REPUBLIC OF SLOVENIA
MINISTRY OF THE ENVIRONMENT AND SPATIAL PLANNING
**SLOVENIAN NUCLEAR SAFETY ADMINISTRATION**

# Annual Report 2016 on Radiation and Nuclear Safety in the Republic of Slovenia

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# Annual Report 2016 on Radiation and Nuclear Safety in the Republic of Slovenia

July 2017

Prepared by the **Slovenian Nuclear Safety Administration** in cooperation with:

The Slovenian Radiation Protection Administration;
The Administration of the Republic of Slovenia for Civil Protection and Disaster Relief;
The Ministry of Infrastructure;
The Administration of the Republic of Slovenia for Food Safety, Veterinary and Plant Protection;
The Ministry of the Interior;
The Agency for Radwaste Management;
The Nuclear Insurance and Reinsurance Pool;
The Fund for Financing the Decommissioning of the Krško Nuclear Power Plant;
The Krško Nuclear Power Plant;
Žirovski Vrh Mine d. o. o.;
Jožef Stefan Institute; and
The Institute of Occupational Safety.

The report was approved by the Expert Council for Radiation and Nuclear Safety on 22 May 2017.

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# SUMMARY

In 2016 there were no significant events in the field of nuclear safety and radiation protection. The Krško Nuclear Power Plant operated without any major problems. In the autumn of 2016 a regular refuelling outage was carried out, during which some significant modifications were implemented. Just before the start-up the outage was prolonged due to problems with the new built-in valves.

The Krško Nuclear Power Plant implemented a procurement process for a supplier of spent nuclear fuel dry storage, which was, unfortunately, prolonged for eight months due to the appeal of one of the bidders. The National Audit Committee invited nuclear experts to assess the technical solutions of the chosen bidder.

The intergovernmental Slovenian-Croatian commission for monitoring the performance of the contract on the ownership of the Krško NPP did not meet in 2016. Therefore, the Republic of Slovenia has not received a formal response from the Republic of Croatia on cooperation in the project on the disposal of low- and intermediate-level radioactive waste at the Central Storage for Radioactive Waste in Vrbina.

The ARAO, the Agency for Radwaste Management, continued its activities for building a low- and intermediate-level radioactive waste disposal site in Vrbina, Krško. Unfortunately, due to the unregulated financing in the first half of the year, the envisaged deadline for the start of its trial operation was moved forward to the year 2021. Due to increasing delays in this project the problem of the shortage of radioactive waste storage space continues to intensify. If the waste disposal site is not finished within the next three or four years, all of the currently available space will be filled and the NPP will not be able to continue operations.

At the Boršt hydrometallurgical tailings disposal site of the former uranium mine Žirovski Vrh in Gorenja Vas additional drainage intervention measurements were taken. These measurements will enable the drainage of the hinterland groundwater and water from the disposal site and thus will likely slow down the rock sliding. Work is to be continued in 2017.

In 2016 there were no major problems at the organisations and institutions that carry out radiation activities. At the same time, there were only a few interventions with regard to finding sources of ionising radiation in the field.

The National Assembly of the Republic of Slovenia adopted the Resolution on the National Programme for the Management of Radioactive Waste and Spent Fuel Management for the period 2016–2025, which determines the strategy and programme of activities in this field. With this resolution Slovenia continues to pursue the goals specified in the previous Resolution, the validity of which expired in 2015.

A thorough amendment of legislation in the field of radiation protection and nuclear safety was drafted, mainly due to new European Union Directives. A public debate on the new Act on Ionising Radiation Protection and Nuclear Safety was carried out. The National Assembly is expected to adopt the Act in 2017.

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# 1 INTRODUCTION

This report is prepared annually in accordance with the provisions of the Ionising Radiation Protection and Nuclear Safety Act. It summarises all developments related to nuclear and radiation safety. The report is endorsed by the Slovenian Government and is thereafter sent to the National Assembly of Republic of Slovenia. It is also the main method of communicating recent developments in the area of ionising radiation protection and nuclear safety to the general public. It has been issued since 1985. This English version is the essential publication for the presentation of these activities in Slovenia to the international public.

In creating the report, the Slovenian Nuclear Safety Administration (SNSA) performs the role of editor, while the content of the report is also provided by other state bodies whose competences include ionising radiation protection and nuclear safety, as well as other institutions in this area. Of these, the most important in 2016 were: the Slovenian Radiation Protection Administration (SRPA), the Administration of the Republic of Slovenia for Civil Protection and Disaster Relief (ACPRD), the Ministry of Infrastructure, the Administration of the Republic of Slovenia for Food Safety, Veterinary and Plant Protection, the Ministry of the Interior, the Agency for Radwaste Management (ARAO), the Nuclear Insurance and Reinsurance Pool, the Krško Nuclear Power Plant (Krško NPP), the Žirovski Vrh Mine, d. o. o., Jožef Stefan Institute (JSI), the Institute of Occupational Safety (IOS) and the Fund for Financing the Decommissioning of the Krško Nuclear Power Plant and for Disposal of Radioactive Waste from the Krško NPP, and others.

The year 2016 passed without any major accidents, therefore we can summarise that the fundamental objective of nuclear and radiation safety was definitely achieved:

*The protection of people and the environment from unnecessary harmful effects of ionising radiation.*

Together with this report, which is aimed at the wider interested public, an extended version in Slovenian has been prepared. The extended report includes all details and data that might be of interest to the narrower group of professionals. It is available on the SNSA website.

# 2 OPERATIONAL SAFETY

## 2.1 Operation of Nuclear and Radiation Facilities

### 2.1.1 Krško Nuclear Power Plant

In 2016 the Krško NPP produced 5,714,517.5 MWh (5.7 TWh) gross electrical energy from the output of the generator, which corresponds to 5,431,273.6 MWh (5.4 TWh) net electrical energy delivered to the grid. During the autumn 2016 regular annual outage the fuel was replaced and all the needed maintenance was carried out. Furthermore, one of the major improvements under the Krško NPP's Safety Upgrade Programme was started, namely the construction of the Emergency Control Room (ECR).

#### *2.1.1.1 Operation and Performance Indicators*

The most important performance indicators of the Krško NPP are shown in Table 1, while changes over the years are described in the following parts of this report. The performance indicators confirm that the plant's operation is stable and safe.

**Table 1: The most important performance indicators for 2016**

| Safety and performance indicators | Year 2016 | Average (1983–2016) |
|---|---|---|
| **Availability [%]** | 89.36 | 86.89 |
| **Capacity factor [%]** | 92.07 | 85.31 |
| **Forced outage factor [%]** | 0 | 1.02 |
| **Gross production [GWh]** | 5,648.29 | 5,132.87 |
| **Fast shutdowns – automatic [number of shutdowns]** | 0 | 2.21 |
| **Fast shutdowns – manual [number of shutdowns]** | 0 | 0.15 |
| **Unplanned normal shutdowns [number of shutdowns]** | 0 | 0.71 |
| **Planned normal shutdowns [number of shutdowns]** | 2 | 0.82 |
| **Event reports [number of reports]** | 8 | 4.24 |
| **Duration of the refuelling outage [days]** | 36.0 | 49.6 |
| **Fuel reliability indicator (FRI) [GBq/m$^3$]** | $1.52 \cdot 10^{-2}$ | $6.53 \cdot 10^{-2}$ |

The operation of the Krško NPP in 2015 is shown in Figure 1. It can be seen that the Krško NPP's operation in 2016 was stable. The plant was shut down only once, i.e. for the refuelling outage.

