

## **RADIOACTIVE WASTE MANAGEMENT AND DECOMMISSIONING IN SLOVENIA**

### **1. NATIONAL FRAMEWORK FOR MANAGEMENT AND REGULATION OF RADIOACTIVE WASTE AND DECOMMISSIONING**

#### **1.1 National framework**

##### ***1.1.1 Overview of national policy***

The governmental policy in the area of safety of spent fuel management and safety of radioactive waste management is governed by the national nuclear legislation and international agreements. Based on the legislation, a number of measures have been implemented to protect the environment and human society from the harmful impact of radioactive waste and spent fuel. The most important measures are:

- Establishment and functioning of the regulatory body, the Slovenian Nuclear Safety Administration (SNSA), which is competent in the area of nuclear and radiation safety and radioactive waste management. It was established in 1987. Previously, the functions of the regulatory body were held by the Committee of Energy and Industry.
- Establishment of ARAO as a state-owned public institution for radioactive waste management (1991).
- Establishment of the Žirovski vrh Mine d.o.o., a public enterprise for the decommissioning of the uranium production site (1992).
- Establishment of the Fund for the Decommissioning of the Krško NPP (1995).

In addition, the Government has prepared several documents pertinent to the policy in the area of radioactive waste management. The most important are:

The Resolution on the National Energy Programme adopted by the Slovenian Parliament in 2004. In this document the following policy was adopted:

- The share of nuclear energy shall be preserved at the current level.
- The Krško NPP shall operate at least until 2023.
- In order to secure safe and reliable operation of the Krško NPP, adequate measures are implemented.
- The decision on life extension of the Krško NPP shall be adopted in 2011 on the basis of an evaluation programme which shall start in 2008.

The draft National Energy Program for the period until 2030 was prepared in 2011, but it has not been finalized yet. This draft National Energy Program foresees the use of nuclear energy as a contributor to the transition to reliable low carbon power supply sources.

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 the Investment, Exploitation and Decommissioning of the Krško NPP (hereinafter the Agreement). In the Agreement the following policy is adopted:

- Decommissioning of the Krško Nuclear Power Plant and management of its radioactive waste and spent fuel are a joint responsibility of the contracting parties, and they should ensure efficient common solutions both from the economic and environmental protection standpoint.
- If the contracting parties do not reach agreement on a common solution for RW and SF management during the lifetime of the Krško NPP, they undertake that two years after that

period they must finish removal of operational RW and SF from the location of the Krško NPP (one half by each party) and will individually bear the costs of their management (including subsequent division and removal of RW from decommissioning).

- The contracting parties shall in equal shares assure funds for the preparation of the decommissioning programme and its execution and the funds for the preparation of the programme for the disposal of radioactive waste and spent fuel. If the contracting parties agree on a joint solution for the disposal of radioactive waste and spent fuel they shall finance it in equal shares or they shall finance their shares of activities.
- The Republic of Slovenia and the Republic of Croatia shall jointly prepare and approve a new plan for decommissioning of the Krško NPP and disposal of LILW and high level waste (hereinafter the Decommissioning Plan).
- The Croatian party has, according to the Agreement, established its own fund for the management and collection of financial resources for its share of decommissioning and radioactive waste disposal costs.

The current contribution to the Slovenian fund for financing one half of the decommissioning and spent fuel and radioactive waste disposal is 0.30 Euro cents per kWh<sub>e</sub> of the Slovenian share of energy produced in NPP Krško.

The revision of the Programme for Decommissioning of the Krško NPP and Disposal of LILW and High Level Waste is not finished yet. According to current information the levy per kWh<sub>e</sub> shall be increased.

The Resolution on the 2006-2015 National Programme for Managing Radioactive Waste and Spent Nuclear Fuel was adopted by the Slovenian Parliament in February 2006. According to the programme, the NPP Krško as the major radioactive waste generator shall continue to operate until 2023 with an option of life extension. After termination of NPP Krško operation, the spent fuel will be transferred to dry storage for a period of about 35 years, when the spent fuel repository should be operable. The LILW waste repository shall be built in Slovenia. The design of the repository should be modular, with sufficient capacity to accommodate all future LILW waste arising in Slovenia. The spent fuel from the Triga Mark II research reactor will be returned to the country of origin. The waste stored at the Central Storage for Radioactive Waste in Brinje and the waste from small producers, meeting the waste acceptance criteria, shall be disposed of in the LILW repository. The remaining waste from the Central Storage for Radioactive Waste in Brinje shall be stored at the facilities of the repository if agreement on this issue is reached with the local community.

As a consequence of the Fukushima accident the stress tests were performed and an action plan how to improve the safety of operation of NPP Krško. According to action plan, among others, the dry storage of spent fuel on the site will be implemented already by 2018. Consequently, the existing Resolution on the 2006-2015 National Programme for Managing Radioactive Waste and Spent Nuclear Fuel (the Programme) will be supplemented.

In 2012, the SNSA prepared a draft of the Resolution on Nuclear and Radiation Safety in the Republic of Slovenia for the period 2013 – 2023. The proposal was adopted by the Parliament in June 2013. As a high level national policy paper it covers the following chapters:

- The fundamental safety principles;
- Description of nuclear and radiological activities in Slovenia;
- Description of international cooperation in the field of nuclear and radiation safety;

- Description of existing legislation (including binding international legal instruments, such as conventions and
- other relevant international instruments);
- Description of the institutional framework;
- Competence of professional support (research, education, training);
- Objectives and measures to be achieved by 2023.

### ***1.1.2 Overview of relevant institutions***

The Parliament and the Government of the Republic of Slovenia are responsible for setting regulatory framework in the country. The Minister responsible for the environment further adopts the specific rules on implementing radioactive waste management as well as decommissioning.

The main organisations for the implementing of radioactive waste management and decommissioning are:

- The Krško NPP,
- The Jozef Stefan Institute,
- Agency for Radioactive Waste and
- Žirovski vrh Mine d.o.o.

## **1.2 National regulatory organisation**

### ***1.2.1 Slovenian Nuclear Safety Administration***

The SNSA, as a regulatory body in the area of nuclear and radiation safety, is a functionally autonomous body within the Ministry of Agriculture and the Environment (hereinafter the Ministry). The SNSA's responsibilities and competencies are defined in the Governmental Decree on Administrative Authorities within Ministries.

The SNSA performs specialised technical and developmental administrative tasks and tasks of inspection in the area of radiation and nuclear safety, radiation practices and use of radiation sources (except in health and veterinary care), protection of the environment against ionising radiation, physical protection of nuclear materials and nuclear facilities, non-proliferation of nuclear weapons and safeguards of nuclear goods; the SNSA furthermore monitors radioactivity in the environment, third party liability, and transport, import and export of radioactive materials.

The SNSA is organised into five divisions and one office. These are:

- Division of Nuclear Safety,
- Division of Radiation Safety and Materials,
- Division of Emergency Preparedness,
- Division of Inspection,
- Division of International Co-operation,
- Office of General Affairs,
- QA Manager.

The staff of the SNSA is interdisciplinary, consisting of employees with different educational backgrounds: physicists, mechanical, electrical and chemical engineers, mining and geotechnologist, architect, metallurgist, geologists, lawyers, linguist, and administrative workers.

