark II research reactor is to be produced and approved no later than during the next periodic safety review by the end of 2030.

M7/5 The provider of the mandatory SGEI of radioactive waste management is to examine the options for the reprocessing, storage and disposal of spent fuel from the TRIGA Mark II research reactor while seeking solutions for the disposal of spent fuel and HLW from the Krško NPP – continuously until final disposal.

-        KI7/5.1 To this end, the provider of the mandatory SGEI of radioactive waste management and the operator of the reactor produce a report every five years, including an analysis of the options for the storage and disposal of spent fuel from the TRIGA Mark II research reactor.

The financial resources for the development of the decommissioning programme, the decommissioning and the management of LILW from the decommissioning, and for the return of spent fuel to the USA or the management of spent fuel if it is not repatriated to the USA, will be provided by the owner, the Republic of Slovenia, in accordance with the provisions of the ZVISJV-1. The funds for the activities of ARAO will be provided from the state budget for the performance of the public service functions within the framework of the financial plan and the long-term programme of the provider of the mandatory SGEI.



Figure 8: A Schematic presentation of the main milestones of Strategy 7

4.8 DECOMMISSIONING OF THE CENTRAL STORAGE FACILITY FOR RADIOACTIVE WASTE (CSF)

The storage of institutional radioactive waste is necessary for as long as such waste is or will be generated by various activities in the country, thus creating the need for radioactive waste storage. Since radioactive waste will continue to be generated in Slovenia by radiation practices in industry, research and healthcare and in the operation of the TRIGA Mark II research reactor even after the disposal of radioactive waste from the CSF at the LILW repository and during the LILW repository's standby phase, the continuation of the central collection of institutional radioactive waste and the operation of the CSF are justifiable in terms of operating costs, the provision of storage space during the standby phase of the LILW repository and in the event of any emergency, and in particular with regard to the fact that Slovenia already has an operating nuclear facility with all the necessary licences, knowledge, and infrastructure in place.

In January 2021, ARAO prepared a new revision of the CSF decommissioning programme [26], which plans the decommissioning of the CSF after its shutdown according to the following scenario:

When the disposal of LILW is available, all LILW from the CSF that meets the acceptance criteria for disposal at the LILW repository will be transported to and deposited in the LILW repository. The CSF will remain in operation as a central storage facility for institutional radioactive waste in the standby period of the LILW repository and at least until the shutdown of the LILW repository, which is planned for 2058. The justifiability, adequacy and timetable of facility operation should be regularly verified as part of the periodic safety review, in the procedures for extending the operating licence and when drawing up and adopting the national programme for radioactive waste and spent fuel management.

Strategy 8: Slovenia maintains the operation of the CSF for radioactive waste that is not generated in the production of electricity in Slovenia for as long as such waste is generated and there is a need for its safe storage. After the facility is emptied and storage is no longer needed, the facility will be decontaminated and repurposed.

The measures to achieve the objectives of the strategy:

M8/1 The provider of the mandatory SGEI of radioactive waste management that manages the CSF is to make all necessary arrangements for the disposal of radioactive waste from the CSF at the LILW repository.

-        KI8/1.1 In the period from 2027 to 2029, ARAO arranges for the transport and disposal of 60% of the total planned disposal quantity of LILW from the CSF by 2058, which is equivalent to 24 N2d containers or on average 8 containers per year.

M8/2 After the waste from the CSF is deposited in the LILW repository, the provider of the mandatory SGEI of radioactive waste management is to prepare a new revision of the CSF decommissioning programme, giving priority to the strategy of immediate decommissioning.

-        KK8/2.1 By 2030, the provider of the mandatory SGEI of radioactive waste management prepares a new revision of the CSF decommissioning programme, taking into account all the key changes, and in particular the fact that the transport and disposal of the majority of the LILW from the CSF have been carried out.

M8/3 ARAO is to continue to operate the CSF and manage the institutional radioactive waste at the CSF site at Brinje – continuously until the planned decommissioning in 2058. Depending on the analysis of the radioactive waste storage needs for the continued use of radioactive material in the future, the operation of the CSF may be extended and the timing of its decommissioning and closure adjusted accordingly.

-        KI8/3.1 After the disposal of LILW from the CSF, ARAO continues with the processing of radioactive waste and other procedures for reducing the quantity of radioactive waste and endeavours at all times to ensure that the storage facility keeps available space reserved for the storage of radioactive waste generated in the event of a radiological emergency and that the occupancy of the storage facility does not exceed 80% of the administrative storage capacity.

Financial resources for the operation of the CSF are provided by the ministry financing the provision of the mandatory SGEI of radioactive waste management and by users of radioactive waste management services by paying for the services according to the price list of the public service of radioactive waste management.



Figure 9: A Schematic presentation of the main milestones of Strategy 8

The Act Governing the Permanent Cessation of Uranium Ore Exploitation and Prevention of the Effects of Mining at the Žirovski Vrh Uranium Mine [38] set the time limit for the closure of the Jazbec and Boršt repositories for the end of 2010. However, the repositories had not been closed by that date. The Boršt repository is situated on a fossil landslide that reactivated during the remediation of the repository.

In 2008, the landslide started to move at a rate of approximately 1 cm per month. Although the rate of movement decreased to 2.5 cm per year in 2014, the conditions for closure have not yet been met.

In December 2012, the Slovenian Government adopted a decision on the basis of which the SNSA issued a decision in March 2013 declaring the Jazbec repository a national infrastructure facility. Pursuant to the permit for the closure of the Jazbec repository of mining tailings, which was issued to the Žirovski Vrh Uranium Mine (RŽV, d.o.o.) by the SNSA in December 2014, the Jazbec repository no longer has the status of a radiation facility. In 2015, the repository was closed and the site was removed from the designated mine's extraction area. In November 2015, the conditions were met for the start of the SGEI of the long-term monitoring and maintenance of the repository, which is provided by ARAO. In September 2019, an amendment to the safety report for the Jazbec repository of mining tailings came into force, which lays down a modified scope and frequency of long-term monitoring and maintenance in accordance with the facility's status of a closed repository.

In 2019, additional remediation measures were carried out at the Boršt repository of hydrometallurgical tailings to ensure the long-term stability of the repository. Furthermore, the safety report for the repository was also revised and a special expert opinion of an approved expert on nuclear and radiation safety was obtained regarding the performed remediation activities to ensure stability, which was required for a permit for the closure of the repository to be granted. The required conditions are expected to be met and all the necessary procedures for closing the repository and transferring its management to ARAO are to be carried out by the end of 2023.

Pursuant to the ZVISJV-1, the long-term monitoring and maintenance of the two repositories are carried out as the mandatory SGEI of radioactive waste management.

Strategy 9: ARAO, as the provider of the mandatory SGEI of radioactive waste management, carries out the management, long-term monitoring and maintenance of the closed repositories of mining and hydrometallurgical tailings.

The measures to achieve the objectives of the strategy:

M9/1 The provider of the mandatory SGEI of radioactive waste management is to carry out, in accordance with the approved safety reports, the management, long-term monitoring and maintenance of the national infrastructure facilities – the Jazbec repository of mining tailings and the Boršt repository of hydrometallurgical tailings – continuously.

-        KI9/1.1 ARAO carries out the management, long-term monitoring and maintenance of the closed Jazbec and Boršt repositories as specified in the respective safety reports for the repositories and in such a way that the approved limit value of 0.3 mSv/year of an additional effective dose received by members of the public as a result of the presence of the two repositories and the closed pit is never exceeded.

The financial resources for the management, long-term monitoring and maintenance of the repositories are provided by the ministry that finances the provision of the mandatory SGEI of radioactive waste management from the state budget.



Figure 10: A Schematic presentation of the main milestones of Strategy 9

4.10 MANAGEMENT OF RADIOACTIVE WASTE CONTAINING NATURALLY OCCURRING RADIONUCLIDES

Radioactive waste containing naturally occurring radionuclides, which is generated in the extraction and processing of nuclear minerals or in other industrial processes and are not considered sealed sources of radiation under the Act governing ionising radiation protection and nuclear safety, is material with enhanced natural radioactivity, which is usually not treated as radioactive but contains naturally occurring radionuclides to such an extent that it may cause the radiation exposure of workers or members of the public. Such waste is treated as material that is part of a technological procedure, taking into account the management methods applied to low-level radioactive waste. In accordance with Council Directive 2013/59/Euratom, the mixing of radioactive and non-radioactive materials in a technological process is allowed for the purpose of reuse or recycling. In 2018, the Decree on the reduction of exposure due to natural radionuclides and past activities or events was adopted [28], which lays down the programme for protection against the increased exposure of workers and members of the public due to radioactive contamination of the environment as a result of remaining radioactive material or activities involving materials containing naturally occurring radionuclides.

Strategy 10: The impact of materials that are usually not regarded as radioactive but contain naturally occurring radionuclides on the population and the environment should be regularly monitored. If the permissible effects are exceeded, measures are taken to remedy the situation, which are adopted on a case-by-case basis. Radioactive waste containing naturally occurring radionuclides is managed in accordance with the established level of radioactivity and other waste properties.