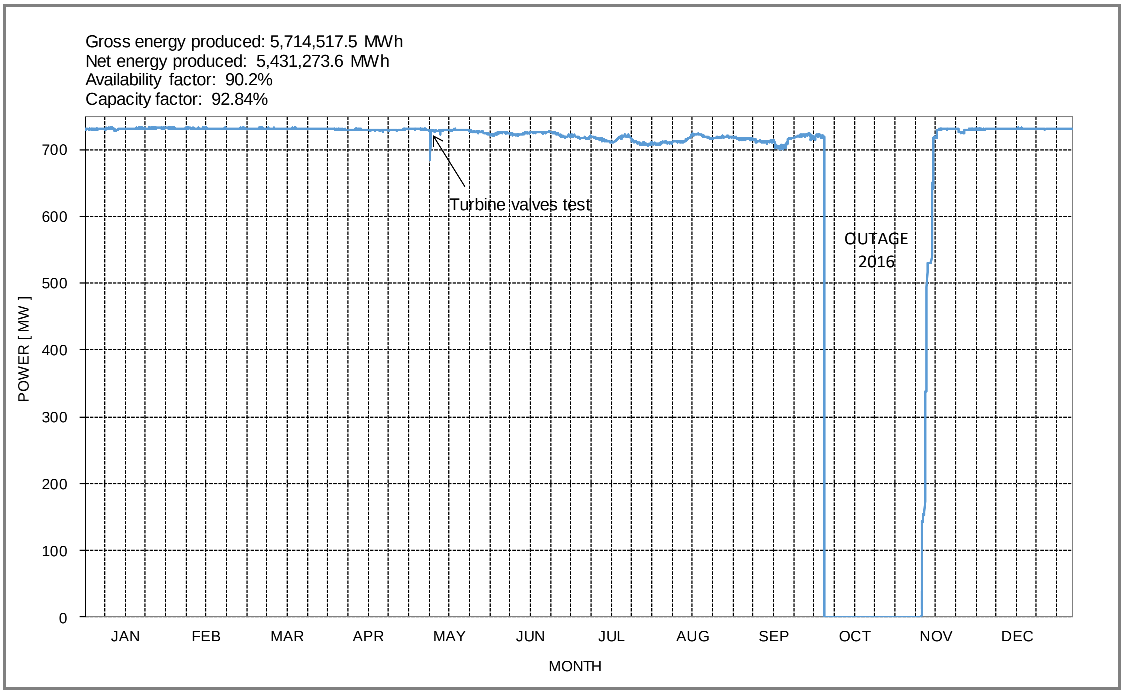


**Figure 1: Operating power diagram of Krško NPP in 2016**

Figures 2 and 3 show the number of plant shutdowns.

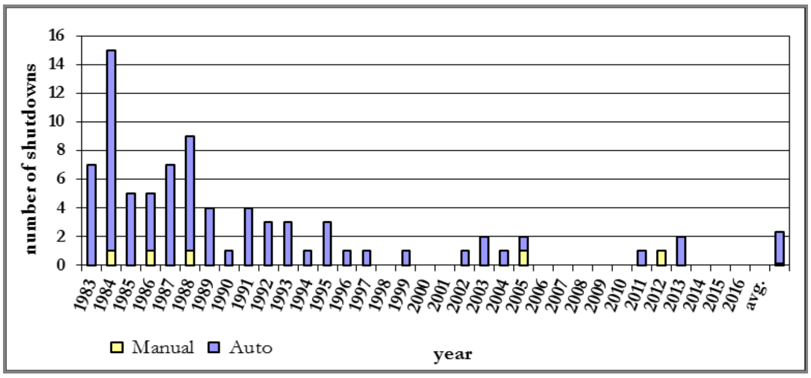


**Figure 2: Fast reactor shutdowns – manual and automatic**

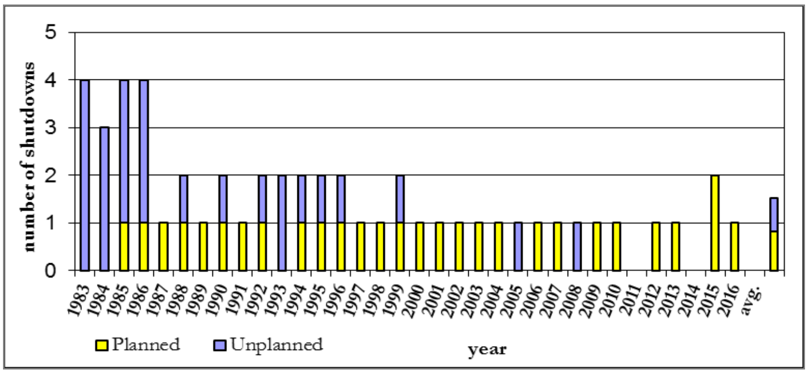


**Figure 3: Normal reactor shutdowns – planned and unplanned**

In 2016 there was only one normal shutdown, which was due to a refuelling outage. There were no fast reactor shutdowns in 2016.

In Figure 4 the capacity factor is shown. The capacity factor is a quotient between the actual produced electrical energy and the energy that could be produced if the plant had operated at the reference maximum capacity. The value in 2016 was 92.84%. In calculating this factor, the reference maximum capacity is used, which is the plant's theoretical capacity during the worst weather conditions. Since the Krško NPP mostly operates with higher capacity, the value of this factor can be higher than 100%.

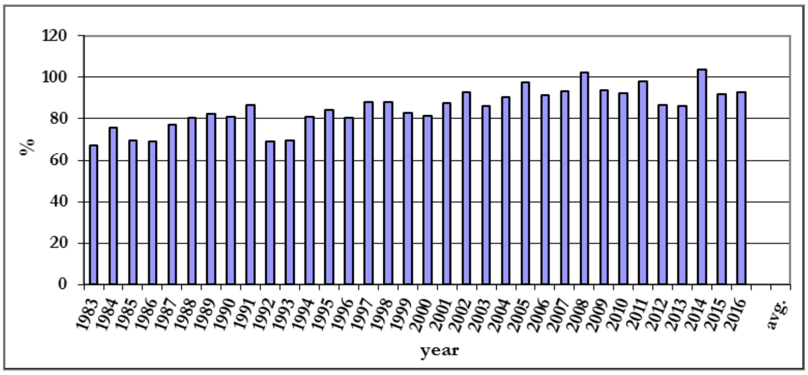


**Figure 4: Capacity factor**

Figure 5 presents the availability factor. Since in 2016 the plant was not available only during the regular refuelling outage, the availability factor was relatively high, 90.2%.

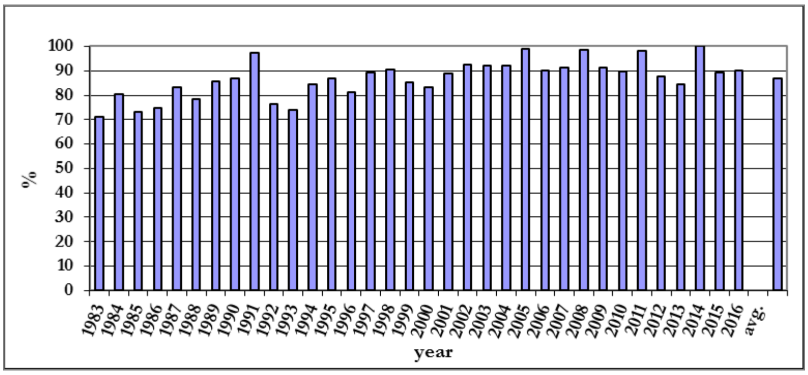


**Figure 5: Availability factor**

Figure 6 presents data on different means of electrical energy production in Slovenia, specifically electricity production in nuclear, hydro, thermal, and solar power plants. In 2016 the production of electrical energy reached a value of 15.7 TWh, which is the second highest value in the history of independent Slovenia.

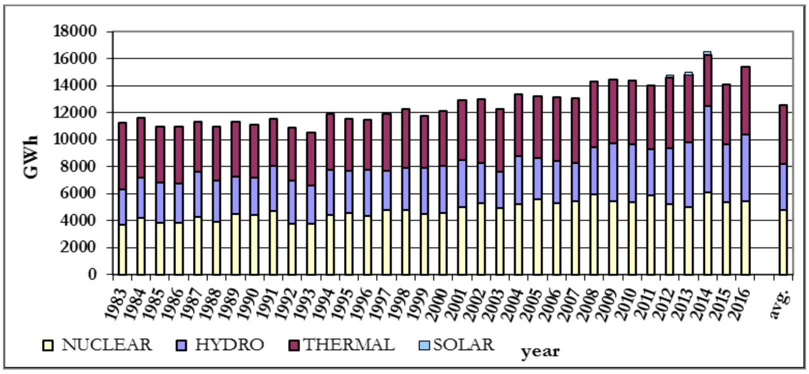


**Figure 6: Production of electrical energy in Slovenia**

Figure 7 shows the unplanned capability loss factor. It is calculated as a rate between the unplanned loss of energy generation and the reference energy generation (maximum energy generation with average weather conditions). A low value of this indicator shows good maintenance of important equipment. In 2016 the Krško NPP had some energy losses due to the outage extension, thus the value of this indicator was 1.15%.