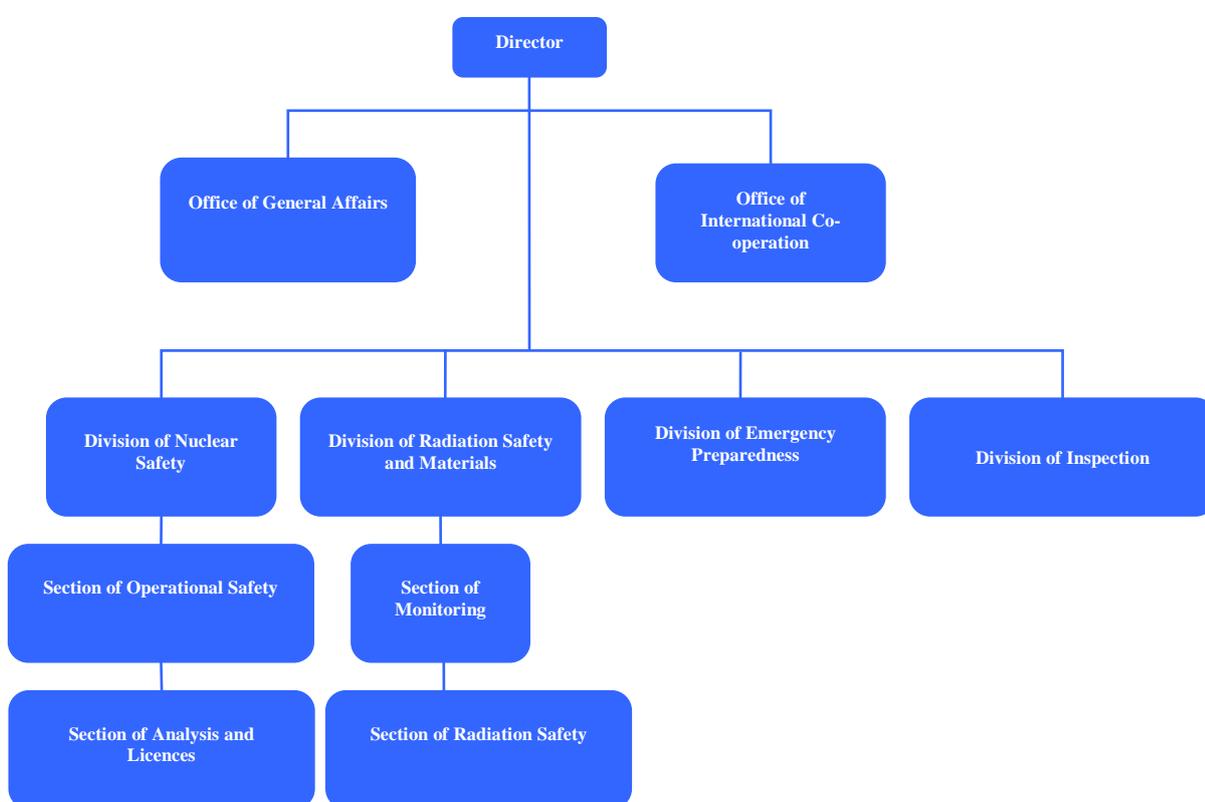
The Director of the SNSA is the head of the regulatory authority and represents the SNSA. On the Governmental and Parliamentary level, the SNSA is represented by the Minister of Agriculture and the

Environment. The Director is responsible to the Minister for his work and for the work carried out by the SNSA. The organisation of the SNSA is prepared by the Director and approved by the Government on the motion of the Minister.

Regulatory matters related to spent fuel and radioactive waste management are dealt with by the Division of Radiation Safety and Materials.

The budget of the SNSA is determined on the basis of the realisation of the previous year, taking into account new needs, which have to be well justified. The budget is the only source for financing the SNSA's basic activities. There are also very limited extra-budgetary sources, i.e. within the licensing process for some direct costs.

Figure 1: SNSA's internal organisational units



### 1.2.2 Other Regulatory Bodies

The 2002 Act gives the competence in the area of radiation practices and use of radioactive sources in health and veterinary care to the Slovenian Radiation Protection Administration (SRPA) within the Ministry of Health. In general the competences between the SNSA and the SRPA are divided in the area of radiation protection, while the area of nuclear safety is the SNSA's sole competence. The SNSA is responsible for the monitoring of emissions into the environment, while the SRPA is responsible for the monitoring of exposure to population. Based on the 2002 Act the SNSA is competent for consents to mining work, licensing for operation, the completion of decommissioning and the closure of a repository, while the SRPA performs inspection tasks in the area of radiation protection (dose limits, protection of exposed workers, etc.).

The SRPA responsibilities and competencies are (as for all other governmental bodies) defined also in the Decree on Administrative Authorities within Ministries. The SRPA performs technical, administrative, inspection and development tasks in the area of radiation practices and use of radiation sources in health and veterinary care; health protection of people against detrimental effect of ionising radiation; systematic inspection of working and living premises due to exposure of people to the natural radiation sources; implementation of monitoring of radioactive contamination of foodstuffs and drinking water; reduction, restriction and prevention of health detrimental effects of non-ionising radiation and assessment of compliance and authorisation of radiation protection experts."

Besides the SNSA and the SRPA, some other administrations, ministries and organisations are also entrusted with the implementation of the 2002 Act, in particular:

- The Administration for Civil Protection and Disaster Relief (within the Ministry of Defence), as the operator of the National Notification Centre, is responsible for notification procedures in the event of radiological emergency,
- The Ministry of the Interior, inter-alia, has competencies in the area of physical protection of nuclear materials and nuclear facilities in general, while the SNSA only approves the Safety Analysis Report, to which the plan of physical protection is attached as a separate and restricted document,
- The Environmental Agency within the Ministry of the Environment and Spatial Planning,
- The Spatial Planning Directorate within the Ministry of the Environment and Spatial Planning,
- The Directorate for Energy (within the Ministry of the Economy).

Based on the 2002 Act, the Expert Council for Radiation and Nuclear Safety was appointed as an advisory body to the Ministry of the Environment and Spatial Planning and the SNSA, as well as the Expert Council for the Protection of People against Ionising Radiation, for radiological procedures and use of radiological sources in health and veterinary care, as an advisory body to the Ministry of Health and the SRPA.

### 1.3 National implementing organisations

The major implementing organisations in the field of radioactive waste management and decommissioning are Krško NPP, Jozef Stefan Institute, Agency for Radioactive Waste and Žirovski vrh Mine d.o.o. Their main responsibilities are described below.

**The Krško Nuclear Power Plant** (Krško NPP) is one of the main pillars of the Slovenian power system. It is a Westinghouse two-loop Pressurised Light Water Reactor with nominal output power 727/696 MW<sub>e</sub> (gross electrical power/net electrical power). It is designed to operate until the end of 2023. The designed life extension is being considered. On 20 June 2012 Slovenian Nuclear Safety Administration issued a decision approving the modifications, which will enable long-term operation of the Krško nuclear power plant (NPP). By this, the extensive and long process, initiated after the first Periodic Safety Review of the nuclear power in 2003, is completed. At that time, the Krško NPP began with the preparation and introduction of a aging monitoring programme, which is a precondition for the extension of operation beyond the originally projected 40 years of life.

The Krško NPP is the major producer of radioactive waste in the Republic of Slovenia. As part of the technological process of electricity production, all operational radioactive waste and spent nuclear fuel are stored within the plant area. Solid radioactive waste is treated and then packed into steel drums, which are then stored in the solid radwaste storage facility. Spent nuclear fuel is stored under water in the spent fuel pool.

**The Jožef Stefan Institute Reactor Infrastructure Centre** (IJS Reactor Infrastructure Centre) is a part of the Jožef Stefan Institute (IJS). The main purpose of the centre is operation of the TRIGA Mark II research reactor for the needs of IJS and other research groups. The TRIGA Mark II research reactor is a General Atomic open-pool type research reactor with the thermal power of 250 kW. It was initially licensed in 1966 and was re-licensed for steady state and pulse operation after renovation and reconstruction in 1991. The facility is used in research projects, and to a limited extent for the production of isotopes for medicine and industry as well as for education. Fuel elements are kept in the reactor building of the IJS Reactor Infrastructure Centre. In addition to spent fuel, the reactor produces a minor amount of low and intermediate level waste (LILW).

**The Agency for Radwaste Management (ARAO)** is a non-profit organisation of the Slovenian Government which provides a state-owned public service for radioactive waste management.

Its mandate under the 2002 Act encompasses three missions:

- Commissioning, collecting, transporting, preconditioning, interim storage and disposal of radioactive waste and spent fuel, not originating from energy producing nuclear facilities,
- Preconditioning, interim storage and disposal of radioactive waste and spent fuel originating from energy producing nuclear facilities and long-term monitoring and maintenance of repositories for radioactive waste and spent fuel,
- Long-term maintenance and supervision of the repositories of hydrometallurgical tailings and mine waste tailings originating from production of nuclear minerals raw materials.

Another part of its mandate is to participate in the elaboration of a national programme of radioactive waste and spent fuel management.

**The Žirovski vrh Uranium Mine** was in operation in the period from 1984 to 1990. Its lifetime production was 610,000 tons of ore, from which 452.5 tons of  $U_3O_8$  was produced. The Žirovski vrh Uranium Mine terminated its regular operation in 1990. All entrances to the underground mine are closed. The uranium mill is decommissioned and the resulting wastes are disposed off on the mining waste disposal site Jazbec. To this site all mining waste from numerous other mining waste piles has been moved and disposed of. The total amount of disposed material on this site is 1,910,425 tons with a total activity of 21.7 TBq. The remediation work on Jazbec disposal site is finished. On the uranium mill tailings disposal site Boršt, 610,000 tons of hydrometallurgical waste, 111,000 tons of mine waste and 9,450 tons of the material collected during decontamination of the mill tailings site Boršt vicinity have been disposed of with a total activity of 48.8 TBq. The remediation work on Boršt disposal is delayed due to activation of a landslide. After final administrative closure of the sites the long term surveillance and maintenance will be, according to the law, entrusted to the ARAO.