The measures to achieve the objectives of the strategy:

M10/1 The authority responsible for nuclear safety is to implement the programme of the systematic monitoring of working environments for activities involving materials containing naturally occurring radionuclides, in accordance with the Decree on the reduction of exposure due to natural radionuclides and past activities or events [28] – continuously.

-        KI10/1.1 The authority implementing the programme of the systematic monitoring of working environments (the SNSA) inspects at least five activities per year from the list of activities (Annex to the Decree on the reduction of exposure due to natural radionuclides and past activities or events, Official Gazette of the Republic of Slovenia [*Uradni list RS*], No 38/18 [28]) that may involve naturally occurring radioactive materials.

M10/2 The programme of the systematic monitoring of working environments is to ensure protection and measures against the increased exposure of workers and members of the public due to exposure to naturally occurring radionuclides and past activities or events.

-        KI10/2.1 Exposure of the general public and the environment due to natural radionuclides and past activities or events must not exceed the permissible effects – continuously.

-        KI10/2.2 If the permissible effects are exceeded, measures to remedy the situation are carried out, which are determined on a case-by-case basis.

The implementation of the programme of the systematic monitoring of working environments for activities involving materials containing naturally occurring radionuclides and raising the awareness of the workers and the general public are financed from the state budget. The implementation of measures to reduce the exposure of workers or individuals to natural radiation sources is to be paid for by the performer of the activity.

4.11 DISCHARGES OF RADIOACTIVE SUBSTANCES

Subject to the approval of the competent administrative authority and provided that they are subsequently diluted, waste radioactive substances may be discharged into the environment. Such controlled discharges of radioactive substances into the environment are considered to be the disposal of radioactive waste. Radioactive waste management thus includes the discharge of liquid and gaseous radioactive waste into the environment in accordance with licences to discharge radioactive substances into the environment during the operation of nuclear and radiation facilities and during a radiation practice. Discharges of liquid or gaseous radioactive waste into the environment must not exceed the approved limit values, and must be carried out in a controlled manner and kept to a minimum.

Strategy 11: Radioactive waste is discharged into the environment in accordance with the approved limit values for individual nuclear or radiation facilities and radiation practices, whereby the holder of the radioactive waste must ensure that the discharge of liquid or gaseous radioactive waste into the environment is controlled, kept at a minimum and within the approved limit values. The approved limit values are not planned to be increased.

The measures to achieve the objectives of the strategy:

M11/1 Liquid and gaseous radioactive waste is to be discharged into the environment from nuclear and radiation facilities and radiation practices in accordance with the approved limit values – continuously.

M11/2 Holders of radioactive waste are to ensure that discharges of radioactive waste into the environment are kept to a minimum and controlled – continuously.

-        KI11/2.1 The operators of nuclear and radiation facilities carry out their activities in such a way that discharges of liquid and gaseous radioactive waste into the environment do not exceed 80% of the approved limit values for the facility concerned.

M11/3 Any changes to the approved limit values are made in a transparent manner and in accordance with the regulations laying down the procedures for amending radiation practice licences, licences for radiation source use and safety reports.

4.12 LEGISLATIVE AND INSTITUTIONAL FRAMEWORK AND RESEARCH, DEVELOPMENT AND DEMONSTRATION ACTIVITIES TO SUPPORT THE IMPLEMENTATION OF THE RESOLUTION

With a view to achieving all the goals set out in this Resolution, the state is to provide and maintain an appropriate legislative and institutional framework. The existing legislation must be maintained and amended in accordance with the contemporary international standards and good practices. The important priority tasks also include the provision of a sufficient number of staff with appropriate expertise and the prompt provision of information to the public.

Strategy 12: The state maintains and updates the legislative and institutional framework, ensures the research, development and demonstration activities required for the implementation of the national programme and informs the public of the progress made in the implementation of this programme.

The measures to achieve the objectives of the strategy:

M12/1 National authorities are to monitor the adequacy of the legislative and institutional solutions and, where appropriate, propose amendments thereto – continuously.

M12/2 The state is to ensure that radioactive waste and spent fuel management is researched and developed through ARAO or as part of a wider research programme implemented in accordance with this radioactive waste and spent fuel management programme and the Nuclear and Radiation Safety Resolution – continuously.

-        KI12/2.1 Every three years, the provider of the mandatory SGEI of radioactive waste management (ARAO) draws up a programme of research, development and demonstration activities in radioactive waste and spent fuel management and includes it in the long-term programme for the provision of the mandatary SGEI of radioactive waste management for a period of five years.

-        KI12/2.2The Slovenian Government, as the founder of ARAO, ensures the adoption and adequate financing of the long-term programme for the provision of the mandatory SGEI, based on which ARAO will then carry out all the activities planned under the programme of research, development and demonstration activities. ARAO reports on the implementation of the programme of research, development and presentation activities to the Government every year as part of the annual report on the implementation of the business plan of the mandatory SGEI of radioactive waste management.

4.13 PLANS FOR THE PERIOD FOLLOWING THE CLOSURE OF THE REPOSITORIES

When nuclear energy and sources of ionising radiation are no longer used in Slovenia, there will be at least three or four repositories in its territory. These include the Jazbec repository of mining tailings and the Boršt repository of hydrometallurgical tailings at the site of the former uranium mine in Žirovski Vrh. An LILW repository will be constructed in Vrbina near Krško. And a spent fuel repository will also have to be constructed in Slovenia, if a regional solution is not found.

The areas of closed repositories will become state-owned infrastructure facilities and will not be legally tradable. The long-term environmental monitoring and maintenance of repositories and intervention measures in the event of any damage to repositories will be carried out by the provider of the mandatory SGEI of radioactive waste management. Administrative control will be performed by the administrative authority responsible for nuclear safety.

M13/1 The long-term monitoring and maintenance of closed repositories are to be carried out as the mandatory SGEI. The plans and programmes for the long-term monitoring and maintenance of closed repositories are to be regularly reviewed and, if necessary, updated by the provider of the mandatory SGEI of radioactive waste management – continuously.

-        KI13/1.1 Plans and programmes for the long-term monitoring and maintenance of closed repositories must be reviewed and, if necessary, updated at least every five years, or sooner if this follows from the results of long-term monitoring and maintenance or is required under the Act governing ionising radiation protection and nuclear safety.

4.14 RADIOACTIVE WASTE MANAGEMENT AFTER A NUCLEAR OR RADIOLOGICAL ACCIDENT

In July 2021, the Slovenian Government adopted the Protection Strategy for Nuclear and Radiological Accidents [39] as the principled and long-term guideline for ensuring the preparedness of Slovenia for nuclear and radiological accidents. The protection strategy also includes the management of radioactive waste based on the Guidelines for the Management of Large Quantities of Radioactive Waste [40].

Nuclear accidents at nuclear facilities of Category I [41] may also be radiological accidents since nuclear facilities also contain large quantities of nuclear and radioactive materials, which in the event of major deviations from normal operation can be released into the environment and potentially irradiate people.

The radioactive waste management strategy is primarily developed for the management of radioactive waste arising as a result of an accident at a nuclear power plant. With the necessary changes and taking into account a graded approach, it can also be applied to the management of radioactive waste in the event of other radiological accidents in the territory of Slovenia.

Radioactive waste management starts after the immediate protective measures for the population have been implemented and the protection and rescue phase has been completed. Waste generated as a result of a nuclear accident has specific physical, chemical and radiological properties and therefore poses a major challenge in terms of treatment, packaging, storage, transport, conditioning for disposal and disposal.

The programme for the remediation of the accident site must also include the principles of radioactive waste management and clearance, the reduction of radioactive waste quantities, the separation and classification of radioactive waste, the prevention of the mixing of radioactive waste with other (in particular hazardous) waste, the availability of temporary storage capacities, radioactive waste treatment methods, and the acceptance criteria for storage and disposal.

Radioactive waste must be classified according to the level and type of radioactivity and the expected management, as specified in the national regulation [6], in order to take advantage of the technologies and procedures for radioactive management already in place in the country and the experience gained in the application of these technologies and procedures. If the classification system proves to be too rigid, a special classification of radioactive waste for accidents should be introduced.

M14/1 Radioactive waste resulting from a nuclear or radiological accident is to be primarily managed in the same way as radioactive waste generated in Slovenia in the use of nuclear and radiation technologies. Radioactive waste is to be appropriately classified according to the level and type of radioactivity in accordance with national regulations and its clearance from regulatory control, sorting, processing and packaging, labelling, decay-storage, storage, handover and acceptance, transfer and final disposal are to be ensured. Should this not be possible, additional procedures and technologies are to be introduced for radioactive waste management. The provider of the mandatory SGEI of radioactive waste management is to periodically update and supplement the guidelines for the management of radioactive waste arising from a nuclear or radiological accident.

-        KI14/1.1 The provider of the mandatory SGEI of radioactive waste management updates and supplements the guidelines for the management of radioactive waste arising from a nuclear or radiological accident for the first time in 2025 and then in 2030.