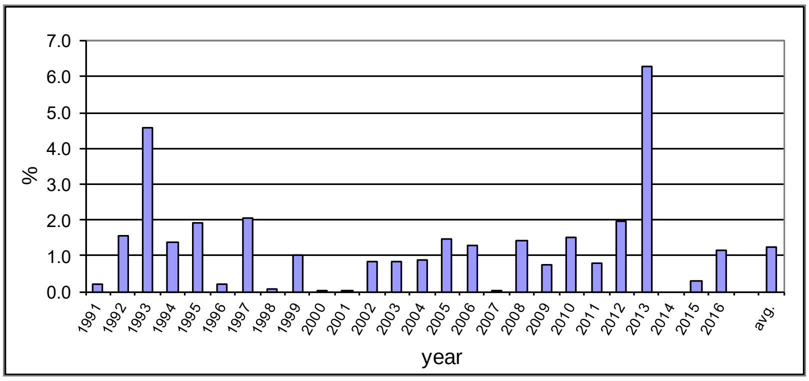


**Figure 7: Unplanned capability loss factor**

The collective exposure to radiation is shown in Figure 8. A low value of this indicator shows the high effectiveness of exposure control, as well as leadership commitment to radiological protection. In 2016 the value of this factor was 517.8 man mSv, which is, compared to years of operation with a refuelling outage, a record low value.

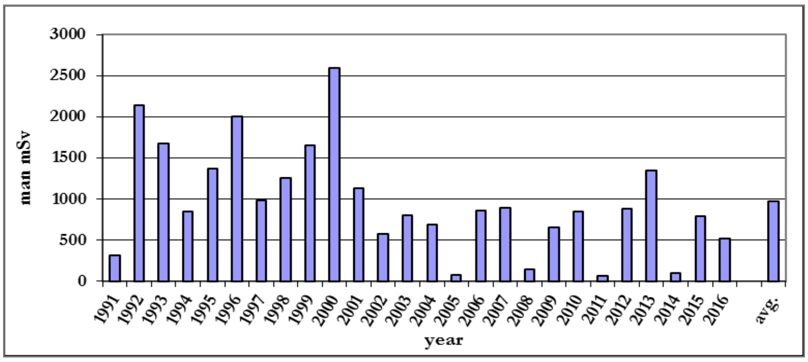


**Figure 8: Collective exposure to radiation in the Krško NPP**

The purpose of the unavailability factors given in Figures 9, 10, and 11 is to show whether important safety systems can ensure their function in the event of an accident.

Figure 9 shows the unavailability factor of the safety injection system. In 2016 the value of this factor was 0.0027, which is less than the Krško NPP's goal value (0.005). All instances of the unavailability of this system were due to planned on-line maintenance.

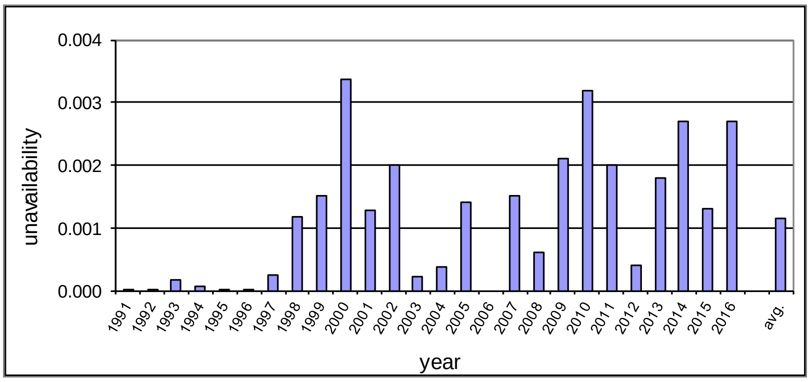


**Figure 9: The unavailability of the safety injection system**

The unavailability factor of the emergency power supply (the emergency diesel generators) is shown in Figure 10. This system is important when the normal off-site and on-site power supplies are not functioning. The operability of the diesel generators has been stable in recent years. In 2016 this system was completely available, thus the value of this factor is 0.

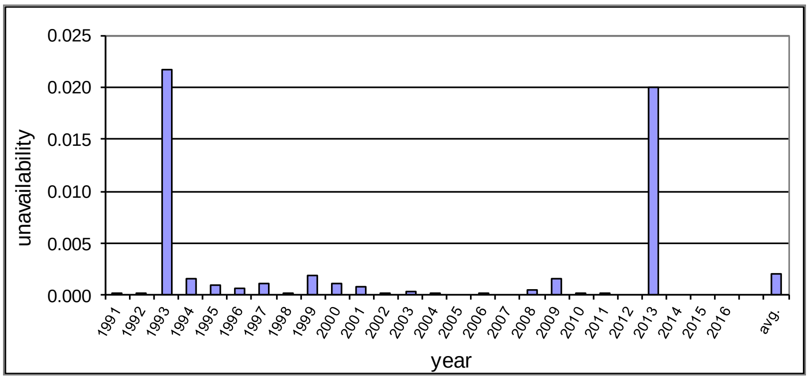


**Figure 10: The unavailability of the emergency power supply**

In Figure 11, the unavailability factor of the auxiliary feedwater system is shown. This system is used to supply water to steam generators when the main feedwater system is unavailable. In 2016 the value of this indicator was 0.0010, which is below the Krško NPP's goal value (0.005). In 2016 the system was unavailable only during the planned on-line maintenance.

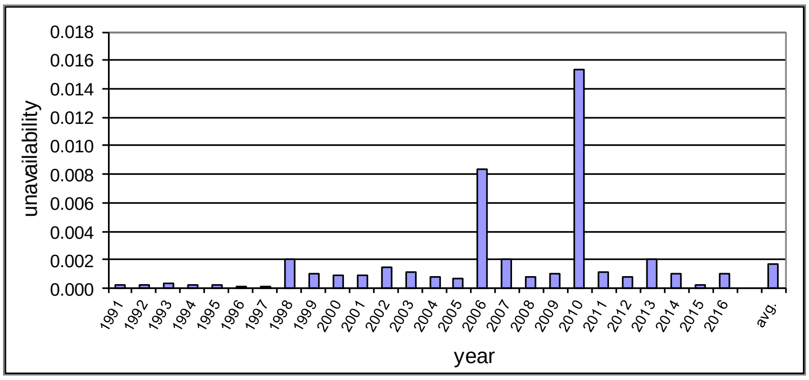


**Figure 11: The unavailability of the auxiliary feedwater system**

#### 2.1.1.2 Abnormal events and operating experiences in the Krško NPP

Event reporting is defined by the Rules on the Operational Safety of the Radiation of Nuclear Facilities and Technical Specifications. These Rules define the list of events that have to be specially reported by nuclear power plant operators. Krško NPP reported two events for which there was no need to shut down the plant. These events were as follows:

- the earthquake on 9 April 2016;
- control valve PCV 56572 leaks and does not maintain stable pressure on the outlet;

These events did not threaten nuclear and radiation safety. The SNSA monitored and analysed both of them.

**The earthquake on 9 April 2016**

On 9 April 2016, at 15:02, a strong earthquake tremor occurred, which was detected by Krško NPP seismic instrumentation and the national seismic network system. The estimated magnitude of the earthquake was 3.3 on the Richter scale, the epicentre of the earthquake was 89 km east of Ljubljana near Brežice. It was estimated that the intensity of the earthquake in the wider area did not exceed level V regarding the European seismic scale (EMS-98). The earthquake was felt by residents of the wider area. At the time of the earthquake the plant was operating at full power. All safety and more important components were operable and capable of performing their intended function. When the earthquake occurred, only the seismic instrumentation alarm was triggered. Other alarms or system response functions caused by the earthquake were not initiated. In accordance with procedures, at 15:18 the event was declared an "abnormal event". The staff of the plant carried out a visual inspection of the buildings, components, and systems. No deviations as a result of the earthquake were observed at the plant. Krško NPP informed the SNSA, the RECO, and CORS by the prescribed deadlines.

The Krško NPP and the SNSA closely examined and analysed the event.

**Control valve PCV 56572 leaks and does not maintain stable pressure on the outlet**

On 7 December 2016 plant personnel observed a small leak of nitrogen across safety valve PCV 56572. This valve is a part of the passive filter system of the containment system (PCFVS - Passive Containment Filtered Venting System), and is important for ensuring proper operation of the PCFVS in the event of a severe accident. The valve is a control valve and provides adequate protection for the iodine filter PCFVS in the event of the release of the atmosphere of the containment containing combustible gas (e.g. hydrogen), which could cause a fire or explosion in the iodine filter if it were in an atmosphere having oxygen content (e.g. air). Due to the leaking valve, the isolation valve to the cylinder of nitrogen was closed in order to prevent unnecessary losses of nitrogen. But by doing so the operability of the PCFVS was also reduced, because this situation enables safety conditions only for the first release of the containment atmosphere through the PCFVS, which otherwise (under the appropriate conditions and within the capacity of iodine filter recharge with nitrogen) has no such restrictions on its operation. The repairs will be conducted by the manufacturer; the cause of the event has not yet been determined. The reason for the leakage will be known after examination of the valve's inner parts. The SNSA will examine this event in great detail since this is already the second event occurring on the same component – the first one happened in 2015.