## **2. LEGAL FRAMEWORK**

### **2.1 Primary Legislation and General Regulations**

The main Act of the Republic of Slovenia in this area is the Ionising Radiation Protection and Nuclear Safety Act of 2002 (as amended in the years 2003, 2004 and 2011). Based on this Act, 6 Governmental decrees and 21 rules prescribed by pertinent Ministers were issued. Almost all of them are relevant also to radioactive waste management.

By the Act of 2002, the authorities and responsibilities are assigned to the Ministries responsible for environment, health, agriculture and the interior. The majority of administrative functions are assigned to

the Slovenian Nuclear Safety Administration and to the Slovenian Radiation Protection Administration. The latter mainly deals with the use of radioactive sources in medicine and occupational radiation exposure. The Ministry of the Interior has major responsibilities in the area of physical protection of nuclear material.

General provisions and responsibilities of the holder of the radioactive waste and spent fuel (as well as of the State) are defined in Section 4.8. - "Radioactive waste and spent fuel management" of the 2002 Act. The 2002 Act (Articles 93 to 99) contains the following provisions:

- on radioactive waste and spent fuel management,
- on the national public utility service for radioactive waste management,
- on the national public utility service for the disposal of waste from energy producing nuclear facilities,
- on repositories of mining and hydro-metallurgical tailings,
- on national public utility institutions,
- on the national programme of radioactive waste and spent fuel management,
- on national infrastructure facilities.

On 1 February 2006 the Parliament of the Republic of Slovenia passed the Resolution on the 2006-2015 National Programme for Managing Radioactive Waste and Spent Nuclear Fuel (Official Gazette RS, No. 15/2006). The Programme for Managing Radioactive Waste and Spent Fuel is a part of the National Environment Protection Programme and sets goals and tasks in the field of radioactive waste and spent nuclear fuel management.

Besides the above mentioned legislation and authorities, the provisions of other national legislation should be fulfilled in the particular areas of environment and health protection. The laws on environment protection and civil protection, together with relevant authorities, play an important role in the process of siting, construction and decommissioning of facilities.

## **2.2 General Regulations**

Within the legislative and regulatory framework which covers spent fuel and radioactive waste management, the following decrees and acts should be mentioned:

- Rules on Radioactive Waste and Spent Fuel Management,
- Rules on Radiation and Nuclear Safety Factors,
- Rules on Operational Safety of Radiation and Nuclear Facilities,
- Decree on Establishment of a Public Agency for Radwaste Management,
- Decree on the Method and Subject of and Conditions for Performing a Public Utility Service of Radioactive Waste Management,

The Rules on Radioactive Waste and Spent Fuel Management contains the following provisions:

- on classification of radioactive waste with regard to the aggregation state, the level and type of radioactivity,
- on requirements for radioactive waste and spent fuel management (general requirements – radioactive waste or spent fuel management procedures, programmes, plans; special requirements – sorting, treatment and packing, labelling, keeping, storing, decay-keeping, handover and takeover, reshuffling, liquid and gaseous radioactive waste releasing, disposal,

acceptance criteria for storage or disposal, waste from exploitation and reprocessing of raw nuclear mineral material, very low-level radioactive waste management),

- on recording and reporting (holder's records, central records, reporting, loss and findings).

For detailed list and contents of general and specific legislation and documents you can see [http://www.ursjv.gov.si/en/legislation\\_and\\_documents/](http://www.ursjv.gov.si/en/legislation_and_documents/)

## **2.3 Specific Legal Framework**

There are some specific regulations issued for individual facilities and the most important are listed below:

- 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 the Investment, Exploitation and Decommissioning of the Krško NPP
- Act Governing the Fund for Financing Decommissioning of the Krško Nuclear Power Plant and Disposal of Radioactive Waste from the Krško NPP,
- Act on Permanent Cessation of Exploitation of the Uranium Ore and Prevention of Consequences of Mining in the Uranium Mine at Žirovski vrh.

## **2.4 Regulatory Documents**

### **2.4.1 Radioactive Waste Management**

There were specific guidelines PS1.03 prepared and published in 2012 by the SNSA on the content of the safety analysis report for the low and intermediate level waste repository.

### **2.4.2 Decommissioning**

No specific guidelines are issued for decommissioning.

## **2.5 Licensing Procedure**

A system of licensing of spent fuel and radioactive waste management is provided in the 2002 Act, while the Rules on Radiation and Nuclear Safety Factors lay down details on the documentation which must be submitted in a particular phase of licensing. The prescribed licensing process is of general nature, thus it is applicable to whole spectra of nuclear and radiation facilities.

The basic classification of facilities is provided by the Act itself, where in definition No. 22 of Article 3 it provides that a nuclear facility is "a facility for the processing or enrichment of nuclear materials or the production of nuclear fuels, a nuclear reactor in critical or sub-critical assembly, a research reactor, a nuclear power plant and heating plant, a facility for storing, processing and disposal of nuclear fuel or high radioactive waste, a facility for storing, processing or disposal of low and intermediate radioactive waste". Therefore the entire spectrum of licensing requirements (for sitting, construction, trial operation, operation, decommissioning, and/or closure of the repository) has to be taken by the applicant (investor or operator of the facility) in accordance with provisions of the 2002 Act and of the Rules on Radiation and Nuclear Safety Factors.

An investor planning to construct a radiation or nuclear facility shall compile and submit in application for the facility among other the following principal documents demonstrating nuclear and radiation safety:

- A special safety analysis in the procedure of approval of the national spatial plan,
- The environment impact assessment in the procedure of approval of the use of land,
- A safety analysis report in the procedure of approval of construction.

General requirements for the design basis for a radioactive waste or spent-fuel storage facility and for a radioactive waste or spent-fuel repository are laid down in the Rules on Radiation and Nuclear Safety Factors.

In the licensing processes the investor/operator shall attach to the license application, in addition to the design documentation, a Safety Analysis Report, and the opinion of an authorised radiation and nuclear safety expert (authorised by the SNSA) and other prescribed documentation set by the Rules on Radiation and Nuclear Safety Factors.

In the subsequent licensing processes (for approval of trial operation, operation, decommissioning or closure of the facility) the licensee has to submit the above described application containing an appropriately amended set of documents and opinions. The operating experience and feedback, and modifications of the facility have to be clearly documented and described.

Consequently, all relevant licenses are needed, including the operating license. Operation of spent fuel and radioactive waste management facilities without a license is prohibited according to Article 57 of the 2002 Act.

## **2.6 Information and Participation of the Public**

All activities are made transparent to the public through annual reports, the Internet and other outreach activities. Special attention is devoted to communication and participation in decision making with the public in local municipalities with nuclear facilities and in the area where the LILW repository site is selected and to non-governmental organisations.

## **3. WASTE MANAGEMENT STRATEGY AND CURRENT PRACTICE**

### **3.1 Waste classification and quantities**

The regulation on radioactive waste management and classification of radioactive wastes consider, with some modifications, the radioactive waste categorisation as recommended in the "EC Recommendation on a Classification System for Solid Radioactive Waste" (OJ L 265, 13.10.1999, p. 37).

Provisions of this regulation apply to substances in gaseous, liquid or solid form, objects or equipment containing radioactive substances or being so contaminated that they exceed clearance levels, if generated as waste from radiation practices or from intervention measures, or if their holder intends or has to discard them since their further use is not foreseen, or if the holder does not have a license for their use in accordance with the regulations on protection against ionising radiation.

With regard to their **aggregation state**, radioactive waste is divided into **solid, liquid and gaseous waste**.

With regard to the **level and type of radioactivity**, the **solid radioactive wastes** are categorised as follows:

1. transitional radioactive waste;
2. very low level radioactive waste, for which the competent regulatory body for nuclear and radiation safety may approve conditional clearance;
3. low and intermediate level radioactive waste (LILW), with insignificant heat generation, which is classified into two groups:
  - 3.1. short-lived LILW, containing radionuclide's with a half-life shorter than 30 years and specific activity of alpha emitters equal to or lower than 4,000 Bq/g for an individual package, but on average not higher than 400 Bq/g in the overall amount of LILW;
  - 3.2. long-lived LILW, where specific activity of alpha emitters exceeds the limitations for short-lived LILW;
4. high level radioactive waste, which contains radionuclides whose decay generates such an amount of heat that it has to be considered in its management;
5. radioactive waste containing naturally occurring radionuclides that are produced in processing of nuclear mineral materials or other industrial processes and are not sealed sources of radiation in accordance with the regulations on the use of radioactive sources and radiation practices.