5. ESTIMATED COST OF THE IMPLEMENTATION OF THE NATIONAL PROGRAMME

The evaluation of the implementation of the measures under this programme is presented by areas. Financial resources are indicated for each area. The estimates are based on the existing studies of competent organisations and institutions applying various methods from internal and international practice. The costs for the 2023–2032 period are presented in more detail in the annual estimates, while the costs for the 2033–2112 period are presented as the total costs of the main activities of radioactive waste and spent fuel management by facilities or by planned main and supporting management activities. The estimates do not include the cost of the potential remediation of facilities, radioactive waste management due to emergencies, the purchase of additional equipment or the cost of additional permits and analyses due to amendments to legislation. For long-term planning purposes, the financial estimates are given in constant prices as at 31 December 2020.

The cost of the provision of the mandatory SGEI of radioactive waste management relating to the acceptance, collection, transport, processing and storage prior to disposal, preparations for the construction of the repository, the construction of the repository and the disposal of radioactive waste other than waste from nuclear power generation facilities is covered in part from the payments made by holders or producers of radioactive waste and in part by funds provided by the state from the state budget.

The cost of the provision of the mandatory SGEI of radioactive waste management relating to radioactive waste and spent fuel processing prior to disposal, preparations for the construction of the repository, the construction of the repository and the disposal of radioactive waste from nuclear power generation facilities and from the operation of radioactive waste repositories is covered from the Krško NPP Decommissioning Fund, in accordance with Article 172 of the ZVISJV-1.

The state provides funding for the performance of the mandatory SGEI of the management, long-term monitoring and maintenance of closed repositories, the management of radioactive waste or spent fuel if the producer of the radioactive waste or spent fuel is unknown, the provision of mandatory SGEI services of which the users are not identifiable or the use of which is not quantifiable, the cost of carrying out the systematic monitoring of working and living environments for exposure to natural radiation sources and existing exposure that cannot be disregarded in terms of radiation protection. The cost of the management of radioactive waste arising from remediation after an emergency is covered on the basis of the polluter pays principle by the user of the radiation source or the operator of the facility if the radioactive contamination is due to the use of its radiation source or facility or from an emergency related thereto. If the remediation of the consequences of an emergency and the cost of remediation cannot be attributed to specific or identifiable responsible entities or the responsible entities are disputed, or if the consequences cannot be otherwise remedied, the resources for remedying the consequences of an emergency are provided by the state (subsidiary responsibility).

As stated above, the sources of funding differ from area to area. However, the vast majority of funds come from the sale of the electricity produced by the Krško NPP. Thus, all costs related to the management of radioactive waste and spent fuel from the Krško NPP are financed through the price of electricity. The only source of these funds are the payments of electricity buyers. The cost of the management and storage of radioactive waste and spent fuel at the Krško NPP during operation are directly included in the electricity price charged by the Krško NPP. The costs of the future disposal of Slovenia's share of radioactive waste and spent fuel are covered by the share of the funds obtained by the direct owner of Slovenia's half of the Krško NPP, i.e. GEN energija, d.o.o., through the sale of electricity from the Krško NPP on the market and paid to the Krško NPP Decommissioning Fund.

The funds for the management of institutional radioactive waste derive from several sources, the two largest being the state budget and the own resources of holders or producers of radioactive waste that the users pay to the provider of the mandatory SGEI of radioactive waste management upon the handover of radioactive waste in accordance with the public service price list. The holder or producer of radioactive waste covers part of the costs of the service provided in accordance with the applicable price list published pursuant to the Decree on the method and conditions for providing the mandatory national public service of general economic interest of radioactive waste management [8]. The remainder of the costs are covered by the state budget funds, which are disbursed pursuant to a contract on the provision of the public service of radioactive waste management.

-        Operation of the CSF and the management of institutional radioactive waste

The sources of financing: the state budget and the payments of service users in accordance with the public service price list. The responsibility for planning and implementation lies with the provider of the mandatory SGEI of radioactive waste management, which is ARAO. The operation of the CSF is a prerequisite for the smooth and safe functioning of the public service. In the 2013–2020 period, the average operating costs of the CSF were EUR 750,000 per year. Labour costs account for the largest share of the costs (on average 35%), closely followed by the costs incurred for the payment of compensation for restricted land use and other charges (on average 30%). Assuming that the annual costs will be similar in the following years of operation, the projected costs of the operation of the CSF and the management of institutional radioactive waste in the 2023–2032 period amount to EUR 7.50 million.

-        Cost of the long-term monitoring and maintenance of the closed Jazbec and Boršt repositories at the former Žirovski Vrh Uranium Mine

The sources of financing: the management, long-term monitoring and maintenance of the Jazbec and Boršt repositories are provided as a public service in accordance with the Decree on the method and conditions for providing the mandatory national public service of general economic interest of radioactive waste management. The financial resources for long-term monitoring and maintenance are provided from the state budget through the ministry that finances the mandatory SGEI of radioactive waste management, which is provided by ARAO. In past years, ARAO has spent on average EUR 110,000 on management, long-term monitoring, maintenance and other activities at the Jazbec repository. Due to the slightly higher scope and frequency of long-term monitoring and maintenance, additional funds of EUR 150,000 per year are planned for the Boršt repository in the coming years. The total planned funding for the management, long-term monitoring and maintenance of the closed Jazbec and Boršt repositories of mining and hydrometallurgical tailings amount to EUR 260,000 per year.

-        Cost of the construction and operation of the LILW repository

The cost of the construction of the LILW repository and the financial structure are based on the investment programme for the LILW repository, which was revised and approved in 2021 [30] [31]. The value of the investment in the construction, decommissioning and closure of the repository amounts to EUR 194.62 million, including VAT, of which EUR 95.13 million had already been invested by 30 June 2020. The cost of the operation, long-term monitoring and maintenance of the repository is estimated at EUR 206.72 million, including VAT. Of these, the cost of the long-term monitoring and maintenance of the repository is estimated at EUR 9.27 million.

The total investment costs and the costs incurred over the lifetime of the repository (2024-2058), including the cost of the long-term monitoring and maintenance of the repository, amount to EUR 401.34 million, including VAT.

The construction and operation of the repository are financed from the Krško NPP Decommissioning Fund and the state budget for the portion of LILW not originating from the Krško NPP. The distribution of costs between the two financing resources is based on the volume share of the waste from the Krško NPP and the volume share from other sources, except for the costs of the preparations for active long-term monitoring and of the provision of active long-term monitoring.

In the investment programme [30], the volume share of LILW from the Krško NPP is estimated at 90.62% and the volume share of other waste at 9.38%.

|  |  |  |  |
| --- | --- | --- | --- |
| Cost (permanent prices) in EUR million |  | Total | Share |
| 1. Krško NPP Fund resources | Investment | 176.365 | 90.62% |
| Operation | 178.924 | 86.55% |
| 2. State budget funds | Investment | 18.255 | 9.38% |
| Operation, long-term monitoring and maintenance | 27.794 | 13.45% |
| 3. Total Krško NPP Fund resources | Investment and operation | 355.289 | 88.53% |
| 4. Total – State budget funds | Investment, operation and long-term monitoring and maintenance | 46.049 | 11.47% |
| T O T A L |  | 401.338 | 100.00% |

Table 8: The total cost of investment in and the operation, long-term monitoring and maintenance of the repository

The ratio of shares is expected to change somewhat with the new inventory estimates; therefore, the final costs should be divided between the NPP Krško Decommissioning Fund and the state budget based on the actual volume of deposited radioactive waste.

-        Cost of the storage of HLW and spent fuel from the Krško NPP

The cost of constructing a dry storage facility falls within the operating costs of the Krško NPP, i.e. the costs of the Krško NPP operators. The same applies to the operating costs of the storage of spent fuel during the lifetime of the Krško NPP, i.e. until 2043. The costs of spent fuel relocation, the operation of the dry storage facility for spent fuel and HLW after 2043 and the decommissioning of the dry storage facility, which are estimated at EUR 75.60 million, are included in the third revision of the Krško NPP Decommissioning Programme [22]. The third revision of the Programme for the Disposal of Radioactive Waste and Spent Fuel from the Krško NPP [29] additionally takes into account the costs of compensation for restricted land use for the duration of the HLW and spent fuel storage. The total cost of the HLW and spent fuel storage estimated in both programmes, which includes the cost of the final phase of spent fuel relocation, storage containers, the decommissioning of the dry storage facility and compensation for restricted land use, amounts to EUR 125.52 million. This cost will be financed in equal shares from the funds in Slovenia and Croatia. Pursuant to the provisions of the Slovenian-Croatian Agreement on the Krško NPP, Slovenia is required to provide funding for half of the estimated cost of the HLW and spent fuel storage, which amounts to EUR 62.76 million. Slovenia's share of the cost of the storage of HLW and spent fuel from the Krško NPP is financed from the Krško NPP Decommissioning Fund in accordance with Article 172 of the ZVISJV-1.