**The impact of falsification issues at a French forge factory on Krško NPP**

In mid-2016 in France the falsification of documentation was discovered regarding the quality of forged steel from the French Creusot Forge factory, where many steam generators for nuclear power plants were made in recent decades. The French regulatory body for nuclear safety (ASN) informed all other countries through WENRA of the potential problems that could result from this issue and that could have an impact on their nuclear power plants. After notification, all archival documents in the Krško NPP were reviewed because new steam generators installed in 2000 were supplied by the French company Siemens-Framatome (now called Areva). The review showed that all forged parts for replaced steam generators were made in Japan and also that the quality of the steel was already tested during the manufacturing and later additionally confirmed by the analysis of independent experts. The SNSA carried out an inspection review that confirmed that the materials installed in the Krško NPP are not from the French factory at issue.

#### 2.1.1.3 Implementation of the environmental impact assessment on the Krško NPP life time extension

In summer of 2016 Krško NPP asked the Agency for the Environment (EARS) for an opinion on whether the performance of an environmental impact assessment is required the extension of the plant life time operation from 2023 until 2043. EARS contacted several national authorities for their position on this issue and all delivered a negative opinion. On the basis of these opinions and additionally its own discretion as regards meeting the criteria set out under the Environmental Protection Act, in early 2017 the Environmental Agency issued a decision finding that an environmental impact assessment is not required for the extension of the service life of the Krško NPP from 40 to 60 years.

#### 2.1.1.4 Safety improvement projects in the Krško NPP

In September 2011, the SNSA issued a decision that the Krško NPP carry out a Safety Upgrade Programme (SUP). The plant performed an analysis of the needed improvements and based thereon prepared a proposal of the SUP, which was reviewed by the SNSA and approved in February 2012.

The original deadline for the SUP was December 2016, but this was later extended until December 2018. In December 2015 the Krško NPP applied for another deadline extension to December 2021 (a detailed description of the reasons for the deadline extension can be found in the SNSA 2014 Annual Report). With the last revision, also the content of the Programme changed, namely, the following:

- The alternate ultimate heat sink was revised to a 30-day capability for reactor cooling through steam generators – the injection of coolant from an additional reservoir, which can be replenished from the underground well. The reservoir shall have the capacity for the first 24 hours after the accident, because the possibility of replenishing the reservoir can be guaranteed only after the first 24 hours.
- Reinforcing injection into the reactor coolant pump seals is replaced by installing new high temperature resistant seals in the reactor coolant pumps.
- In addition to the already planned alternative heat removal pump, also a dedicated heat exchanger will be installed (in the previous version, the use of a mobile heat exchanger was envisaged).

The SNSA approved the 3$^{rd}$ revision of the SUP on 20 January 2017 by a written order.

The Krško NPP's SUP is divided into three phases.

Phase I, which was implemented in 2013, consisted of the following:

- the installation of passive autocatalytic recombiners (PARs);
- the installation of a passive containment filtered vent system.

Phase II, which is underway and is to be implemented by the end of 2019, includes:

- flood protection of the nuclear island;
- the installation of pressuriser bypass relief valves, qualified for severe accidents;
- the acquisition of a mobile heat exchanger with provisions for quick connections to the spent fuel pool;
- the installation of a fixed spray system on the spent fuel pool with provisions to use mobile equipment and different sources of water;
- the installation of an additional heat removal pump with a dedicated heat exchanger (which will be cooled by water from the Sava River through mobile equipment) capable of removing heat from the primary system and the containment;
- the upgrade of the Bunkered Building 1 (BB1) electrical power supply (provisions for connecting an additional mobile 2 MW diesel generator, seismic requalification of the 3$^{rd}$ emergency bus, the upgrade of the connection between 400 V safety buses and mobile diesel generators, etc.);

- the installation of an emergency control room (ECR) with the capability to shut down the reactor and maintain the long-term safe shutdown state. The ECR will include habitability systems for ensuring a safe long-term environment for operators even in the event of severe accidents;
- the installation of additional instrumentation with an independent power supply intended for severe accidents; and
- the upgrade of the operational support centre and technical support centre (emergency centres) to ensure a safe long-term environment for operators even in the event of severe accidents.

Phase III, which shall be implemented by the end of 2021:

- the installation of additional injection systems for the reactor cooling system / containment and steam generators capable of ensuring reactor cooling for at least 30 days (additional reservoirs of cooling water (also borated) capable of being replenished with water from underground wells) - the Bunkered Building 2 (BB2) project;
- construction of a dry spent fuel storage facility.

**Post-Fukushima action plan**

In December 2012 the SNSA prepared a comprehensive action plan (The Slovenian National Action Plan, NAcP) based on the lessons learned from the Fukushima accident. The document was published on the SNSA website. The Action Plan comprises all activities by which the risk due to external and other hazards that could affect the Krško NPP location would be further reduced.

The core of the Action Plan is the implementation of the Safety Upgrade Programme described in the previous chapter. Besides the SUP, the SNSA identified 11 additional activities to improve the preparedness for the severe accident events. Among them are legislative changes, additional international review missions, additional studies, enhancements in the area of emergency preparedness, and improvement in the safety culture of both the licensee and the regulatory body.

The implementation of most of the actions from the Action Plan started already in 2013. In 2016 the following actions were in the process of being implemented:

- legislative changes – two rules were published by which the Slovenian legislation came into line with the newest WENRA Safety Reference Levels published in September 2014;
- in the area of emergency preparedness, a simulation of an EPREV mission (the IAEA's Emergency Preparedness Review Service) was carried out, in relation to which several organisations cooperating in the area of emergency preparedness prepared for a real EPREV mission, which is scheduled for 2017. The simulated EPREV mission identified several actions to be implemented that will enhance preparedness for the EPREV mission, as well as for potential emergency events;
- special inspection regarding extreme flooding in combination with a severe earthquake;
- upgrades of the Krško NPP's probabilistic safety assessment (PSA) – the PSA for shutdown states is under review;
- preparations for the construction of the dry spent fuel storage at the Krško NPP site (more details are available in Chapter 5.1.2.1).

The updated Action Plan (December 2016) is published on the SNSA website.

#### 2.1.1.5 Inspection reviews

In 2016 the SNSA performed 67 inspections of the Krško NPP. All inspections were regular since the NPP operated smoothly, i.e. without unplanned events that might cause the need to perform reactive inspections. Three of the inspections were unannounced.

Based on the inspections, the SNSA concluded that during operation and the 2016 refuelling outage the Krško NPP faced some problems with safety-related equipment. However, all of the problems were resolved in a professional and effective manner. Therefore, a high level of nuclear safety was maintained throughout. Major problems are related to the operability of equipment installed in recent outages, namely to autocatalytic recombiners and the drive mechanisms of the in-core instrumentation. A root cause analysis is still in progress. The SNSA inspections carefully monitor compliance with the Technical Specifications (TS) and the implementation of long-term corrective actions.

Due to the fuel leakage during recent fuel cycles, the SNSA inspection thoroughly monitored activities related to nuclear fuel. The fuel in the 28$^{th}$ fuel cycle had no damage. This indicates the effectiveness of the "reactor vessel upflow conversion" modification implemented in the 2015 outage and the design improvements regarding fuel elements.

Inspections confirmed that in 2016the Krško NPP operated safely, i.e. without causing harm to people and the environment. Refuelling and outage activities were carried out professionally. The SNSA inspection service assessed the work of the organisational units of the NPP as good. The inspection reviews confirmed a high level of safety culture amongst the majority of experts. This is reflected in the high quality of the activities carried out, where safety was the priority, as well as in identifying potential problems based on the NPP's own and foreign operational experiences and an orientation towards the implementation of appropriate corrective measures.

#### 2.1.1.6 The 2016 Outage

The refuelling outage at the end of the 28$^{th}$ fuel cycle took place from 1 October to 5 November 2016. The overall assessment of the SNSA is that the activities were carried out comprehensively and took into account high standards of radiation and nuclear safety. Unforeseen complications were promptly and professionally resolved by the Krško NPP.