The Decree on Activities Involving Radiation defines the conditional and unconditional clearance of radioactive material as follows: "The competent ministry may approve the clearance of radioactive substances or radiation sources, provided that there is no possibility that after such clearance the radioactive substance or radiation source causes a collective dose higher than 1 manSv per year, nor that the effective dose received by any member of the public exceeds 10 µSv per year".

The regulatory control over radioactive substances can be terminated without a prior decision of the competent ministry if the specific activity of radionuclides in substances does not exceed the values set in the Decree on Activities Involving Radiation.

## **Inventory of Radioactive waste**

### **Central Storage for Radioactive Waste in Brinje**

At the end of 2012, there were 742 packages stored in the Central Storage for Radioactive Waste (CSRW), namely:

- 418 packages of radioactive waste (solid waste, sorted according to the compressibility, burn, shape and size),
- 152 packages containing sealed radiation sources,
- 166 packages with ionization smoke detectors,
- 6 packages of mixed waste from medicine.

The volume of stored waste was 89.1 m<sup>3</sup> with the total estimated activity of at 3.1 TBq and a total weight of 49.1 tons.

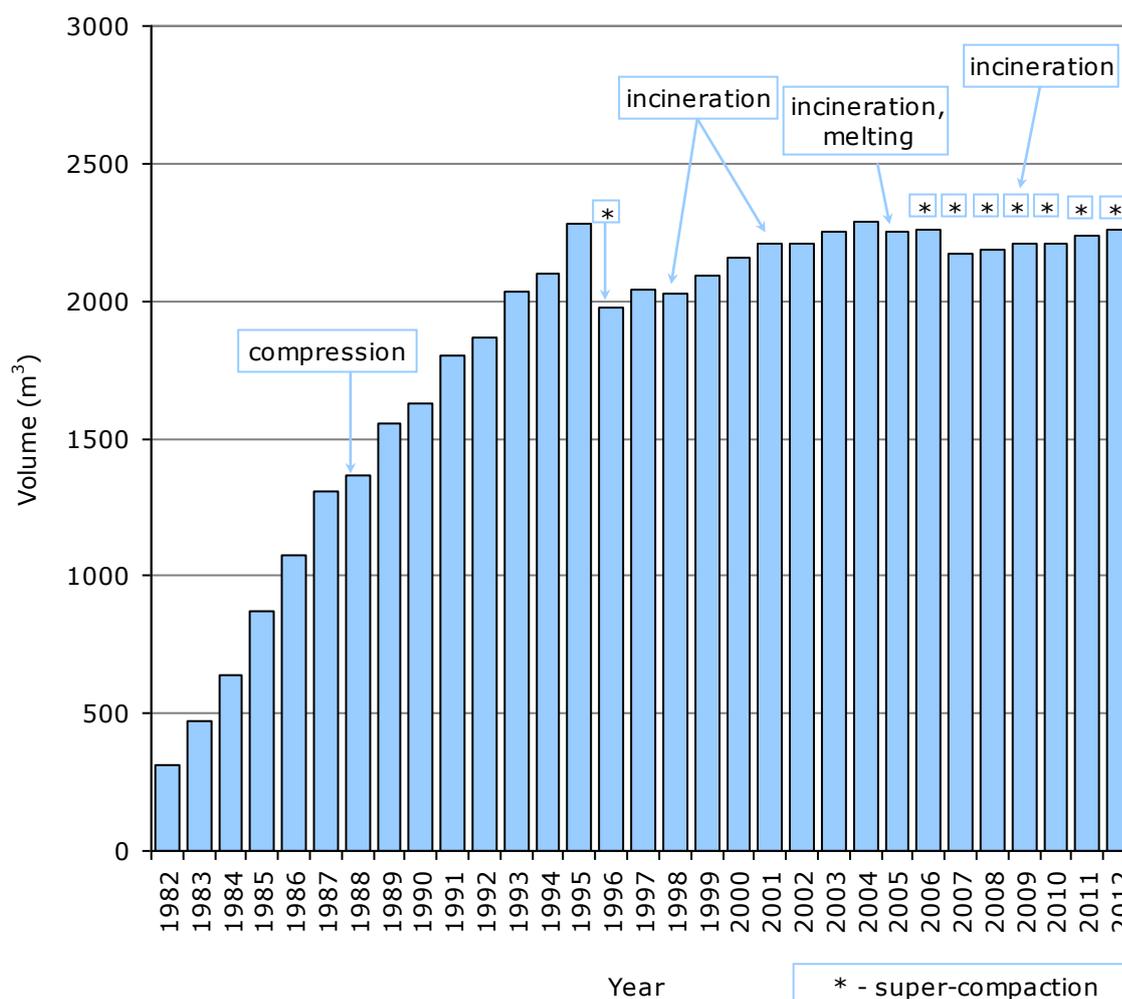
## **Krško NPP**

In recent years, the volume of low- and intermediate-level radioactive waste (LILW) has been reduced by compression, super-compaction, drying, incineration, and melting. The total volume of waste accumulated by the end of 2012 amounted to 2,262 m<sup>3</sup>. The total gamma and alpha activity of the stored waste were 2.04·10<sup>13</sup> Bq and 2.64·10<sup>10</sup> Bq respectively. In 2012, the equivalent of 118 standard drums

containing solid waste was stored. The total gamma and alpha activity of stored drums was  $8.74 \cdot 10^{11}$  Bq and  $3.39 \cdot 10^8$  Bq respectively.

Figure 4 shows the accumulation of low- and intermediate-level radioactive waste in the Krško NPP storage. Periodical volume reductions, which are a consequence of compression, super-compaction, incineration and melting, are marked. After 1995, the accumulation of waste volume has reduced as a result of a new in-drum drying system (IDDS) for evaporator concentrate and spent ion exchange resins.

In 2006, the super-compactor was installed in the storage facility at the Krško NPP, which thus started with the continuous super-compaction of its radioactive waste. Super-compacted radioactive waste has been stored in the tubular container TTC.



**Figure 2:** Accumulation of low- and intermediate-level radioactive waste at the storage in the Krško NPP

### The Jazbec mine waste pile and the Boršt mill tailings site

Mine waste and other debris at the Jazbec and Boršt sites with basic data are summarised in next tables.

Mine waste and other debris at the Jazbec mine waste pile.

<b>Deposited</b>	mine waste and red mud 1982-1990 (mine ore production), contaminated material, technological equipment 1991-2007 (decontamination, demolition)
<b>Final arrangement</b>	2008
<b>Surface, total</b>	67,325 m <sup>2</sup> (the area of the mine waste pile inside the drainage channels) 74,239 m <sup>2</sup> (the area inside safety fence of the mine waste pile)
<b>Altitude</b>	bottom 427 m, top 509 m (above sea level)
<b>Volume of disposed waste</b>	854,500 m <sup>3</sup> of mine waste, 126,000 m <sup>3</sup> of low grade uranium ore, 34,000 m <sup>3</sup> of red mud, 2,600 m <sup>3</sup> of filter cake from mine water treatment station, 181,000 m <sup>3</sup> of contaminated soil and rubble from uranium ore processing facilities and crash station demolition, 800 m <sup>3</sup> of technological equipment from uranium ore processing facilities and crash station, <b>total volume of disposed material is 1,198,900 m<sup>3</sup></b>
<b>Amount of disposed waste</b>	1,366,589 t of mine waste, 200,684 t of low grade uranium ore, 48,000 t of red mud, 4,220 t of filter cake from mine water treatment station, 289,723 t of contaminated soil and rubble from uranium ore processing facilities and crash station demolition, 1,209 t of technological equipment from uranium ore processing facilities and crash station, <b>total amount of disposed material is 1,910,425 t</b>
<b>Average specific activity of disposed material</b>	7.7 kBq/kg mine waste (53 g U <sub>3</sub> O <sub>8</sub> /t), 65 kBq/kg red mud ( <sup>230</sup> Th 97%), 34.4 kBq/kg filter cake (236 g U <sub>3</sub> O <sub>8</sub> /t), 29.2 kBq/kg low grade uranium ore (200 g U <sub>3</sub> O <sub>8</sub> /t), < 2 kBq/kg contaminated soil and rubble
<b>Total activity of disposed material</b>	<b>21.7 TBq</b>
<b>Dose rate, average</b>	0,12 µGy/h (covered with final layer)

**Note:** most of the <sup>230</sup>Th was not contained in the mill tailings, but remained in the so-called red mud as a neutralisation by-product.