-        Costs of the disposal of HLW and spent fuel from the Krško NPP

According to the planned management of spent fuel and HLW resulting from the Krško NPP decommissioning, the spent fuel and HLW are first stored in a dry storage facility at the Krško NPP site and then permanently disposed of in a geological repository in Slovenia or Croatia. For the purpose of cost estimation, the third revision of the Programme for the Disposal of Radioactive Waste and Spent Fuel from the Krško NPP [29] envisages the repository as a joint Slovenian and Croatian disposal project. The third revision of the disposal programme includes an estimate of the investment cost of the design and construction of the spent fuel and HLW repository, which comprises the investment costs of siting, project management, research and development and land purchase, the costs of the construction of the repository facilities and the spent fuel encapsulation facility, as well as the costs of its decommissioning and closure. In addition, there are operating costs, which comprise the costs of the operation and maintenance of the underground and above-ground facilities of the repository. In view of similar disposal programmes in Finland and Sweden, the long-term monitoring and maintenance of the repository is not planned at this stage and is therefore not included in the cost of the basic disposal scenario.

|  |  |  |
| --- | --- | --- |
|  | Cost in EUR million | Cost structure |
| Siting, project documentation, research and development, land | 124.13 | 10.92% |
| Investment and construction – disposal part | 202.63 | 17.82% |
| Investment and construction – encapsulation facility  | 35.33 | 3.11% |
| Operation and maintenance – disposal | 93.44 | 8.22% |
| Operation and maintenance – above-ground facilities | 147.05 | 12.93% |
| Decommissioning and closure | 42.98 | 3.78% |
| Cost of compensation | 126.12 | 11.09% |
| Total | 771.68 | 67.88% |
| Contingencies | 193.67 | 17.03% |
| Total cost with contingencies | 965.35 | 84.91% |
| VAT | 171.53 | 15.09% |
| Total cost, including VAT | 1,136.88 | 100.00% |

Table 9: The cost of the disposal of the entire HLW and spent fuel inventory from the Krško NPP [29]

The total cost of the disposal of the entire inventory of HLW and spent fuel from the Krško NPP at a repository built in Slovenia is estimated at EUR 1,136.88 million for the basic scenario (Table 9). Pursuant to the provisions of the Slovenian-Croatian Agreement on the Krško NPP, Slovenia is required to provide funding for half of the estimated cost of the HLW and spent fuel disposal, which amounts to EUR 568.44 million. The Slovenian share of the cost of the disposal of HLW and spent fuel from the Krško NPP is financed from the Krško NPP Decommissioning Fund in accordance with Article 172 of the ZVISJV-1.

-        Cost of the storage and disposal of spent fuel from the TRIGA Mark II research reactor

Should the transport of spent fuel from the research reactor to the USA not be possible, spent fuel from the TRIGA reactor is planned to be deposited in a deep geological repository together with the LILW and spent fuel from the Krško NPP. The cost of the disposal of spent fuel from the TRIGA research reactor is estimated at approximately EUR 4.80 million based on the estimated cost of the disposal of spent fuel from the Krško NPP. The cost of purchasing three storage containers and the cost of storing spent fuel until at least 2093, when the geological repository is expected to be put into operation, should also be added to this. The total cost of spent fuel storage is estimated at approximately EUR 25 million and the total cost of storage and disposal at approximately EUR 29.80 million.

The funding for the storage and disposal of spent fuel is to be provided by Slovenia.

-        Cost of decommissioning the CSF

The cost of shutting down and decommissioning the CSF until it is released for unrestricted use is estimated at EUR 378,000. The funding for the decommissioning will be provided by Slovenia as the owner of the facility.

-        Cost of decommissioning the TRIGA Mark II research reactor

The decommissioning programme falls within the responsibility of the operator of the TRIGA Mark II research reactor, i.e. the Jožef Stefan Institute. The cost of decommissioning the research reactor is estimated in the decommissioning programme drawn up in 2021 [18]. The cost in the case of immediate decommissioning is estimated at EUR 12.67 million. The funding for the decommissioning will be provided by Slovenia as the owner of the facility.

-        Cost of decommissioning the Krško NPP

The cost of decommissioning the Krško NPP is assessed in the applicable Krško NPP Decommissioning Programme of 2019 [22], which was approved at the 14th session [14] of the intergovernmental commission on monitoring the implementation of the Slovenian-Croatian Agreement on the Krško NPP in July 2020, and provides the basis for raising funds in the Krško NPP Decommissioning Fund. The total cost of decommissioning the Krško NPP under the basic scenario amounts to EUR 474.0 million, including VAT. The activities that will take place after the shutdown to ensure the smooth and safe transition of the power plant to the decommissioning stage (project management, engineering and support, security, monitoring and maintenance) are the most important factor in the estimate of the decommissioning costs and account for more than 40% of the total cost of decommissioning. All costs of the final stage of spent fuel relocation and the purchase of storage containers, the operation of the dry storage facility and its decommissioning, which are estimated at EUR 75.60 million, are also taken into account as part of the decommissioning cost after the Krško NPP is shut down.

Pursuant to the provisions of the Slovenian-Croatian Agreement on the Krško NPP, Slovenia is required to provide funding for half of the total estimated cost of the Krško NPP decommissioning, which amounts to EUR 192.80 million, excluding the cost of HLW and spent fuel storage. Slovenia's share of the cost of the Krško NPP decommissioning is financed from the Krško NPP Decommissioning Fund.

The Krško NPP decommissioning costs will be reviewed anew in the next revision of the Decommissioning Programme, which has to be done by 2025 at the latest, and then again in 2030. The cost of the revision of the Krško NPP Decommissioning Programme is estimated on the basis of the cost of the production of the previous programmes. Financial resources for the decommissioning are being raised by the NPP's owners from their own resources, which are paid to two separate funds in both countries.

-        Cost of carrying out systematic monitoring of working and living environments with regard to materials that may be radioactive waste containing naturally occurring radionuclides

The SNSA must ensure a programme for the systematic monitoring of working environments by areas and activities and for awareness-raising among the population about the importance of measures to reduce exposure, pursuant to Article 63 of the ZVISJV-1 and the Decree on the reduction of exposure due to natural radionuclides and past activities or events [28].

Financial resources for the implementation of the programme for the systematic monitoring of working environments and awareness-raising among the population regarding measures to reduce exposure due to the presence of natural radiation sources are planned at EUR 15,000 per year and are provided from the state budget by the ministry responsible for the environment.

If it is determined that measures to reduce exposure need to be carried out, the cost of this is to be borne by the person carrying out the activity concerned.

-        Cost of compensation paid to local communities

In accordance with the Compensation Decree, compensation for restricted land use must be paid for the areas of a nuclear power plant that is not in operation or is being decommissioned on whose site its radioactive waste is stored, as well as spent fuel in a spent fuel pool or in a dry storage facility, a storage facility for radioactive waste or spent fuel, or a repository of LILW or HLW and spent fuel.

The entity liable to pay compensation for the CSF is ARAO, the source is the state budget.

The entity liable to pay compensation for the LILW repository is the Krško NPP Decommissioning Fund until consent is obtained to start the repository's trial operation, then it is ARAO as the future operator of the LILW repository. The financial resources for the payment of compensation for the storage and disposal facilities for radioactive waste and spent fuel from the Krško NPP are the funds raised in the Krško NPP Decommissioning Fund.

The resources for the compensation must be provided by the liable entity from its own funds.

In determining the amount of compensation for the current year, the basis for assessing the compensation should be revalued with regard to the annual inflation rate in EU Member States. Only a difference in inflation higher than a 1.5 % inflation rate in EU Member States will be taken into account in the revaluation. The estimated cost of non-revaluated compensation is set out below, assuming that inflation in the EU Member States will not be higher than 1.5%.

The annual cost to ARAO of the payment of compensation for the CSF is approximately EUR 0.22 million. The cost of compensation to be paid during the construction and closure of the LILW repository, together with compensation amounts already paid in previous years (EUR 60.40 million as of 30 June 2020), amounts to EUR 84.30 million. The cost of compensation to be paid during the repository's operation until its decommissioning in 2058 amounts to a further EUR 118.51 million. Total cost thus amounts to EUR 202.81 million. After the Krško NPP's shutdown, the cost of compensation for the dry storage of HLW and spent fuel at the Krško NPP is estimated at EUR 37.12 million, and the cost of compensation for the disposal of HLW and spent fuel in a deep geological repository at EUR 126.12 million [29]. Pursuant to the provisions of the Slovenian-Croatian Agreement on the Krško NPP, Slovenia is required to provide funding for half of the estimated cost of compensation for the storage and disposal of HLW and spent fuel from the Krško NPP.

|  |  |
| --- | --- |
| Facility | Compensation for restricted land use in EUR million |
| CSF | 8.14 |
| HLW and spent fuel storage facility | 18.56 |
| LILW repository | 202.81 |
| HLW and spent fuel repository | 63.06 |
| Decommissioning of the Krško NPP | 8.30 |
| Total – Slovenia | 300.87 |

Table 10: The estimated amount of compensation for nuclear facilities in Slovenia for which Slovenia is required to provide the funds for compensation. The table shows the total amount of compensation by facility, according to the period planned and payment amounts as explained in this Chapter

-        Cost of research, development and demonstration activities concerning radioactive waste and spent fuel management

As indicated in Chapter 3.6 on research and development, the financial resources for the implementation of the nuclear and radiation safety research programme, which will include radioactive waste and spent fuel management, have already been envisaged in the Nuclear and Radiation Safety Resolution.