Regular outage tasks, i.e. refuelling and inspection of the fuel, periodic maintenance, and inspection and testing of equipment were carried out professionally. The tasks were performed in accordance with the approved procedures. In general, the results of the inspections and tests did not show unexpected defects on the equipment. Identified deviations were eliminated before restarting the plant. The outage was carried out very smoothly and in accordance with the plan until the plant start-up, when the operator discovered that two isolation valves in the reactor coolant pumps seal water line were leaking. The valves were located after the filters. Both valves were replaced and sealing ensured. This corrective action prolonged the outage by four days. In addition, at the start-up of the plant some deviations on the fission cells' drive mechanisms were observed. However, the operator ensured that the requirements of the reactor core parameters in the Krško NPP Technical Specifications were fulfilled at all time.

The Krško NPP carried out a great number of preventive maintenance works, replacements, and modernisation of the equipment. As a general rule, the full scope of activities was carried out and the quality of the tasks performed was good. Those deviations that have not been resolved completely do not jeopardise nuclear safety. The number of events and deviations were comparable to previous outages.

In the 2016 outage no fuel damage was uncovered, i.e. no fuel leakage was detected. The fuel leakage was successfully remediated in the 2015 outage with the implementation of the modification in the direction of the core bypass flow. In the long-term, this modification will also strengthen the fuel integrity.

As has been the case for many years, external control of outage activities was provided by independent technical support organisations. The technical support organisations communicated their observations and comments to the SNSA and the NPP at weekly meetings.

Mutual cooperation between the NPP and the technical support organisations was generally very good. Those responsible for the individual activities in the NPP were open and always ready to provide the requested information, including all necessary information, which were provided to the technical support organisations.

The SNSA reviewed the summary report on the outage prepared by the technical support organisations as well as their proposed recommendations. During focussed inspections of the NPP, the explanations related to the implementation of the recommendations and the deadlines for their implementation were submitted by the operator.

### 2.1.2 The TRIGA Mark II Research Reactor in Brinje

The operator of the TRIGA Mark II Research Reactor is the Jožef Stefan Institute (JSI) and its operation is carried out by the personnel of the Reactor Infrastructure Centre (RIC).

#### 2.1.2.1 Operation

In 2016 the reactor operated for 134 days and released 104.8 MWh of heat during operation. The reactor operated in stationary mode and in pulse mode – six pulses were performed. The reactor was mostly used as a neutron source for neutron activation analysis, for irradiation of electronic components or other materials, and for educational purposes. A total of 758 samples were irradiated in the carousel and the channels, as well as 35 in the pneumatic post.

In the Hot Cell Facility (OVC) of the Department of Environmental Sciences, the JSI radiation protection service and the ARAO regularly carried out radioactive waste treatment and preparations for the purpose of radioactive waste storage.

In 2016 there were six automatic reactor shutdowns, two of which were caused by an error made by a course participant, three due to sample extraction and one during the performance of an experiment. During the quick extraction of larger samples from the central of the triangular channel the reactor power varies so much that the automatic control cannot compensate for it. Thus, the power exceeded the linear channel limiting value for fast shutdown of the reactor and the reactor shut down. The shutdown during the performance of an experiment occurred while operational conditions approached the operational limit, however, this limit had not been exceeded at the time of the automatic shutdown.

There were no violations of the operational limits and conditions under the Safety Analysis Report in 2016. There were also no events in 2016 that required reporting to the SNSA.

The operational indicators regarding the doses acquired by the operating staff and those conducting experiments showed values far below the regulatory limits. The collective dose in 2016 was 678 man μSv for operating staff and 1053 man μSv for personnel carrying out work at the reactor.

#### 2.1.2.2 Nuclear Fuel

In 2016 a total of 84 fuel elements were located on the reactor site. There were no spent fuel elements. All fuel elements were standard elements with 12% uranium content and 20% enrichment. Control measurements of radioactivity in the reactor building and in the reactor coolant showed that no fuel elements were damaged. Inspection of 17 fuel elements showed no anomalies. This completed a four-year cycle of inspection of all fuel elements in the reactor pool with the exception of instrumented ones. The JSI reported on the fuel balance monthly to EURATOM and to the SNSA. In November 2016, EURATOM and the IAEA performed an inspection of the status of the nuclear material and the inspection findings showed no anomalies.

#### 2.1.2.3 Staff Training

All TRIGA Research Reactor operators extended their licenses for reactor operation on 23 November 2016. Two operators were promoted to the rank of shift supervisor. Regular training of staff was performed in line with the annual programme of expert training of the TRIGA Research Reactor operators for the year 2016.

In November 2016, a training course for extinguishing initial fire with portable powder and carbon dioxide fire extinguishers was carried out. Nine visits to the reactor and hot cell facility were organised for firemen from the Ljubljana Fire Brigade and on these occasions the firemen were instructed regarding possible hazards during emergencies.

#### 2.1.2.4 Modifications, Inspections of the Systems, Structures, and Components of the Nuclear Facility, Fire Safety, and Physical Security

The reactor operated in stationary mode and in pulse mode. Pulsing operation was performed in May in order to provide practical exercises to students of the Faculty of Mathematics and Physics of the University of Ljubljana and to record a documentary film on the occasion of the fiftieth anniversary of the TRIGA Research Reactor. On this occasion the testing of electronic components was carried out. The Reactor Safety Committee approved the pulsing operation in advance and the SNSA was notified of the pulsing operation.

In 2016 six reactor core modifications were made for the experimental purposes of the Nuclear Physics Department. Most of the new cores were established for the irradiation of electronic components with burned-up fuel (without neutrons) and the reactor did not operate with such cores.

In 2016 the following modifications to the reactor were implemented:

- Installation of a system for the control of reactor coolant quality, quantity, and flow. In the year 2017 the work will continue with a software upgrade and process automation according to the project documentation.
- Installation of additional radiation monitors in the reactor building.
- Installation of a deafening device regarding the exhaust of the pulsing rod.
- Installation of new radiation-resistant LED lighting in the reactor pool.
- Modification of channel No. 6, which will enable the neutron irradiation of larger samples. In the year 2017 the work will continue with the installation of a protection device that will prevent reactor operation when the radiological shielding is removed.

The JSI personnel and the authorised external organisations conducted periodic inspections and supervisions of the safety structures, systems, and components (SSC). The inspections did not find any deficiencies.

#### 2.1.2.5 Periodic Safety Review

The periodic safety review of the nuclear facility that comprises the TRIGA Research Reactor and the hot cell facility was completed in December 2014 with the SNSA approving the periodic safety review report with an action plan for the implementation of modifications and improvements. In 2016 the implementation of the action plan, with a total of 85 modifications and improvements, was carried out. By means of semi-annual reports, the JSI reported on the status of the implementation. Altogether, 46 actions were implemented. The implementation of the action plan for modifications and improvements should be completed by December 2019.

#### 2.1.2.6 Review of the Safety Analysis Report

In 2016 an administrative procedure was conducted to upgrade the Safety Analysis Report of the TRIGA Mark II Research Reactor. The administrative procedure should be completed in 2017.

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

The Central Storage for Radioactive Waste (CSRW) in Brinje is managed by the Agency for Radwaste Management (ARAO).

The CSRW operated safely; there were no recorded incidents or accidents. All periodic preventive maintenance inspections and testing of CSRW structures, systems, and components (SSC), as well as of the operability of the measurement equipment, were carried out as planned. Some corrective maintenance on the structures, systems and components had to be undertaken, e.g. unscheduled maintenance and monitoring of the implementation of the measures.

The physical and technical security was improved in February 2016 at a CSRW facility by replacing woodwork (exterior doors and windows) with built-in anti-theft protection.

The records of radioactive waste and sealed radiation sources that are no longer in use, of nuclear materials, of preventive and corrective maintenance of SSCs, as well as of software changes, operational events, and other relevant events were kept.

The acceptance of radioactive waste in the CSRW in 2016 and the inventory of the waste stored as at the end of 2016 are described in more detail in Chapter 5.4.

### 2.1.4 The Former Žirovski Vrh Uranium Mine

In the area around Žirovski Vrh the excavation of uranium ore took place between 1982 and 1990 and uranium concentrate was processed therefrom. Mill tailings were disposed of in the Jazbec mine tailings disposal site and hydrometallurgical tailings were disposed of at the Boršt site. In 1990, after the exploitation of uranium ore was temporarily halted and the subsequent decision on permanent cessation was made, the process of the remediation of this mining process and its consequences began.