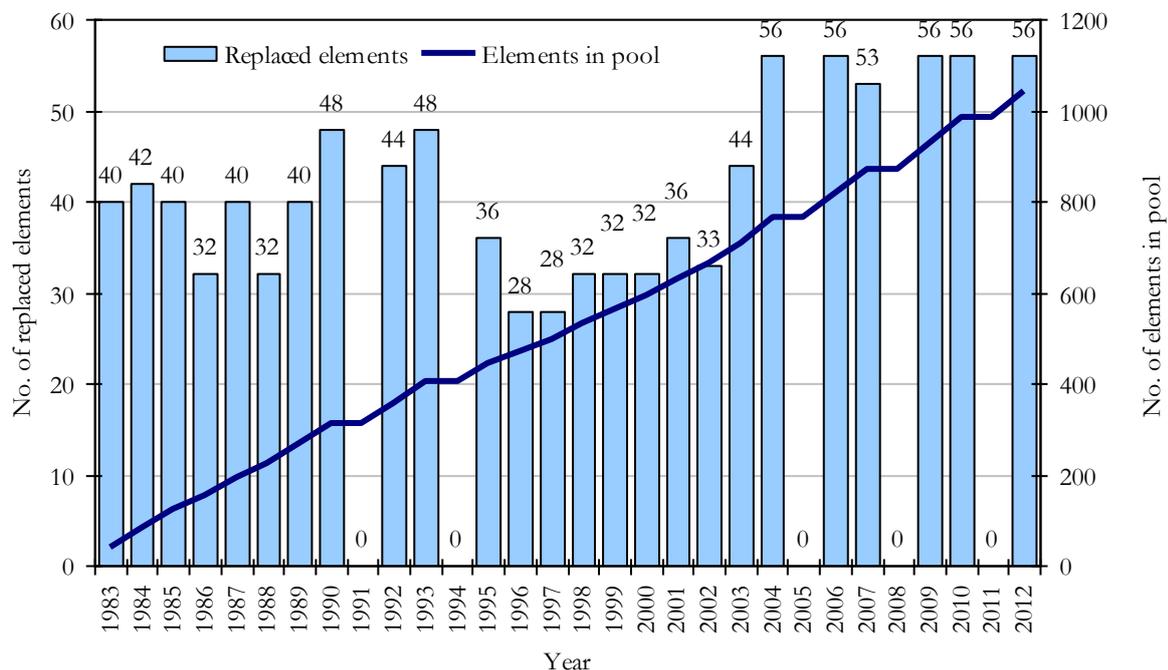
Boršt mill tailings site with basic data.

<b>Deposited</b>	mill tailings 1984-1990 and mine waste 1984-2004, contaminated material 2008-2009
<b>Final arrangement</b>	2010 arrangement of the mill tailings, till 2013 remediation of the mill tailings base rock sliding
<b>Surface, total</b>	42,000 m <sup>2</sup> (mill tailings surface), 67,923 m <sup>2</sup> (surface inside the safety fence of the mill tailings)
<b>Altitude</b>	bottom 535 m, top 565 m (above sea level)
<b>Volume of disposed waste</b>	339,000 m <sup>3</sup> of mill tailings, 70,000 m <sup>3</sup> of mine waste, 6,543 m <sup>3</sup> contaminated materials <b>total volume of disposed material is 415,543 m<sup>3</sup></b>
<b>Amount of disposed waste</b>	610,000 t of mill tailings, 111,000 t of mine waste, 9,450 t contaminated materials, <b>total amount of disposed material is 730,450 t</b>
<b>Average specific activity of disposed material</b>	78.2 kBq/kg mill tailings, 10.2 kBq/kg mine waste
<b>Total activity of disposed material</b>	<b>48.8 TBq</b>
<b>Dose rate, average</b>	0.14 µGy/h (covered with final layer)

**Note:** Specific activity of contaminated materials has not been measured, however it was low.

### Inventory of Spent Fuel in Krško NPP

All spent fuel in the Krško NPP is stored in the spent fuel pool with 1,694 cells. In the spring of 2012, a regular outage was held (the shipment of fresh fuel arrived in the NPP at the end of 2011). At the end of 2012, 1,041 fuel assemblies were stored in the pool for spent fuel taking into account also the container with fuel rods ("reconstitution"). The number of annually spent fuel assemblies and the total number of such elements in the pool are shown in Figure 3.



**Figure 3:** The number of annually spent fuel assemblies and the total number of such elements in the NPP pool

### 3.2 Waste Management Strategy

#### 3.2.1 Nuclear Fuel Waste

In 1996, the Slovenian Government adopted the Strategy for Long-Term Spent Fuel Management, which was later superseded by the **Resolution on the 2006-2015 National Programme for Managing Radioactive Waste and Spent Nuclear Fuel**, adopted by the Slovenian Parliament in February 2006. The National Programme duly implements the relevant provisions of the Agreement with Croatia.

According to the Agreement the contracting parties shall, in equal shares, assure funds for the preparation of the decommissioning programme and its execution, and funds for the preparation of the programme for disposal of radioactive waste and spent fuel. If the contracting parties agree on a joint solution for the disposal of radioactive waste and spent fuel they shall finance it in equal shares or they shall be responsible for their shares of waste and they shall finance the related activities.

On the basis of the Agreement, the Republic of Slovenia and the Republic of Croatia jointly prepared and approved a **Programme for Decommissioning of the Krško NPP and Disposal of LILW and High Level Waste** (hereinafter the Decommissioning Programme) in 2004. In accordance with requirements from the Agreement that a new revision of the document should be adopted every 5 years, in 2008 the preparation of revision 2 of the Decommissioning Programme started. The document is still under discussion and pending for approval by intergovernmental commission. For the decommissioning and disposal several options were evaluated.

According to the Decommissioning Programme for all domestic scenarios the disposal in deep geological formations is considered to be the only technically feasible and safe long-term solution for spent fuel and high level waste. In preparing the evaluation, the Swedish concept was used as a guideline.

The basic characteristics of the concept are:

- direct disposal of spent fuel in appropriate canisters, capacity for 1600 fuel elements or 620 metric tons of metallic uranium with a small additional volume of high level waste (~16 m<sup>3</sup>),
- the following phases were studied and evaluated: research and development including site selection and characterisation, design and construction, operation and closure.

As an alternative to the disposal in deep geological formation either in Slovenia or in Croatia, also an option of export and disposal of spent nuclear fuel in a third country was considered.

The Decommissioning Programme in its long-term strategy for spent fuel management foresees spent fuel storage in dry casks. Spent fuel will be moved from pool to dry storage between 2024 and 2030 and will be stored in casks until 2065, when a deep geological repository is assured. The operational phase of the spent fuel repository will end in 2070 and the repository should be closed in 2075. In the case of export option, the removal of spent fuel from dry storage is planned between 2066 and 2070. As a consequence of the Fukushima accident the stress tests were performed and an action plan how to improve the safety of operation of NPP Krško. According to action plan, among others, the dry storage of spent fuel on the site will be implemented already by 2018.

### **Spent Fuel Management Practices**

The Republic of Slovenia has no facilities for off-site management of spent fuel. The spent fuel that is generated by the Krško NPP and the IJS Reactor Infrastructure Centre (TRIGA Mark II research reactor) is managed in wet storage facilities that are an integrated part of these nuclear facilities.

#### **Krško NPP**

All the spent fuel is stored in the spent fuel pool. To minimise the amount of spent fuel and reduce fuel costs, the Krško NPP is extending the burnup of fuel elements. The average spent fuel burnup in the spent fuel pool is 38.9 GWD/MTU while the last three spent fuel regions had an average burnup of 49.7 GWD/MTU. The Low Leakage Loading Pattern was introduced in the design several years ago. With this type of design additional reduction of spent fuel production was achieved.

Spent fuel pool is inside the Fuel Handling Building of the Krško NPP. In 2003, a project of increasing the storing capacity of the spent fuel pool (reracking) was completed. After the reracking, 1694 storage locations are available for spent fuel. The storage capacity is sufficient for the planned lifetime operation until the year 2023. In 2012 1,041 locations were occupied with nuclear fuel, out of which 849 are spent fuel elements.