These activities supporting the provision of the mandatory SGEI of radioactive waste management are planned to be commissioned directly by ARAO based on the approved long-term programme for the provision of the mandatory SGEI of radioactive waste management for a period of five years, and on the funds provided for this purpose by the state in the framework of ARAO's financial plan. The financial resources for these activities are state budget funds provided in the financial plan of the ministry responsible for the provision of the mandatory SGEI of radioactive waste management and funds for decommissioning and the disposal of radioactive waste and safe fuel provided by the Krško NPP Decommissioning Fund. The source of funding is determined with regard to the area and scope of the activities.

EUR 3.96 million is planned for research, development and demonstration activities in radioactive waste and spent fuel management in the 2023–2032 period, of which EUR 3.46 million is to be provided from the Krško NPP Decommissioning Fund and EUR 0.5 million from the state budget. The funds planned in the investment documentation for the LILW repository in the 2023–2032 period amount to EUR 0.91 million. EUR 0.25 million per year is planned for the preparatory activities for the disposal of HLW and spent fuel from the Krško NPP in the 2023–2032 period, which includes research, development and demonstration activities as planned in Strategy 5 of this programme. Funds planned for research and development in support of the operation, decommissioning and closure of the CSF and the TRIGA Mark II research reactor amount to EUR 50,000 per year. The total cost of research, development and demonstration activities in the 2023–2112 period is estimated at EUR 67.97 million, of which EUR 66.02 million is to be provided from the Krško NPP Decommissioning Fund [29] [37] and EUR 1.85 million from the state budget. More than 90% of this estimated amount is earmarked for the period after 2053, for activities related to the construction of the HLW and spent fuel repository. [37]

-        Cost of radioactive waste management after a nuclear or radiological accident

Under the ZVISJV-1, the responsibility for radioactive waste lies with the entity that caused the accident, or the owner of the source or the operator of the facility, or, if they are not known, with the state. [1] [39] The management and disposal of waste arising from a nuclear or radiological accident is carried out by the provider of the SGEI of radioactive waste management within its activities and services. To this end, the provider of the SGEI of radioactive waste management carries out the activities and services for all radioactive waste generated as a result of emergency events in the territory of Slovenia, which Slovenia must deal with pursuant to an intergovernmental agreement. The cost of managing radioactive waste following a nuclear or radiological accident during the period of validity of this programme is not included in the estimate of total implementation costs, since all activities are aimed at preventing accidents. Should this nevertheless happen, an appropriate assessment will be made based on the site remediation programme and the planned procedures for the management and disposal of radioactive waste.

5.1 ESTIMATE OF THE TOTAL COST OF DECOMMISSIONING AND RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT

The preceding Chapter provides the bases, following from the strategies and key objectives, for an assessment and the estimated cost of the main activities of decommissioning and radioactive waste and spent fuel management. The cost estimate also includes the envisaged source of funding and the dynamics of spending the planned funds.

Table 12 and Figure 11 present, for both sources of funding, the estimated annual cost of the main decommissioning and radioactive waste and spent fuel management activities for the period of validity of the programme (2023–2032), excluding the cost of managing radioactive waste resulting from any emergencies.



Figure 11: The estimated costs of radioactive waste and spent fuel management by year for the 2023–2032 period

The total cost of decommissioning and the management of radioactive waste and spent fuel in the 2023–2032 period is estimated at EUR 129.74 million, of which more than 83% is to come from the Krško NPP Decommissioning Fund (Table 13). The remaining costs envisaged to be financed from the state budget are planned for the activities of the acceptance and storage of radioactive waste not originating from power generation facilities, the corresponding share of the financing of LILW disposal, which is covered from the state budget, and the management, long-term monitoring and maintenance of closed repositories.

During the period of validity of this programme, most of the planned costs are the costs of the construction and the trial and regular operation of the LILW repository, which applies to both sources of funding. The costs envisaged for the disposal of LILW are highest during construction and operation, and slightly lower when the repository enters a standby phase. The cost of compensation for restricted land use will account for a significant share of the cost of LILW management throughout the period of validity of the programme, except during construction, when the share of construction and equipment costs will, of course, be relatively higher.

The cost of decommissioning activities is low in this period (only comprising the cost of preparing the revisions of the decommissioning programmes), as most of the decommissioning activities are planned for the period after 2043.

The total cost of activities related to decommissioning and radioactive waste and spent fuel management in the 2023–2112 period is estimated at EUR 1,186.95 million, of which more than 89% is to comes from the Krško NPP Decommissioning Fund (EUR 1,058.14 million). The estimated cost of the management of radioactive waste and spent fuel from the Krško NPP in the 2023–2112 period is lower than that estimated in the third revision of the Programme for the Disposal of Radioactive Waste and Spent Fuel (EUR 1,090.10 million) [25], because the periods considered are different (the third revision of the disposal programme covers the 2018–2110 period) and because an updated cost estimate is used for the LILW repository based on the approved revised investment programme [30].

In this period, the construction and operating costs of the LILW and HLW and spent fuel repositories represent the highest share, followed by the costs of decommissioning the Krško NPP and other nuclear facilities (TRIGA, CSF). A significant share of these costs consists of the payments of compensation for restricted land use (Tables 10 and 11).

|  |  |  |  |
| --- | --- | --- | --- |
| Year and source of funds | 2023–2032 | 2033–2112 | Total 2023–2112 |
| Activity costs in EUR million | Krško NPP Decommissioning Fund | State budget | Krško NPP Decommissioning Fund | State budget | Krško NPP Decommissioning Fund | State budget |
| Operation of the CSF and the provision of the public service of institutional radioactive waste management | 0 | 7.50 | 0 | 19.50 | 0 | 27.00 |
| Cost of the construction and operation of the LILW repository | 104.13 | 10.78 | 125.56 | 12.81 | 229.69 | 23.59 |
| Cost of the construction and operation of the repository of HLW and spent fuel from TRIGA  | 0 | 0 | 506.37 | 4.80 | 506.37 | 4.80 |
| Cost of the storage of HLW and spent fuel from the Krško NPP and TRIGA | 0 | 0 | 62.76 | 25.00 | 62.76 | 25.00 |
| Cost of decommissioning the Krško NPP (2043–2058) | 0.50 | 0.00 | 192.80 | 0.00 | 193.30 | 0 |
| Costs of decommissioning the CSF (2058) | 0 | 0.12 | 0 | 0.38 | 0 | 0.38 |
| Costs of decommissioning the TRIGA reactor (2043–2053) | 0 | 0 | 0 | 12.79 | 0 | 12.79 |
| Long-term monitoring and maintenance of the LILW repository (2060–2112) | 0 | 0 | 0 | 9.47 | 0 | 9.47 |
| Long-term monitoring and maintenance of the Jazbec and Boršt repositories | 0 | 2.60 | 0 | 21.06 | 0 | 23.66 |
| Implementation of the programme for systematic monitoring of working and living environments to reduce exposure due to natural radionuclides and past activities or events  | 0 | 0.15 | 0 | 0 | 0 | 0.15 |
| Research, development and demonstration activities related to radioactive waste and spent fuel | 3.46 | 0.50 | 62.56 | 1.35 | 66.02 | 1.85 |
| Total:  | 108.09 | 21.65 | 950.05 | 107.16 | 1,058.14 | 128.81 |
|  |  |  |  |  | Total Krško NPP Decommissioning Fund | 1,058.14 |
|  |  |  |  |  | Total - state budget | 128.81 |

Table 12: The estimated total cost of radioactive waste and spent fuel management activities in the 2023–2112 period

**Year and source of funds**

**Costs of the activity in million**

**EUR**

Fund

NEK

State

budget

Fund NEK

State budget

Fund

NEK

State

budget

Fund

NEK

State

budget

Fund

NEK

State

budget

Fund

NEK

State budget

Fund NEK

State

budget

Fund

NEK

State

budget

Fund

NEK

State

budget

Fund

NEK

State budget

**Fund NEK**

**State budget**

**CSF operation and costs of SGEI**

**services for RW not generated in**

**nuclear facilities for energy**

**production**

0

0,75

0

0,75

0

0,75

0

0,75

0

0,75

0

0,75

0

0,75

0

0,75

0

0,75

0

0,75

0

7,50

**Costs of LILW repository**

**construction and operation**

24,79

2,57

18,05

1,87

9,06

0,94

8,93

0,93

8,92

0,92

8,58

0,89

6,46

0,67

6,45

0,66

6,45

0,66

6,45

0,66

104,13

10,78

**Costs of Krško NPP and Triga RR**

**HLW&SF repository construction and**

**operation**

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

**Costs of Krško NPP and Triga RR**

**HLW&SF storage**

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

**Costs of Krško NPP decommissioning**

**(2043-2058)**

0

0

0

0

0,25

0

0

0

0

0

0

0

0

0

0,25

0

0

0

0

0

0,50

0,00

**Costs of CSF decommissioning (2058)**

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

**Costs of TRiga RR**

**decommissioning(2043-2053)**

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0,12

0

0

0

0

0

0,12

**Long-term monitoring and**

**maintenance of LILW repository (2060-**

**2112)**

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

**Long-term monitoring and**

**maintenance of Jazbec and Boršt**

0

0,26

0

0,26

0

0,26

0

0,26

0

0,26

0

0,26

0

0,26

0

0,26

0

0,26

0

0,26

0

2,60

**Cost of carrying out the programe of**

**systematic monitoring of working and**

**living environments for exposure to**

**natural radiation radionuclides and**

**past activities or events**

0

0,015

0

0,015

0

0,015

0

0,015

0

0,015

0

0,015

0

0,015

0

0,015

0

0,015

0

0,015

0

0,15

**Research, development and**

**demonstration activities for HLW and**

**SF**

0,57

0,05

0,47

0,05

0,26

0,05

0,26

0,05

0,33

0,05

0,29

0,05

0,32

0,05

0,32

0,05

0,32

0,05

0,32

0,05

3,46

0,50

**Total:**

**25,36**

**3,64**

**18,52**

**2,94**

**9,57**

**2,01**

**9,19**

**2,00**

**9,25**

**2,00**

**8,87**

**1,96**

**6,78**

**1,75**

**7,02**

**1,86**

**6,77**

**1,74**

**6,77**

**1,74**

**108,09**

**21,65**

**Total 2023-**

**2032 Fund**

**NEK**

**108,09**

**Total 2023-**

**2032 State**

**budget**

**21,65**

**2028**

**2023**

**2024**

**2025**

**2026**

**2027**

**2029**

**2030**

**2031**

**2032**

**Total 2023-2032**

Table 13: Cost of the planned radioactive waste and spent fuel management activities in the period of validity of the programme (2023–2032)