The Jazbec mine tailings disposal site was closed in 2015. An area covering the landfill body of the site became an object of the national infrastructure, and since the end of 2015 it has been managed by the ARAO under the State's authority.

In 2016, after the final arrangements were completed, the regular activities of the fifth year of the transitional period, which was extended for one year, were carried out at the hydrometallurgical tailings landfill at the Boršt site. In addition to these ongoing activities, also the remediation of the drainage tunnel under the landfill due to damage to the concrete lining and the implementation of emergency drainage measures were carried out. More information on remediation activities regarding the former mining activities at Žirovski Vrh can be found in Chapter 5.6.

## 2.2 Radiation Practices and the Use of Radiation Sources

The Ionising Radiation Protection and Nuclear Safety Act requires advanced notification of the intention to carry out a radiation practice or to use a radiation source, and that a licence must be obtained to carry out a radiation practice or to use a radiation source, along with a certificate of registration of radiation sources.

### 2.2.1 Use of Ionising Sources in Industry, Research and Education

As of the end of 2016, 167 organisations in industry, research and the state administration in the Republic of Slovenia were using 321 X-ray devices; 710 sealed sources were being used in 75 organisations. As many as 32 radioactive sources were stored at 16 organisations, which are intended to be handed over to the ARAO in the future.

In 2016, 65 licences to carry out radiation practices, 93 licences for the use of a radiation source, 12 certificates of the registration of radiation sources, 15 approvals for external operators of radiation practices, 5 decisions on the termination of the validity of licences to carry out radiation practices, and 2 decisions on the sealing of an X-ray device were issued by the SNSA.

Ionisation smoke detectors, utilising isotope $^{241}$Am, form a special group of radiation sources. According to the registry of radiation sources, there were 22,440 ionisation smoke detectors being used at 278 organisations as at the end of 2016. 271 ionisation smoke detectors were also stored at the users' premises, 161 of which in the organisation dealing with mounting and dismounting of ionisation smoke detectors.

### 2.2.2 Inspections of Sources in Industry, Research and Education

In 2016 the SNSA inspection service conducted 80 inspections related to industry, research and educational institutions, and ministries, including inspections related to scrap dealers. Among others, the regular annual inspections concerning the use of high-activity radioactive sources were also performed. In particular, the SNSA inspectors paid special attention to industrial radiography, where the observed level of safety was still not satisfactory, i.e. it was not high enough. In 2016 one intervention was initiated by the report of a high personal dose received by one radiographer in a company that has been practicing industrial radiography for years. The radiographer had forgotten his personal dosimeter in the exposure room for a few days. He did not report the loss to the radiation protection officer. After finding the dosimeter, he again used it. The SRPA identified the unexpected result of the occupational dose during a routine analysis of dose records, which is performed each month. The recorded dose of 3.9 mSv was well above the dose constraint applicable in the company, i.e. the dose constraint was 1.6 mSv/month. The SNSA inspection service identified numerous instances of non-compliance in the inspections of this company that followed.

In 2016 altogether 14 inspections were focused on instances of non-compliance related to smoke detectors using ionising radiation. In addition, two interventions were related to such smoke detectors. In 2016 smoke detectors were completely lost at two locations; three times they were found among scrap materials; while contamination with radiotoxic $^{241}$Am was identified only once. The inspection service also received an anonymous report of non-compliance regarding the installation, removal, and disposal of such smoke detectors. This report was related to a company that has been involved in fire protection for years. Challenging issues regarding the use of smoke detectors include changes in the purpose of buildings, the adaptation of sites, and the demolition of buildings, as well as changes in the owners or managers of real property.

In 2016 the SNSA inspection service continued the inspection of suppliers of sources of ionising radiation as well as of companies providing related services. The inspectors noted that very often the personnel of such companies do not possess knowledge of the relevant safety measures or legal requirements. As a result, such companies do not inform the final users of sources of the requirements related to the safe use of sources foreseen by the producer. Such companies do not inform the users of the necessary handling of sources when the source is no longer used. In particular, the inspectors noted that service companies from abroad require special attention as such companies are not aware of the legal requirements in Slovenia. It is clear that the inspection programme associated with supplies and companies providing related services should continue.

One of the challenging inspection fields is the inspection of bankrupt companies. In general, during and after bankruptcy the safety rules related to practices with ionising radiation sources or related to ownership of sources are not followed. In 2016 the SNSA inspection service continued to monitor companies obliged to perform measurements of radioactivity in scrap material as well as to monitor companies obliged to follow the SNSA inspection service's requirements imposed in inspections in previous years.

A total of 18 interventions were conducted in 2016. This number is somewhat larger in comparison to the number of interventions in previous years. The increase is related to the larger number of interventions related to the cross-border transport of radioactive sources or radioactive waste. As a rule, the actions of all those involved which should be carried out are well established.

Only three interventions were related to the use of sources on the premises of a user. Namely, one was related to smoke detectors using ionising radiation and one related to industrial radiography, while one such intervention was related to four orphan sources found during the cleaning of the laboratories of the National Laboratory of Health, Environment and Food. The sources, stored in a suitcase, were later taken by the ARAO and put in the Central Storage for Radioactive Waste. In 2016 twelve interventions related to the transport of radioactive sources or radioactive waste, of which seven concerned sources or waste returned to the state of origin. Three interventions were related to smoke detectors found in cargo with scrap materials, twice in scrap electronics. The analysis of one of the intervention mentioned revealed that scrap electronics from Slovenia had been rejected for use in Austria due to the elevated dose rate of the cargo measured in Austria. The Austrian regulatory authority did not inform the SNSA of this rejection and the cargo came back to Slovenia. The analysis also revealed the need to ensure the prompt response of qualified experts as regards carrying out measurements focused on the identification of sources or contamination when needed.

The SRPA also conducts inspections related to the protection of workers against ionising radiation and thus oversees the implementation of radiation activities. In 2016 the SRPA inspection service conducted one inspection regarding the use of radiation sources in industry, research and education. Due to an anonymous report from a worker, the inspection service reviewed the status of radiation protection in the company Zarja Elektronika, d. o. o. The inspection service did not find any violations of regulations and no deficiencies as regards care for the health of the employees or the members of the public were found.

### 2.2.3 Use of Radiation Sources in Medicine and Veterinary Medicine

The Slovenian Radiation Protection Administration (SRPA) is responsible for the administration and inspection of practices involving radiation in medicine and veterinary medicine.

#### X-ray Devices in Medicine and Veterinary Medicine

According to the records of the SRPA, 1,062 X-ray devices for medicine and veterinary medicine were installed as of the end of 2016; 126 of them were not in use, 11 required servicing, 40 were on reserve, and 75 were proposed for decommissioning. The categorisation of X-ray devices based on their purpose is given in Table 2.Table 2: Number of X-ray devices in medicine and veterinary medicine by purpose.

| Purpose | Status 2015 | New | Written-off | Status 2016 |
|---|---|---|---|---|
| **Dental** | 522 | 59 | 16 | 565 |
| **Diagnostic** | 297 | 16 | 7 | 306 |
| **Therapeutic** | 12 | 0 | 0 | 12 |
| **Simulator** | 4 | 0 | 0 | 4 |
| **Mammography** | 34 | 4 | 4 | 34 |
| **Computed tomography CT** | 28 | 1 | 0 | 29 |
| **Densitometers** | 45 | 1 | 0 | 46 |
| **Veterinary** | 66 | 1 | 1 | 66 |
| **TOTAL** | **1008** | **82** | **29** | **1,062** |

In the field of the use of X-ray devices in medicine and veterinary medicine in 2016, the SRPA granted 122 licences to carry out a radiation practice and 266 licences to use X-ray devices. Furthermore, 5 evaluations of the protection of workers exposed to radiation were issued and 4 confirmations of programmes of radiological procedures were issued in cases where the procedure started before the entry into force of the Act Amending the Ionising Radiation Protection and Nuclear Safety Act in October 2015.

In medicine (not including veterinary medicine), 465 X-ray devices were used in private dispensaries and 532 in public hospitals and institutions. The average age of X-ray devices was 9.6 years (9.4 years in 2015, 9.6 years in 2014, 9.5 years in 2013, and 9.1 in 2012) in the public sector, and 10.2 years (10.1 years in 2015, 9.9 years in 2014, 9.8 years in 2013, and 9.2 years in 2012) in the private sector.