After reracking, the spent fuel racks are of two types. The old racks are designed without neutron poison control. These racks provide 621 cells (6 times 72, plus 3 times 63 cells), and constitute storage capacity for spent fuel plus one full core for emergency unload. The new racks are designed with neutron poison control and comprise nine modules providing 1073 usable cells.

The spent fuel racks are designed to withstand shipping, handling, normal operating loads (impact and dead loads of fuel assemblies) as well as Safe Shut-down Earthquake and Operating Base Earthquake seismic loads meeting Seismic Category I and American Institute of Steel Construction requirements.

## **Spent fuel from Research Reactor**

The two spent fuel pools are part of the TRIGA Mark II research reactor. The first spent fuel pool was constructed with the reactor in 1966 and is no longer in use. The second one was constructed in 1992. Its capacity is 195 spent fuel elements. It is located in the basement of the reactor building. It is accessible by the crane through the lid in the reactor hall floor. The pool is 3.5 m deep and is plated with stainless steel sheets. It is equipped with an on-line water radioactivity monitor.

Both pools have been empty since 1999, when all spent fuel elements (total 219) were shipped to the USA. The new pool is maintained operational and prepared for immediate use if necessary.

In 2007, 10 fresh fuel elements were transferred to the French company AREVA and shipped to France. The total number of the remaining fuel elements (irradiated and fresh) at the reactor is 84.

A detailed criticality analysis of the spent fuel racks design was performed. Heat removal is not applicable for the TRIGA Mark II research reactor fuel. A safety analysis of accidents with spent fuel during normal operation and fuel handling was performed and is included in the Safety Analysis Report.

Slovenia has an offer for shipping spent nuclear fuel from research reactor to the USA until May 2019. In this case reactor must stop operating until 2016. If the operator decides to extend the operational time beyond 2016, it shall propose the solution for HLW and SNF management shall prepare the decommissioning programme.

### ***3.2.2 Low and Intermediate-Level Radioactive Waste***

**The Resolution on the 2006-2015 National Programme for Managing Radioactive Waste and Spent Nuclear Fuel** (the Programme), which was adopted by the Slovenian Parliament in March 2006, is one of the key documents in the field of radioactive waste management and is prepared in accordance with the 2002 Act.

In the Programme, LILW management is treated as an integral process, covering all stages from waste generation to waste disposal. Different current and near-future radioactive waste streams and waste arising are taken into account, considering the present and the planned waste management practices. Besides radioactive waste from the Krško NPP also other small producers (medicine, industry, research) and other activities with radioactive waste (uranium mine under decommissioning, TENORM, decommissioning of reactors, etc.) are described. The Programme includes the analysis of measures for minimisation of radioactive waste production, its treatment and its conditioning before disposal. The siting and the construction of a repository for short-lived LILW is one of the principal goals of LILW management in Slovenia. The limited storage capacities at nuclear facilities call for decisions and practical solutions.

A significant step forward in solving this problem was made by selection and approval of the site for LILW disposal in 2009. The Vrbina site in the municipality of Krško has been approved by the Government decree on the national spatial plan.

The responsibility in the area of LILW management is clearly defined. Three independent parties, the producers of radioactive waste, the SNSA as the regulatory body and the ARAO as a state-owned public service for radioactive waste management, are involved in the process of radioactive waste management. The operators of nuclear and radiation facilities are responsible for radioactive waste management at their facilities. The ARAO has the responsibility of collecting, transporting, treating, storing and disposing of LILW coming from small producers in the Republic of Slovenia. The ARAO also has the responsibility of

disposal of all radioactive waste coming from the operators of nuclear and radiation facilities when applicable.

The Programme also includes the works for remediation of consequences of mining at the Žirovski Vrh uranium mine. Remediation of the Žirovski Vrh uranium mine has been finished. There are two permanent waste disposal sites: the Jazbec mine waste pile and the Boršt mill tailings site. All temporary mine waste disposal piles in the area were relocated to the Jazbec mine waste pile.

The general goal of the site rehabilitation project was to minimise, to the lowest reasonable level, radiological and chemical long-term impacts on the environment. The major objective was decontamination of the sites, buildings, structures and equipment, so that the facilities and the land can be reused or opened for the public.

Most of the land was returned to unlimited use, with limitations foreseen only for waste piles of mine and hydrometallurgical tailings.

### Radioactive Waste Management Practices

#### **The Central Storage for Radioactive Waste for small producers**

After receipt from small producers, the radioactive waste is stored in the centralised storing facility for radioactive waste, located in Brinje near Ljubljana. The facility is operated by the ARAO. In the past, the government financed the storage of waste. However, in 2000 the "polluter pays" principle was also introduced into the segment of small producers of waste. The producers now pay the costs of waste management, including the cost of storing, treatment and conditioning, as well as future disposal of waste. With the transfer of waste all liabilities for further waste management are on the ARAO.

In order to comply with regulatory requirements, major refurbishment of the storage was finished in 2004. The Safety Analysis Report was updated and the license for two-year trial operation was issued in 2005. Until mid 2007 all deficiencies that occurred during the trial operation were corrected and some additional improvements were made. The Safety Analysis Report was updated again. At the end of this process in early 2008 the ARAO obtained from the SNSA the operating license for the Central Storage for Radioactive Waste which is valid for 10 years.

#### **The Žirovski vrh Uranium Mine**

There are two permanent waste disposal sites: the Jazbec mine waste pile and the Boršt mill tailings site. All temporary mine waste disposal piles in the area were relocated to the Jazbec mine waste pile. The general goal of the site rehabilitation project was to minimise, to the lowest reasonable level, radiological and chemical long-term impacts on the environment. The major objective was decontamination of the sites, buildings, structures and equipment, so that the facilities and the land can be reused or opened for the public.

In the course of remediation of the mine, part of the galleries have been backfilled with mine waste. All entrances into the mine have been sealed. Institutional water and air monitoring is assured.

The ore processing area and buildings have been decontaminated or demolished. After rehabilitation, the ore processing area is in free public use. Contaminated waste materials (scrap metal, plastics, building debris) were disposed of either into the mine or onto the Jazbec mine waste pile. No regular monitoring is needed at the mill site.

At the Jazbec mine waste pile there are 1,862,425 tons of mine waste, uranium ore, contaminated soil and building debris with average concentration 69 g U<sub>3</sub>O<sub>8</sub>/t and 48,000 tons of red mud from raffinate neutralisation, with the specific activity 65 kBq <sup>230</sup>Th/kg. The area of Jazbec is 67,325 m<sup>2</sup>. Remedial actions were finished in the year 2008. Institutional monitoring on seepage water, ground water level, air, object surface and stability control will be needed in the future.

The Boršt mill tailings site is situated on a hillside, 535-565 m above the sea level. During the short operational life of the tailing approximately 610,000 tons of mill tailings and 73,000 tons of mine waste were deposited there. In 2004, additional 38,000 tons of mine waste was transported to Boršt. During the years 2008 and 2009 9,450 tons of contaminated materials from decontamination of auxiliary objects were deposited on Boršt. The total mass of deposited materials is 730,450 tons. The area of Boršt is 42,000 m<sup>2</sup>. The mill tailing materials are sands and slimes under 28 mesh (0.5 mm). Average activity of <sup>226</sup>Ra is 8,600 Bq/kg.

The accomplishment of remediation is complicated due to reactivation of landslide of the base of the tailing. The current rate of movement is approximately 10 cm per year. The expert group concluded that probability of collapse of the slope is negligible, and proposed investigation of the landslide by drill holes. Life and health of local population is not endangered. The decision on final closure of disposal site is postponed.

## **Krško NPP**

The Krško NPP has its own Radioactive Waste Management Programme, supplemented by a technical report. The Programme is revised and updated at least every two years. The Krško NPP considers this document a valuable source of input for future decision making and long-term planning in the area of operational radioactive waste management. The waste generation rates based on the present situation and future options are predicted. The available storage capacity for radioactive waste at the Krško NPP is assessed by extrapolation. In addition, a Radioactive Waste Committee was formed at the Krško NPP as an interdisciplinary team through which communication and transparency in the area of radioactive waste management have been enhanced.

### Radioactive waste volume reduction programme

Numerous programme improvements, design changes and work practice improvements have been pursued at the Krško NPP to decrease the generation rate of radioactive waste of different types. With the introduction of the 18-month fuel cycle, the generation of radioactive waste was additionally reduced.