6. EDUCATION, INFORMATION AND REPORTING

6.1 EDUCATION AND RESEARCH

An adequate level of expertise, skill and competence ensures a high level of safety and efficiency in radioactive waste and spent fuel management. Unfortunately, such research activities are poorly supported in Slovenia. The Resolution on the Research and Innovation Strategy of Slovenia does not classify individual research disciplines in terms of national priorities. It only provides a basic framework for regulating research and innovation in the country. The regulation of nuclear research and the associated research on radioactive waste management involves specific strategic arrangements for this field and a more active role of line ministries so that they, in accordance with the sectoral legislation, provide support for nuclear research that they regard as insufficiently supported in terms of their competencies. The knowledge, technology and skills required for safe, efficient and sustainable radioactive waste management are available within the EU and also within the wider international area. This applies in particular to the more advanced programmes of Finland, France, Sweden and Canada. It is certainly reasonable for Slovenia to closely follow the developments in the international sphere, to actively participate in international associations and to engage in bilateral cooperation with countries with more developed research programmes.

The effective transfer of new knowledge and technologies from abroad requires successful and internationally recognised research, development, and educational efforts of national experts, which must be financed from domestic resources. A lack of adequate domestic funding for such activities, which may become even more pronounced in times of economic crisis or due to the poor implementation of strategic documents related to nuclear power and radioactive substances (the Resolution on Research and Innovation Strategy of Slovenia and the Nuclear and Radiation Safety Resolution), is one of the critical risks as regards safe radioactive waste and spent fuel management.

Education and research are essential for the development, transfer and preservation of knowledge, skill, and competencies concerning radioactive waste and spent fuel management in Slovenia.

Slovenia's integration in global knowledge flows is facilitated through international groups and joint projects by membership in the EU and OECD and cooperation with the International Atomic Energy Agency (IAEA).

Research activities in nuclear and radiation safety are defined in the Nuclear and Radiation Safety Resolution. Such activities pursue three main goals: the safety of nuclear facilities, safe radioactive waste management, and radiation protection and the safety of ionising radiation sources.

The ZVISJV-1 stipulates that ARAO must ensure, as part of the provision of the mandatory SGEI of radioactive waste management, the development of the profession of radioactive waste and spent fuel management and the transfer of knowledge from the international environment to Slovenia. In addition to research and development, ARAO also monitors international developments and participates in working groups within international associations and Slovenia's membership in international organisations in the field of the processing and disposal of radioactive waste and the operation of radioactive waste repositories.

6.2 PUBLIC INFORMATION AND PUBLIC PARTICIPATION IN DECISION-MAKING

Slovenia consistently complies with the principles of the Aarhus Convention with regard to public participation in planning and decision-making related to radioactive waste and spent fuel management. Transparency is of great importance in spent fuel and radioactive waste management. Such should be achieved by efficiently providing public information and ensuring that all relevant interested parties, including local authorities and the public, are aware of the possibility of participation, in accordance with the applicable legislation.

In accordance with the principle of the public nature of information laid down in the ZVISJV-1, the state ensures that data on radioactivity in the environment, the exposure of members of the public and the procedures and activities of state authorities, providers of mandatory national services of general economic interest and bearers of power relating to radiation protection and nuclear and radiation safety are public. Data related to the nuclear and radiation safety of nuclear and radiation facilities, data on radioactive waste and spent fuel management, and data on the results of radioactivity monitoring are public and available to radiation practice operators, workers and the general public, unless otherwise provided for by legislation regulating the protection of nuclear materials, physical protection and the protection of radiation sources, by the Act governing access to public information or by the international obligations of the Republic of Slovenia.

Since 1985, information has been regularly published in the annual report on ionising radiation protection and nuclear safety, which is produced by the operators of nuclear and radiation facilities, closed radioactive waste repositories and other radiation practice operators in Slovenia, as coordinated by the SNSA. The report in Slovenian and English is available to the public in electronic form on the website of the SNSA.

Since the curricula in Slovenian basic and upper secondary education include very little on the subject of radioactivity and ionising radiation, and, consequently, the majority of people know little about the scientific facts regarding these phenomena, the national strategy also includes measures to inform the public and raise public awareness. To this end, the possibility of including this topic in school curricula will be considered. In general public information, general radiation literacy is promoted, which improves public participation in and an understanding of procedures and decision-making. Education in radiation literacy is intended for all segments of the public. It involves informing the public of the technically proven effects of ionising radiation on living organisms and humans, and of the measures for the protection of human health, different types of radioactive waste, the legislation governing radioactive waste and spent fuel management, and wider aspects of environmental protection, which also includes the need for adequate radioactive waste and spent fuel management.

6.3 REPORTING

As a Party to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, Slovenia is required to draw up a report on spent fuel and radioactive waste management every three years. A report, which is to be submitted to the European Commission every three years, is also required under the Radioactive Waste and Spent Fuel Management Directive, where the reporting and reviews made in accordance with the above-mentioned Joint Convention can be used.

The SNSA is responsible for the preparation of both reports. The SNSA draws up the required report in collaboration with the Slovenian Radiation Protection Administration, the Department of Nuclear Medicine of the University Medical Centre Ljubljana, the Institute of Oncology Ljubljana, the Krško NPP, the Jožef Stefan Institute, the Žirovski Vrh Mine, d.o.o., the Energy Directorate within the Ministry of Infrastructure and Spatial Planning and ARAO.

A group of up to 15 people whose areas of work include radioactive waste and spent fuel management and the coordination of the report participate in drawing up the report, monitoring the activities carried out in the period between two review cycles and reporting. The work of all those involved in such reporting and the monitoring and implementation of the recommendations adopted at the Review Conference under the Joint Convention and the Radioactive Waste and Spent Fuel Management Directive are estimated as amounting to 0.5 person years. These costs are borne by the organisations involved in drawing up the report and in the monitoring and implementation of the recommendations.

7. RESPONSIBILITY FOR THE IMPLEMENTATION OF THE NATIONAL PROGRAMME

7.1 NATIONAL AUTHORITIES

Independent administrative control of nuclear and radiation safety is provided by the SNSA within the Ministry of the Environment and Spatial Planning, the Slovenian Radiation Protection Administration within the Ministry of Health, the Administration for Civil Protection and Disaster Relief within the Ministry of Defence, and the Ministry of the Interior.

The SNSA is responsible for supervision of nuclear safety, nuclear and radiation facilities, and sources of ionising radiation in the country, with the exception of sources in human and veterinary healthcare, which are the responsibility of the Slovenian Radiation Protection Administration.

The SNSA performs expert, administrative and development functions in the following areas: nuclear and radiation safety; radiation practices and the use of radiation sources, except in human or veterinary healthcare; the protection of the environment against ionising radiation; the physical protection of nuclear materials and facilities; the non-proliferation of nuclear weapons and the protection of nuclear goods; monitoring of environmental radiation; and liability for nuclear damage. It also carries out inspections in these areas and, in the event of a radiological or nuclear emergency, cooperates with the Civil Protection Headquarters in determining protective measures for the population and in providing information. The SNSA maintains a central register of radioactive waste and spent fuel generated on the territory of Slovenia.

The Slovenian Radiation Protection Administration performs expert, administrative, supervisory and development functions in the following areas: radiation practices and the use of sources of ionising radiation in human and veterinary healthcare; the protection of human health against the harmful effects of ionising radiation; the systematic monitoring of working and living environments with regard to human exposure to natural sources of ionising radiation; monitoring of the radioactive contamination of food and drinking water; the prevention, restriction and reduction of the harmful effects of ionising radiation; the assessment of the competencies of radiation protection experts and the approval thereof.