In veterinary medicine, 13 X-ray devices were in use in public institutions and 54 in the private sector. The average age of X-ray devices was 15.5 years (15.5 years in 2015, 14.5 years in 2014, 13.5 years in 2013, and 13.8 years in 2012) in the public sector and 8.7 years (10.1 years in 2015, 9.4 years in 2014, 9.6 years in 2013, and 8.0 years in 2012) in the private sector.

A detailed classification of X-ray devices in medicine and veterinary medicine according to their ownership is given in Table 3.

**Table 3: Number of X-ray devices in medicine and veterinary medicine by ownership**

| Ownership | Diagnostic | | Dental | | Therapeutic | | Veterinary | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No. (%) | Age (years) | No. (%) | Age (years) | No. (%) | Age (years) | No. (%) | Age (years) | No. (%) | Age (years) |
| **Public** | 338 (81%) | 9.6 | 112 (20%) | 9.7 | 13 (100%) | 7.2 | 13 (19%) | 15.5 | 476 (45%) | 9.7 |
| **Private** | 79 (19%) | 11.2 | 453 (80%) | 10.0 | 0 | 0 | 54 (81%) | 8.7 | 586 (55%) | 10.0 |
| **TOTAL** | **417** | **9.9** | **565** | **9.9** | **13** | **7.2** | **67** | **10.0** | **1,062** | **9.9** |

All X-ray devices are examined by approved radiation protection experts at least once a year. The devices are classified, with regard to their quality, into the following groups: fully functional, servicing required, decommissioning proposed, and not functional. The analysis of the data for X-ray devices is presented in Figure 12, which shows that more than 95% of devices were classified as "fully functional".

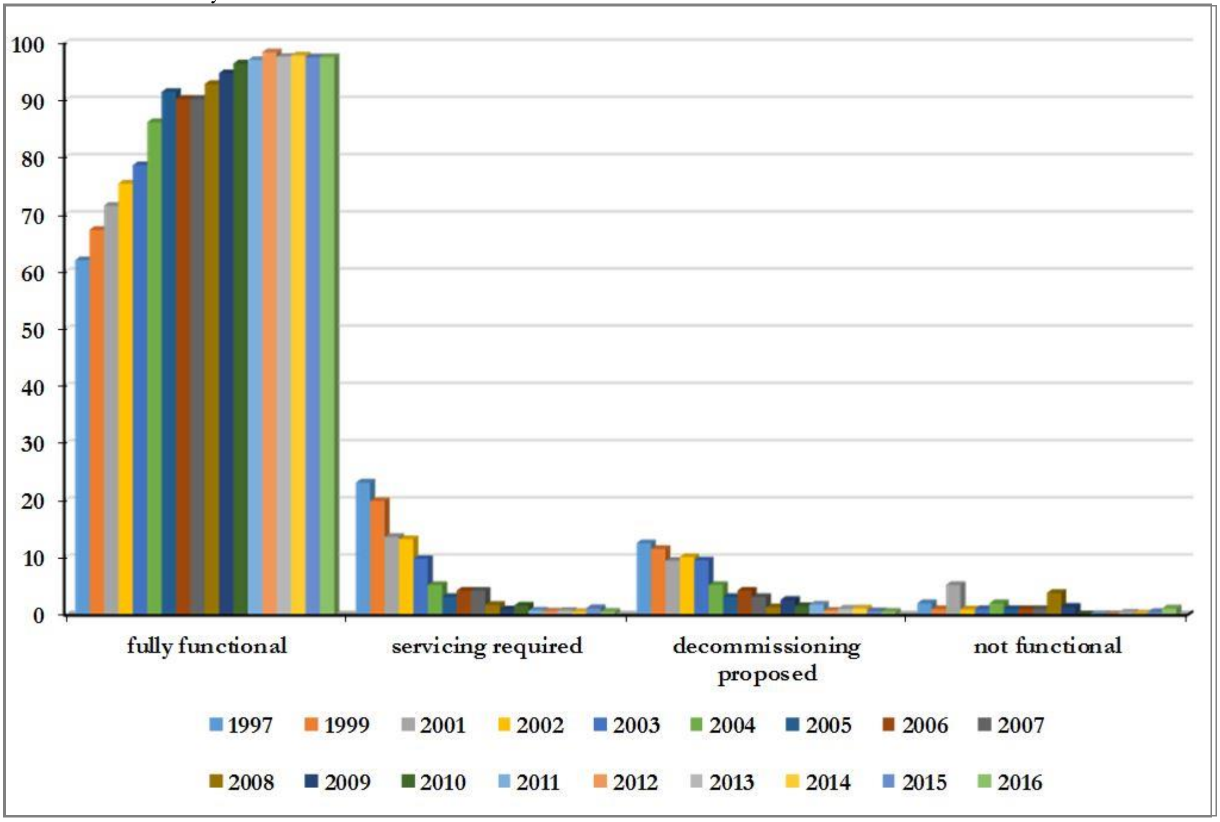


**Figure 12: Percentage of diagnostic X-ray devices according to their quality in the period 1997–2016**

In 2016, 14 in-depth inspections of the use of X-ray machines and linear accelerators for radiotherapy in medicine and veterinary medicine were carried out, of which two reviewed the introduction of tele-radiotherapy (the use of linear accelerators) in the UKC Maribor, one inspection investigated an incident in radiotherapy, and five inspections were primarily intended for monitoring the implementation of the principle of the justification of radiological procedures. In five cases, based on the findings of the inspection, the inspection service issued a decision requiring harmonisation with the valid regulations. In two cases, the inspection service required the sealing of an X-ray machine, in order to prevent the use of a device that is kept in reserve.

In case of the accidental exposure of a patient, an inspection at the Institute of Oncology (OI) in Ljubljana was carried out. On 2 June 2016, a female patient who was not even scheduled for tele-radiotherapy treatment was irradiated at the OI. The patient was irradiated instead of another patient in the hospital – a patient with the same first name, last name, year of birth, and pathology in the same part of body. Both patients had been immobilised by pain in the lumbar region. The decision to irradiate the intended patient was made at the University Medical Centre in Maribor, where she also received radiotherapy treatment. The inspection service ascertained that some of the communication between the two institutions was carried out by telephone. The OI immediately ceased to fill out primary forms for irradiation on the basis of information transmitted by phone, and introduced a system for double-checking patients' identity at all levels of their treatment, including by entering the patient's information in the OI information system.

One inspection was carried out at the company BARSOS-MC, Zdravstvene storitve, d. o. o. It was based on a report from the owners of residential units due to the installation of X-ray equipment for computed tomography. As a result of the inspection, a warning was issued that the company should not calibrate, maintain, or use a radiation source without a valid licence to carry out practices involving radiation or to use radiation sources.

Based on a review of the inspection reports on X-ray devices for medical use sent to the SRPA by approved technical support organisations, 8 inspections were conducted during which the SRPA requested that the user provide evidence that the noted shortcomings had been eliminated. There were 39 cases in which the user was asked to present evidence relating to the termination of the use of an X-ray device and 162 cases involving the requirement to comply with the applicable legislation.

**Unsealed and Sealed Radiation Sources in Medicine and Veterinary Medicine**

Seven hospitals or clinics in Slovenia, namely the Clinic for Nuclear Medicine of the University Medical Centre in Ljubljana, the Institute of Oncology, the University Medical Centre in Maribor, and general hospitals in Celje, Izola, Slovenj Gradec, and Šempeter pri Novi Gorici use unsealed sources (radiopharmaceuticals) for diagnostics and therapy in their nuclear medicine departments. In these nuclear medicine departments, altogether 6,469.5 GBq of isotope $^{99}$Mo, 3,797.1 GBq of isotope $^{18}$F, 1,000.1 GBq of isotope $^{131}$I, and minor activities involving the isotopes $^{123}$I, $^{201}$Tl, $^{90}$Y, $^{223}$Ra, and some other isotopes are used for diagnostics and therapy. Isotope $^{99}$Mo is used as a generator of the isotope technetium $^{99m}$Tc, which is used for diagnostics by nuclear medicine departments. From the initial activity of $^{99}$Mo, a few-times higher activity of $^{99m}$Tc can be eluted in one week. At the end of 2014, the Institute of Oncology started to use $^{223}$Ra, which emits alpha particles. Cumulatively, 0.85 GBq of that isotope were imported in 2016 (a bit less than in 2015, when 1.43 GBq of that isotope were imported).