Segregation techniques are used for collecting non-contaminated materials separately, which allows waste streams to be processed separately. Metal materials, exceeding exemption/clearance levels, are stored onsite awaiting melting. To reduce the volume of solid radioactive waste to be stored, supercompaction campaigns have been carried out.

The original Westinghouse procedure for evaporator bottoms and spent resin treatment was replaced with a treatment of these types of waste called the In-drum Drying System. The drying process converts the accumulated wet spent resins into a dry free-flowing bead resin condition. The dried primary resins are filled directly into 200 l stainless steel heavy drums with biological shields (150 l of usable volume). Dried

secondary spent resins are filled into 200 l stainless steel drums without biological shields. The drying and volume reduction process for evaporator bottoms converts the concentrate into dry solid waste products with low residual moisture and no free water. The Krško NPP has started using an external service for the incineration of combustible waste and melting of metal radioactive waste material.

The hazards associated with radioactive waste management are kept reasonably low. Different types of waste are segregated in an early collecting phase and stored separately to avoid chemical interactions. Tube-type containers are used as an overpack for the storage of standard 200 l drums and products for supercompaction in the plant radioactive waste storage facility. Any new type of radioactive waste resulting from a new technology applied is evaluated and incorporated into the Safety Analysis Report.

### **Small Producers of Radioactive Waste in the Republic of Slovenia**

Management of radioactive waste generated by small producers (medical and industrial applications, research activities), was delegated to the state-owned public service, i.e. to the waste management agency ARAO. It includes: receipt of waste at the producer's premises, transport of waste, treatment and conditioning, storage and future disposal of waste. The ARAO is also responsible for the management of radioactive waste in the case of industrial accidents and of historical waste.

### **Jožef Stefan Institute Reactor Infrastructure Centre**

During the lifetime of the TRIGA Mark II research reactor, only a small amount of solid radioactive waste has been produced (approximately 50 litres per year in total). This waste consists mainly of contaminated material and equipment (paper, plastics, glassware, etc.) and contaminated mechanical and chemical filters (e.g. ion exchange resins). Spent resins are collected in drums. The activity content is estimated to be less than 1 GBq/m<sup>3</sup>. The waste is transferred to the Central Storage for Radioactive Waste in Brinje.

The reactor does not directly produce any radioactive liquid waste. However, during the chemical treatment of irradiated samples in adjacent research laboratories, some radioactive liquids are produced. This liquid waste is collected and further conditioned. Waste water, containing radionuclides, is collected in a special 20 m<sup>3</sup> decay tank. After measuring the isotope concentration and activity, the liquids, when they reach the prescribed limits, are released to the Sava River.

No gaseous radioactive waste that needs further treatment and storing is produced. Radioactive gases produced due to normal reactor operation (mainly argon) are released through controlled atmospheric release venting.

### **Radioactive Waste Management in Industry and Research**

Radioactive sources are widely used in industry and research. There are a number of industrial applications, e.g. industrial radiography, thickness, level and density gauges, moisture detectors, eliminators of static electricity, lightning poles, etc. At the end of 2012, based upon the registry of radiation sources, 129 organizations in industry, research and state administration in the Republic of Slovenia were using 238 X-ray devices; 778 sealed sources were used in 84 organizations. As many as 67 radioactive sources have been stored at 23 organizations. Spent and disused radioactive sources were either returned to the suppliers or shipped to the Central Storage for Radioactive Waste in Brinje.

Requirements for use and storage of disused radioactive sources and waste are set in the 2002 Act, Articles 9 to 16. For the conduct of radiation practices it is necessary to obtain a license. The applicant shall submit a plan for the use and storage of the radiation source as well as a plan for the handling of radioactive waste resulting from the radiation practice.

### **Radioactive Waste Management in Medicine**

In the Republic of Slovenia also unsealed radioactive sources (radiopharmaceuticals) for diagnosis and therapy are used in seven clinics or hospitals. The main users are the Institute of Oncology and the Ljubljana University Medical Centre – the Department for Nuclear Medicine. There is no production of radiopharmaceuticals in the Republic of Slovenia.

The Institute of Oncology uses decay storage tanks in order to control releases of radioactive effluents. The Ljubljana University Medical Centre – the Department for Nuclear Medicine releases the effluents directly into sewage systems. Patients from other hospitals are not hospitalised. It is estimated that approximately 0.3 TBq of  $^{131}\text{I}$  is released annually into the environment.

The short-lived radioactive waste (residues contaminated with  $^{131}\text{I}$ ,  $^{99\text{m}}\text{Tc}$ ,  $^{99}\text{Mo}$ ,  $^{201}\text{Tl}$ ,  $^{111}\text{In}$  or  $^{67}\text{Ga}$ ) which is produced during medical practice is stored locally at the users' locations. After decay, the material is transferred to the municipal disposal sites. In 2010, the Ljubljana municipal waste disposal site was equipped with a portal radiation monitor causing alert in several instances. It was determined that certain short lived radioisotopes from medical practices did not decay below clearance levels before being transferred to the disposal site. Corrective measures and procedures were later agreed and implemented.

In August 2010, the last disused teleradiotherapeutic  $^{60}\text{Co}$  source (about 100 TBq) was transported from the Institute of Oncology to the relevant recycling company in Germany. Other small amounts of solid radioactive waste, mainly containing  $^{57}\text{Co}$  (in total less than 1 GBq), are temporarily stored at local sites and periodically transported to the Central storage for radioactive waste in Brinje.

In April 2008, the Institute of Oncology transferred from its storage room to the Central storage for radioactive waste in Brinje all remaining disused sealed sources (mainly  $^{137}\text{Cs}$  with total activity of 3.86 GBq and 5 pieces of  $^{226}\text{Ra}$ ,  $^{133}\text{Ba}$  and  $^{129}\text{I}$  with total activity of 7.3 MBq). The storage room for spent sources and other rooms in the old building were then examined. No contamination was found (only natural background dose rate). Labels and signs have been removed and rooms are used without any restriction. A report has been prepared by an independent radiation

### **3.3 Waste management issues at national level**

#### **Siting and Construction of the LILW Repository**

One of the major tasks in the area of radioactive waste management in the Republic of Slovenia was achieved in 2009 by selecting the site for a LILW repository. The next phase is obtaining the licence for its construction. The organisation authorised to perform this task is the ARAO. The funds for the project are sufficient and will be available through the Fund for Decommissioning of the Krško NPP.

#### **Krško NPP**

In order to optimise the use of the remaining radioactive waste storage capacity in the Solid Radwaste Storage Facility. The new building for manipulation of waste will be built. Burnable waste is periodically sent for incineration and a campaign for radioactive metal waste melting is being prepared.

Incineration of contaminated blow-down ion exchange resin from the past operation is planned for the future. The last batches of used and exhausted blow-down resin have been free-released.

#### **The Central Storage for Radioactive Waste in Brinje**

##### Characterisation of radioactive waste

In order to better assess compliance with the acceptance criteria, all inventory has been categorised, treated and repacked. There are approximately 86 m<sup>3</sup> of radioactive waste stored in the facility, fully in compliance with waste acceptance criteria as approved in the safety report for operation of the central storage facility.

It is planned to regularly maintain all technical components in the storage facility according to prescribed checks in the storage documentation. It is also required in the operation licence, valid until 2018, that periodic safety assessment needs to be performed. All radioactive waste which is stored needs to fulfil the waste acceptance criteria.

#### **Jožef Stefan Institute Reactor Infrastructure Centre**

In 2011 the periodic safety review of the TRIGA Mark II reactor and the hot cell laboratories started. The fire protection system and the physical protection system will be upgraded.

#### **Žirovski vrh Uranium Mine**

The remediation was completed at the Jazbec and Boršt disposal sites in 2008 and 2010 respectively. It is planned that additional measures will be implemented to stabilize the base rock sliding under the Boršt mill tailings pile.

After the administrative closure of waste piles, the implementation of their long-term supervision will be transferred to the ARAO.

The funds for stabilization of the landslide at the Boršt site and long-term supervision of the waste piles are assured from the state budget.

#### **Ljubljana University Medical Centre - Department for Nuclear Medicine**

The University Medical Centre – the Department for Nuclear Medicine has started with a project of construction of containers for collecting faecal water containing  $^{131}\text{I}$ , with the intention to control the discharges of  $^{131}\text{I}$ .

### **3.4 Research and Development**

#### **3.4.1 Research infrastructure**

The Ministry of Higher Education, Science and Technology financially supports research and development projects in the field of nuclear safety in the Republic of Slovenia through a research fund, with the participation of the nuclear industry, the ARAO and the SNSA. The staff of the technical support organisations participate in the R&D of the EU research project and other international projects. The engineering and technical support and expertise are assured also through outsourcing at Slovenian research and engineering organisations or from abroad.