As an organisational unit of the Ministry of Infrastructure, the Energy Directorate carries out functions related to the development of the country’s wider energy policy and the use of nuclear energy. It develops the comprehensive national energy policy on energy supply and ensures the economic management of raw mineral resources by granting mining rights for the exploration and exploitation of various raw mineral resources. The directorate monitors the management of state-owned energy companies, including GEN energija, d.o.o., which is the owner of Slovenia's share in the Krško NPP. In such manner, the directorate also has an indirect influence on the nuclear safety of the facility, since its long-term safety largely depends on its stable business and financial performance. Slovenian Sovereign Holding also influences operations by influencing the financial operations of GEN energija, d.o.o., and, consequently, of the GEN Group. Thus, Slovenian Sovereign Holding also influences the nuclear safety of the facility and, as a diligent owner, has to provide adequate resources for the safe operation of the Krško NPP. The Energy Directorate also monitors the operations of the Fund for Financing the Decommissioning of the Krško NPP and the Disposal of Radioactive Waste from the Krško NPP.

The Ministry of Infrastructure monitors and participates in the work of the intergovernmental commission established under the Slovenian-Croatian Agreement on the Krško NPP.

The supervision of activities related to the physical protection of nuclear materials and of facilities containing nuclear or radioactive material is carried out by the ministry responsible for internal affairs in collaboration with the inspectorate of the SNSA. The operator of a facility containing nuclear or radioactive material, or the carrier or organiser of the transport of nuclear material, must provide a physical protection plan and ensure the implementation of measures for the physical protection of facilities or material in accordance with the plan approved by the ministry responsible for internal affairs.

The Administration of the Republic of Slovenia for Civil Protection and Disaster Relief within the Ministry of Defence is responsible for planning measures to ensure radiation and nuclear safety during emergencies and for developing the national emergency plan in the event of a nuclear or radiological accident.

As the owner of the CSF and TRIGA Mark II research reactor nuclear facilities, the state is responsible for providing financial resources for their operation, maintenance and decommissioning, and for radioactive waste and spent fuel management.

The Police, as a body within the Ministry of the Interior, are responsible for supervising the road transport of radioactive material and spent fuel, the inspectorate of the ministry responsible for transport is responsible for supervising the transport of such material by rail, air and water, and the Administration for Civil Protection and Disaster Relief within the Ministry of Defence is responsible for planning measures to ensure radiation and nuclear safety during emergencies.

The mandatory SGEI of radioactive waste management is defined by the ZVISJV-1 and provided by ARAO. ARAO is a public utility institute that carries out its activities under contracts entered into with the ministry responsible for overseeing the provision of the mandatory SGEI of radioactive waste management.

7.2 THE FUND FOR FINANCING THE DECOMMISSIONING OF THE KRŠKO NPP AND THE DISPOSAL OF RADIOACTIVE WASTE

In 1994, the Fund for the Financing of the Decommissioning of the Krško Nuclear Power Plant and the Disposal of Radioactive Waste from the Krško Nuclear Power Plant was established to raise funds for the effective and permanent decommissioning of and the final disposal of radioactive waste and safe fuel from the Krško NPP.

In September 2022, the Act Governing the Public Fund of the Republic of Slovenia for Financing the Decommissioning of the Krško Nuclear Power Plant and the Disposal of Radioactive Waste from the Krško Nuclear Power Plant (Official Gazette of the Republic of Slovenia [*Uradni list RS*], No 130/22) was adopted. It regulates the operations of the Krško NPP Decommissioning Fund, the method of providing funds for financing decommissioning and the disposal of radioactive waste and spent fuel, and the level and designated use of such funds. The Fund was established in accordance with the international Slovenian-Croatian Agreement on the Krško NPP and is a legal entity under public law. Its founder is the Republic of Slovenia, with the founder’s rights and obligations being exercised by the Slovenian Government. The Act determines the eligible use of the Fund’s resources, the financing of the mandatory SGEI of radioactive waste management from the state budget, and the Fund’s bodies, operations and management of assets.

The operations of the Fund are organised in line with the systemic regulation of public funds so that the resources are used to finance the founder’s policy measures as regards the decommissioning of the Krško NPP and the disposal of radioactive waste and spent fuel from the Krško NPP. To this end, the Fund collects financial resources, manages such, and takes measures to maintain and increase such resources.

In addition to the existing objectives of supervision and operation, business and investment policies and the responsible management of the collected funds, the Act also provides for the establishment of the relevant bases for the unambiguous regulation of relations between the founder, the Fund and the provider of the mandatory SGEI of radioactive waste management, and for the Fund to be integrated into the systemic regulation of public funds and to manage accounts in accordance with public finance regulations.

The Fund’s income comes from the charge for the decommissioning of the Krško NPP and the disposal of radioactive waste and spent fuel from the Krško NPP paid to the Fund by liable entities for every MWh of electricity generated by the Krško NPP they receive directly from the Krško NPP. The Slovenian Government sets the amount of the charge by way of a decision, on the proposal of the minister responsible for energy. Every year, the Fund draws up two-year business and financial plans that are adopted by the Supervisory Board on the proposal of the director, and sent to the minister responsible for energy for approval.

7.3 PROVIDER OF THE MANDATORY SERVICE OF GENERAL ECONOMIC INTEREST

The SGEI of radioactive waste management, as defined in the ZVISJV-1, is provided by ARAO as an independent implementing organisation. Supervision of the business operations of the provider of the mandatory SGEI of radioactive waste management is carried out by the ministry responsible for waste management [1].

In 1999, the Decree on the manner, subject and conditions for performing the mandatory service of general economic interest of radioactive waste management (Official Gazette of the Republic of Slovenia [*Uradni list RS]*, Nos 32/99 and 41/04 – ZVO1) was adopted, determining the method of providing the SGEI of the management of radioactive waste generated in Slovenia, except for the management of radioactive waste and spent fuel generated by the Krško NPP and the former Žirovski Vrh Mine. The Decree specifies the scope of the public service, including the acceptance and management of radioactive waste and the operation of public service infrastructure facilities for the storage of LILW.

The Ordinance on the establishment of a public company for the management of radioactive waste (Official Gazette of the Republic of Slovenia [*Uradni list RS*], No 5/91) was subsequently (in 1999, 2011 and 2009) amended to extend the powers and responsibilities of ARAO.

Pursuant to the ZVISJV-1, the Decree on the method and conditions for providing the mandatory national public service of general economic interest of radioactive waste management [8] and the Ordinance on the establishment of ARAO [9] were adopted in 2022. They lay down the method, conditions and organisational form of the provision of the public service of radioactive waste management, and its financing, the price list for services and activities, and other contents relevant to the performance of all the organisational and physical activities of radioactive waste and spent fuel management.

Pursuant to the ZVISJV-1, the Decree and the Ordinance, ARAO provides the mandatory SGEI of radioactive waste management, which comprises activities and services for the acceptance, collection, transport, processing and storage prior to disposal of radioactive waste, and preparations for the construction of a repository, the construction of a repository and the disposal of radioactive waste not originating from nuclear power generation facilities. As a public service, ARAO also performs activities and services comprising the processing of radioactive waste and spent fuel prior to disposal; preparations for the construction of a repository; the construction of a repository; the disposal of radioactive waste originating from nuclear power generation facilities; the operation of radioactive waste repositories; the management, long-term monitoring and maintenance of closed radioactive waste repositories; and the management, long term management and maintenance of the closed repositories of mining and hydrometallurgical tailings originating from the extraction and exploitation of nuclear minerals.

The activities and services of the mandatory SGEI of radioactive waste management also include ensuring the development of the profession of radioactive waste and spent fuel management and the transfer of knowledge from the international environment to Slovenia. In addition, ARAO also performs other technical and development tasks in accordance with the Act governing ionising radiation protection and nuclear safety, or pursuant to the decisions of the Government directly related to the provision of the public service of radioactive waste management.

8. MONITORING PROGRESS IN THE IMPLEMENTATION OF THE NATIONAL PROGRAMME

Progress in the implementation of the national programme is monitored through annual reviews of the status of the implementation of the measures and key indicators of the programme set out in Chapter 4 in relation to the strategies and activities for radioactive waste and spent fuel management. In accordance with the requirements of the Rules on radioactive waste and spent fuel management [6], any holder of radioactive waste or spent fuel that is also the operator of a radiation or nuclear facility is required to produce a programme for radioactive waste or spent fuel management, which is to be reviewed every two years and must include measurable performance indicators for the envisaged radioactive waste or spent fuel management procedures and methods, equipment and the measures planned to reduce the generation of radioactive waste or spent fuel and to reduce the radiological and other impacts arising from the radioactive waste or spent fuel.

Once a year, the authority responsible for nuclear safety collects information on the implementation of measures and the performance of key indicators by the entities implementing measures to achieve the objectives of the strategies, and includes such in its annual report on ionising radiation protection and nuclear safety, which the Government then submits to the National Assembly of the Republic of Slovenia by the end of July of the next year. The report must highlight the performance of the implementation of measures based on the key indicators of the achievement of the strategy objectives, identify why the key indicators may not have been reached, and indicate possibilities to improve the measures and the performance of key indicators, with a view to updating the national programme for the management of radioactive waste and spent fuel. Similarly, the nuclear safety authority examines the achievement of measurable management performance indicators by holders of radioactive waste and spent fuel and any amendments to the radioactive waste and spent fuel management programmes through the results of the review of these programmes.