#### **3.4.2 Contents of R&D plans**

There are four main research areas, which are considered to be needed in order to maintain sustainable nuclear safety related knowledge in the country. These areas are in line with the scope of activities, which are regulated by the Act on Protection against Ionizing Radiation and Nuclear Safety. The areas are as follows:

Nuclear Safety, mainly addressing the specific issues related to the Krško NPP and the TRIGA research reactor.

Radioactive Waste Management, addressing existing situation as well as sitting and assessment issues related to the future waste repository project.

Radiation Protection and Monitoring focused on research projects related to the improved understanding of environmental issues in the country.

Emergency Preparedness as an important issue, especially after the Fukushima accident, and it is considered separately to improve national arrangements in that area

## **3.5 Financing of Radioactive Waste Management**

### ***3.5.1 Framework and responsibilities***

The licensing and regulatory activities are financed through the annual national budget. The polluter pays principle is in force in Slovenia. All small radioactive waste producers have to transfer their radioactive waste to the ARAO and to pay reduced price for the further steps of radioactive waste management. After transfer, the financial liability rests with the ARAO.

#### ***Krško NPP***

The expenses for radioactive waste treatment, conditioning and storing as well as for spent fuel storage are part of the production costs. The financial resources for these activities are ensured during the operational period of the Krško NPP.

According to the Agreement, the owners of the Krško NPP, GEN energija d.o.o. and Hrvatska Elektroprivreda d.d., are obliged to assure the funds for the decommissioning and the final disposal of radioactive waste and spent fuel.

The Slovenian share of assets for the decommissioning of the Krško NPP and for the post-operational radioactive waste and spent fuel management are assured through the Act Governing the Fund for Financing Decommissioning of the Krško NPP and Disposal of Radioactive Waste from the Krško NPP. This Act was amended in 2003 in the light of 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, Exploitation and Decommissioning of the Krško NPP. The Slovenian share of financial assets is collected through a levy for the kWh<sub>e</sub> delivered to the Slovenian grid since 1996. Due to a revision of the Decommissioning Programme in 2004 the levy was in 2005 increased to 0.30 Euro cents per kWh<sub>e</sub> delivered to the Slovenian electrical power company GEN energija d.o.o.

The Croatian share of assets for the decommissioning of the NPP Krško and for the post-operational radioactive waste and spent fuel management shall be assured in accordance with the bilateral Agreement through an adequate Croatian Fund for Decommissioning and Spent Fuel Management. The Croatian Fund was established by the Act on Governing the Fund for Financing Decommissioning and Disposal of Radioactive Waste and Spent Fuel of the Krško NPP. The Act was adopted by the Croatian Parliament in October 2007.

#### ***Jožef Stefan Institute Reactor Infrastructure Centre***

The financial resources for maintaining the safety of spent fuel and radioactive waste at the IJS Reactor Infrastructure Centre are provided within the budget for reactor operation. Financial provisions for decommissioning are not provided. However, the Republic of Slovenia is the owner of the facility, so it will have the responsibility to assure financial resources for proper decommissioning and spent fuel management.

#### ***Agency for Radwaste Management***

ARAO's activities are financed from different sources:

- the national budget,
- the Decommissioning Fund for the Krško NPP, and
- fees for storage and future disposal of waste according to the price list.

The annual budget varies, depending on the planned activities for the current year. Certain activities are also financed through the EU Framework Programme. The activities of ARAO related to the future

repository for LILW are financed both, from the above mentioned Slovenian decommissioning fund and state budget.

#### ***Žirovski vrh Uranium Mine***

The financial resources for the activities of the public company Žirovski vrh Mine, d.o.o. are assured only through the state budget.

#### ***Isotope Laboratory of the Institute of Oncology***

The Institute of Oncology is mainly financed by the Health Insurance of Slovenia and partly by the budget of the Ministry of Health. The Department of Radiological Safety at the Institute of Oncology will strive to ensure additional financial resources for its projects connected to radiological safety and safe storage and disposal of radioactive waste.

#### ***Ljubljana University Medical Centre - Department for Nuclear Medicine***

Functioning of the University Medical Centre – the Department for Nuclear Medicine is assured by the Health Insurance and the Ministry of Health.

### **3.5.2 Status of financing schemes**

See 3.5.1.

## **4. DECOMMISSIONING STRATEGY AND CURRENT PRACTICE**

### **4.1 Decommissioning strategy**

#### **Krško NPP**

The Agreement between Slovenia and Croatia on the Krško NPP of 2003 requires preparation of a Decommissioning Plan for the Krško NPP by the Slovenian and Croatian agencies for the management of radioactive waste. In accordance with the Agreement a Review of the "Programme for the Decommissioning of the Krško NPP and Disposal of Low and Intermediate Level Waste and Spent Fuel" was prepared in April 2004. Revision 2 of the Decommissioning plan started in September 2008, with the purpose to incorporate relevant developments since the first revision, to improve the level of details and reliability of the decommissioning plan, and to provide updated and more accurate cost estimates and appropriate financing models. The second revision of the decommissioning plan was prepared. The document is still under discussion and pending for approval by intergovernmental commission. According to current information the levy per kWh (0,3 Euro cent) shall be increased and will be sufficient to cover the decommissioning costs.

The Slovenian share of assets for decommissioning of the Krško NPP is collected and managed by the Fund for Decommissioning of the Krško NPP.

As the decommissioning of the Krško NPP will take place after the year 2023, it is assumed that the Krško NPP staff will perform decommissioning together with external contractors.

#### **Jožef Stefan Institute Reactor Infrastructure Centre**

A research project estimating the quantity and composition of LILW material resulting from dismantling was carried out and the Decommissioning Plan for the reactor prepared in 2007. The IJS decided to operate the reactor at least until 2016 and to ship all spent fuel (presumably 84 fuel elements) to

the US within the scope of the "US originating fuel repatriation program" by 2019. The reactor will be decommissioned after the year 2020. It has been estimated that not more than 50 tons of LILW would be produced in decommissioning. The Decommissioning Plan will be revised during the Periodic Safety Review, which started in the year 2011.

### **Žirovski vrh Uranium Mine**

Safety of remediation of the Jazbec mine waste pile and the Boršt mill tailings site is ensured through licensing and regulatory supervision. Both tailings and appropriate surrounding land shall become the property of the Government, who shall assure long-term monitoring and finance remedial actions when needed.

### **Central Storage for Radioactive Waste in Brinje**

The preliminary decommissioning plan for Central Storage for Radioactive Waste was prepared in 2013. The plan addresses two scenarios depend of time of operation and consequently the start of decommissioning. According to the National Programme for Managing Radioactive Waste and Spent Nuclear Fuel, the short lived radioactive waste meeting the acceptance criteria for LILW disposal shall be disposed of in LILW repository. Long lived waste will be moved to the LILW disposal facility location for storage, if agreement with local community will be reached. The Central Storage for Radioactive Waste in Brinje will then be decommissioned. This was the boundary conditions used in the preliminary decommissioning plan

#### **4.2 Status of decommissioning projects**

There are no nuclear facilities being decommissioned. The Žirovski vrh uranium mine, which is a radiation facility in accordance with the definition in the 2002 Act, is the only facility which was recently in the process of being decommissioned in the Republic of Slovenia.

#### **4.3 Decommissioning issues at national level**

See 3.3.

#### **4.4 Research and development**

The Ministry of Higher Education, Science and Technology financially supports research and development projects in the field of nuclear safety in the Republic of Slovenia through a research fund, with the participation of the nuclear industry, the ARAO and the SNSA. The staff of the technical support organisations participate in the R&D of the EU research project and other international projects. The engineering and technical support and expertise are assured also through outsourcing at Slovenian research and engineering organisations or from abroad.

#### **4.5 Financing**

Financing of the decommissioning costs is including in the financial schemes and framework described in chapter 3.5.

## ACRONYMS AND ABBREVIATIONS

SNSA	Slovenian Nuclear Safety Administration
SRPA	Slovenian Radiation Protection Administration
NEP	National Energy Programme (NEP)
ARAO	The Agency for Radioactive Waste Management
CSRW	Central Storage for Radioactive Waste
Krško NPP	The Krško Nuclear Power Plant (Krško NPP)
IJS Reactor Infrastructure Centre	The Jožef Stefan Institute Reactor Infrastructure Centre