9. ABBREVIATIONS

|  |  |
| --- | --- |
| ARAO | Radioactive Waste Management Agency |
| EU | European Union |
| Euratom | European Atomic Energy Community |
| Fond NEK  | *Fond za financiranje razgradnje i zbrinjavanja radioaktivnog otpada i istrošenoga nuklearnog goriva Nuklearne elektrane Krško* (Fund for Financing the Decommissioning and Disposal of Spent Nuclear Fuel from the Krško Nuclear Power Plant), Croatia |
| IAEA | International Atomic Energy Agency |
| SF | spent fuel |
| Krško NPP 2 | Krško Nuclear Power Plant 2 |
| LILW | low- and intermediate-level waste |
| OECD  | Organization for Economic Cooperation and Development |
| PSR | periodic safety review |
| RW | radioactive waste |
| Krško NPP Decommissioning Fund  | Public Fund of the Republic of Slovenia for the Financing of the Decommissioning of the Krško Nuclear Power Plant and the Disposal of Radioactive Waste from the Krško Nuclear Power Plant |
| TRIGA Mark II  | a nuclear research reactor at the Jožef Stefan Institute |
| SNSA | Slovenian Nuclear Safety Administration |
| HLW | high-level waste |
| Waste manipulation building (WMB)  | A building at the Krško NPP where equipment and radioactive waste shipments are handled |
| USA | United States of America |

10. SOURCES

|  |  |
| --- | --- |
| [1]  | Ionising Radiation Protection and Nuclear Safety Act (Official Gazette of the Republic of Slovenia [*Uradni list RS*], Nos 76/17, 26/19 and 172/21) |
| [2]  | Energy permit for the energy project Krško Nuclear Power Plant 2, No 360-52/2020/17-02711771, Ministry of Infrastructure of the Republic of Slovenia, 2021 |
| [3]  | Decree on the national spatial plan for a low- and intermediate-level waste repository at Vrbina in the Municipality of Krško (Official Gazette of the Republic of Slovenia [*Uradni list RS*], Nos 114/09 and 50/12) |
| [4]  | Safety report for the Vrbina LILW Repository, Krško, No NSRAO2-POR-038, ARAO, November 2021 |
| [5]  | Opinions of the SNSA on the construction of a low- and intermediate-level waste repository, No 3510-3/2019/162, January 2022 |
| [6]  | Rules on radioactive waste and spent fuel management (Official Gazette of the Republic of Slovenia [*Uradni list RS*], No 125/21) |
| [7]  | Constitution of the Republic of Slovenia (Official Gazette of the Republic of Slovenia [*Uradni list RS*], Nos 33/91-I, 42/97 – UZS68, 66/00 – UZ80, 24/03 – UZ3a, 47, 68, 69/04 – UZ14, 69/04 – UZ43, 69/04 – UZ50, 68/06 – UZ121,140,143, 47/13 – UZ148, 47/13 – UZ90,97,99 and 75/16 – UZ70a) |
| [8]  | Decree on the method and conditions for providing the mandatory national public service of general economic interest of radioactive waste management (Official Gazette of the Republic of Slovenia [*Uradni list RS*], No 08/22) |
| [9]  | Ordinance establishing the ARAO Public Utility Institute (Javni gospodarski zavod ARAO) (Official Gazette of the Republic of Slovenia [*Uradni list RS*]], No 08/22) |
| [10]  | Integrated National Energy and Climate Plan of the Republic of Slovenia, No 35400-18/2019/22, adopted at the 62nd regular session of the Government of the Republic of Slovenia, February 2020 |
| [11]  | Programme for the Decommissioning of the Krško NPP and the Disposal of LILW and Spent Nuclear Fuel, APO and ARAO, March 2004 |
| [12]  | Minutes of the 11th session of the intergovernmental commission on monitoring the implementation of the Slovenian-Croatian Agreement on the Krško NPP, November 2017 |
| [13]  | Minutes of the 13th session of the intergovernmental commission on monitoring the implementation of the Slovenian-Croatian Agreement on the Krško NPP, September 2019 |
| [14]  | Minutes of the 14th session of the intergovernmental commission on monitoring the implementation of the Slovenian-Croatian Agreement on the Krško NPP, July 2020 |
| [15]  | Minutes of the 15th session of the intergovernmental commission on monitoring the implementation of the Slovenian-Croatian Agreement on the Krško NPP, October 2021 |
| [16]  | Minutes of the 16th session of the intergovernmental commission on monitoring the implementation of the Slovenian-Croatian Agreement on the Krško NPP, April 2022 |
| [17]  | Resolution on the Long-Term Climate Strategy of Slovenia until 2050 (Official Gazette of the Republic of Slovenia [*Uradni list RS*], No 119/21 |
| [18]  | Programme for the Decommissioning the TRIGA Mark II Reactor Nuclear Facility at the Jožef Stefan Institute, IJS, Work Report IJS-DP-9849, Edition: 4 April 2021 |
| [19]  | Long-term Strategy for the Operation of the TRIGA Reactor, IJS, IJS-DP-10797, Edition 2, March 2015 |
| [20]  | Programme for Decommissioning the TRIGA Mark II Reactor Nuclear Facility at the Jožef Stefan Institute, Work Report IJS-DP-9849, December 2007, Revision 0 |
| [21]  | https://www.energy.gov/nepa/downloads/eis-0218-sa-08-supplement-analysis |
| [22]  | 3rd Revision of the NPP Krško Decommissioning Program, NIS – Siempelkamp, document No 4520/CA/F 010640 5/01, June 2019 |
| [23]  | Federal Register Vol. 69, No 230, 1 December 2004, pp. 69901–69903 |
| [24]  | Federal Register Vol. 77, No 20, 31 January 2012, pp.4807–4808 |
| [25]  | Programme for the Decommissioning of the CSF, Revision 0, No 04-01-026-002, ARAO, 2012 |
| [26]  | Programme for the Decommissioning of the CSF, Revision 1, No 04-01-026-002, ARAO, 2021 |
| [27]  | Decree on the conversion of *Žirovski vrh, javno podjetje za zapiranje Rudnika urana, p.o,* to *Rudnik Žirovski vrh, javno podjetje za zapiranje rudnika urana, d.o.o.* (Official Gazette of the Republic of Slovenia [*Uradni list RS*], No 79/01) |
| [28]  | Decree on the reduction of exposure due to natural radionuclides and past activities or events (Official Gazette of the Republic of Slovenia [I], No 38/18 |
| [29]  | Third Revision of the Krško NPP Radioactive Waste and Spent Fuel Disposal Programme, Version 1.3, September 2019, ARAO – Radioactive Waste Management Agency, Ljubljana, Fund for Financing the Decommissioning of the Krško NPP, Zagreb |
| [30]  | Vrbina LILW Repository, Krško, Investment Programme, Revision E, IBE d.d., July 2021 |
| [31]  | Decision of the Minister of Infrastructure No 360-182/2020/35 of 2 August 2021 on the approval of the "Investment Programme for the LILW Repository, Vrbina, Municipality of Krško, Revision E, July 2021" |
| [32]  | Minutes of the 10th session of the intergovernmental commission on monitoring the implementation of the Slovenian-Croatian Agreement on the Krško NPP, July 2015 |
| [33]  | Rules on radiation and nuclear safety factors (Official Gazette of the Republic of Slovenia [*Uradni list RS*], Nos 74/16 and 76/17 – ZVISJV-1) |
| [34]  | Decommissioning of Facilities, General Safety Requirements Part 6, IAEA Safety Standard Series, IAEA, 2014 |
| [35]  | IAEA Position Statement on the Release of Patients after Radionuclide Therapy, February 2010 |
| [36]  | Investment Feasibility Study, Vrbina LILW Repository, Krško, IBE d.d., July 2021 |
| [37]  | Reference Scenario for a Geological Disposal Facility in Hard Rock with a Cost Estimation for Its Implementation, IBE d.d., February 2019 |
| [38]  | Act Governing the Permanent Cessation of Uranium Ore Exploitation and Prevention of the Effects of Mining at the Žirovski Vrh Uranium Mine (Official Gazette of the Republic of Slovenia [*Uradni list RS*], No 22/06 – official consolidated version) |
| [39]  | Strategy of Protection in the Event of a Nuclear or Radiological Accident, SNSA 2021 |
| [40]  | Guidelines for the Management of Large Quantities of Radioactive Waste, ARAO, 2021 |
| [41]  | Assessment of risks in the event of a nuclear or radiological accident in Slovenia, Version 2.2, Administration of the Republic of Slovenia for Civil Protection and Disaster Relief, March 2022 |

11. ENTRY INTO FORCE OF THE RESOLUTION

On the day this Resolution enters into force, the Resolution on the National Programme for Managing Radioactive Waste and Spent Nuclear Fuel for the 2016–2025 Period (Official Gazette of the Republic of Slovenia [*Uradni list RS*], No 31/16) shall cease to be in force.

This Resolution shall enter into force on the fifteenth day following its publication in the Official Gazette of the Republic of Slovenia.

Št. 801-10/22-2/16

Ljubljana, 27 January 2023

EPA 395-IX

National Assembly
of the Republic of Slovenia
**Urška Klakočar Zupančič**
President