Sealed sources for therapy are used at the Institute of Oncology and the Clinic of Ophthalmology, and for the irradiation of blood components at the Blood Transfusion Centre of Slovenia. At the Institute of Oncology, two $^{192}$Ir sources with initial activity of 440 GBq and 44 GBq, and three $^{90}$Sr sources with initial activities up to 740 MBq are in use. The Clinic of Ophthalmology uses four sources of $^{106}$Ru with initial activities up to 37 MBq for treating eye tumours. At the Blood Transfusion Centre of Slovenia a device is used for the irradiation of blood components with a 137Cs source with initial activity of 49.2 TBq.

Sealed sources of minor activities are used for the operational testing of various devices and measurement equipment at some nuclear medicine departments.

In 2016 the following documents with reference to the use of unsealed and sealed sources in medicine were issued: 11 licences to carry out a radiation practice, 7 licences to use a radiation source in medicine, 1 confirmation of a radiological procedure programme, 1 confirmation of the evaluation of the radiation protection of exposed workers, and 39 statements on the shipment of radioactive materials.

Medical departments with unsealed and sealed radiation sources were surveyed (once or twice annually, depending on the source type) by approved experts for radiation protection and medical physics at the Institute of Occupational Safety (IOS). No major deficiencies were found in 2016.

Neither unsealed nor sealed radioactive sources were used in veterinary medicine in 2016.

In the field of the transport of radioactive materials used in medicine and veterinary medicine, one certificate of eligibility for a foreign contractor carrying out a radiation practice was issued.

### 2.2.4 The Transport of Radioactive and Nuclear Materials

The transport of radioactive and nuclear materials is regulated by the Act on the transport of dangerous goods. All road transport of such materials has to be carried out in accordance with the provisions of the European Agreement Concerning the International Carriage of Dangerous Goods by Road (ADR).

In 2016 the SNSA issued one approval for multiple transport under special arrangement to the ZVD Institute of Occupational Safety for the transport of radioactive material to the Central Storage Facility in Brinje or to other consignees in the Republic of Slovenia.

In September 2016, the company Container, d. o. o., requested that the SNSA approve a quality management system for the production of packaging for the transport of radioactive material. Based on an audit and additional explanations, the SNSA concluded that the company Container, d. o. o. had implemented an appropriate management system for the production of packaging for the transport of radioactive material.

### 2.2.5 The import/shipment into Slovenia, transit, and export/shipment out of Slovenia of radioactive and nuclear material

The SNSA and the SRPA issue permits for the import into and export of radioactive and nuclear materials outside the EU and approve prescribed forms (declarations of shipment) for the shipment of radioactive material between EU Member States.

In 2016 the SRPA did not issue any permits for the import of radioactive sources from non-EU countries, but approved 39 applications of consignees of radioactive material for 65 isotopes. Each isotope from an individual producer intended for the same end user is counted separately.

In 2016 the SNSA approved 9 applications of consignees of radioactive material from other EU Member States. The SNSA also issued four permits for the import of radioactive material, one permit for multiple shipments of nuclear material between other EU Member States, one permit for the import of nuclear material, i.e. fresh fuel elements for Krško NPP, and one permit for the export of radioactive material.

In 2016 the SNSA did not issue any permits for the transit of radioactive material with important activity.

## 2.3 Achieving the goals under the Resolution on Nuclear and Radiation Safety

With respect to nuclear and radiation activities, the Resolution on Nuclear and Radiation Safety in Slovenia for the period 2013−2023 sets a rather short, but in terms of content broad-ranging goal:

**Goal 1**

*Nuclear and radiation facilities and operators fulfil the statutory requirements, ensure continuous improvement of nuclear and radiation safety, and closely monitor international improvements in the field.*

**Realisation in 2016**

From the above chapters, it can be summarised that all nuclear and radiation facilities in the state (the Krško NPP, the TRIGA Research Reactor, the Central Storage of Radioactive Waste at Brinje, and the mine and hydrometallurgical tailings) and performers of radiation practices or users of sources of ionising radiation in industry, research activities, education, health and veterinary medicine have fulfilled the statutory requirements and fostered the improvement of nuclear and radiation safety.

The extensive programme of safety improvements at the Krško NPP (Safety Upgrade Programme − SUP), initiated on the basis of stress tests after the nuclear accident at Fukushima in Japan, has continued in line with the decisions issued by the SNSA, but again in this year a delay in its implementation is noted. The reasons for this delay are above all the fact that the Krško NPP is subject to public procurement procedures.

# 3 RADIOACTIVITY IN THE ENVIRONMENT

The purpose of radioactivity monitoring in the environment is mainly the monitoring of the levels of general radioactive contamination, trends as regards the concentrations of radionuclides in the environment and timely warning in the event of a possible sudden increase in radiation on the territory of Slovenia.

Radiation protection of the population is ensured through continuous control of external radiation levels in the environment, monitoring of radioactivity in the environment and regular control of radioactive contamination of drinking water, food and feed based on laboratory measurements.

Radioactivity released into the environment by the nuclear power plant in Krško, the former uranium mine at Žirovski Vrh, the TRIGA Research Reactor and the Central Storage for Radioactive Waste, the latter two of which are both located in Brinje near Ljubljana, is monitored. The doses received by the population living in the vicinity of these nuclear and radiation facilities that emit radioactive substances into the environment are estimated on the basis of measured or modelled data. The doses received by the population should be lower than the dose constraints set by the competent administrative authority.

This chapter contains a summary of reports on the state of environmental radioactivity on the territory of Slovenia in 2016.

The monitoring of exposure to natural sources of radiation is carried out under the Government's programme for systematic inspection of working and living environments and raising the awareness of the population as regards measures to reduce exposure due to the presence of natural radiation sources. This programme was amended in 2016 and includes industrial activities that deal with materials containing naturally occurring radioactive material. For this reason, in 2016 measurements of radon were conducted and for the first time measurements in industrial activities according to the amended programme.

## 3.1 The Early Warning System for Radiation in the Environment

A nuclear or radiological accident occurring in Slovenia or abroad would also have consequences throughout the country. One of the key tasks in such an event is to provide immediate data on radioactivity in the environment. The successful implementation of protective measures for the population depends on this data. During such an emergency, the population would be exposed to external radiation and inhale radioactive particles from the air and consume contaminated water and food. The Slovenian early warning system regarding environmental radioactivity is an automatic system that instantly detects increased radiation in the environment in the event of an emergency.

## 3.2 Monitoring Environmental Radioactivity

Monitoring of global radioactive contamination due to atmospheric nuclear bomb tests (1951–1980) and the Chernobyl accident (1986) has been carried out in Slovenia for almost five decades. Primarily, two long-lived fission radionuclides, $^{137}Cs$ and $^{90}Sr$, have been monitored in the atmosphere, water, soil, drinking water, foodstuffs, and feedstuffs. Other natural gamma emitters are also measured in all samples, while in drinking water and precipitation the levels of tritium ($^{3}H$) are additionally measured.

The results of the measurements for 2016 showed that concentrations of both long-lived fission products in samples of air, precipitation, soil, milk, foodstuffs of vegetable and animal origin, and feedstuffs continued to slowly decrease.

In Slovenia, the consequences of the releases resulting from the nuclear accident in Fukushima on 11 March 2011 were negligible. Only short-term values of the isotopes $^{131}$I and $^{134}$Cs in the atmosphere and in precipitation were measurable.

The biggest contribution to the radiation exposure of the public due to environmental contamination by artificial radionuclides comes from external radiation and from food ingestion. The inhalation dose from aerosols with fission radionuclides is negligible. In 2016 the effective dose from external radiation of $^{137}$Cs (mainly from the Chernobyl accident) was estimated at about 6.1 µSv, which is 0.24% of the dose received by an average adult in Slovenia from natural background radiation. This value is the same as was measured and calculated in 2015.

The annual dose from the ingestion pathway (the consumption of food and drinking water) was 1.3 µSv, which is slightly less than in the previous year (1.8 µSv). The dose in 2008 was higher due to the higher average values of the radionuclide $^{90}$Sr in the selected samples of vegetables sampled in regions with higher Chernobyl contamination (Figure 13). The contribution of $^{90}$Sr to the annual dose due to ingestion is 74%; the contribution of $^{137}$Cs to the annual dose is 25%, while the contribution of $^{3}$H to the annual dose is 1%. The annual contribution due to the inhalation of these radionuclides is only about 0.001 µSv, which is negligible when compared to radiation exposure from other transfer pathways. The effective dose from drinking water was also estimated, taking into account artificial radionuclides. Calculations have shown that on average this dose is around 0.02 µSv per year. The annual limit value of 0.1 mSv per year due to natural and artificial radionuclides in drinking water from local water supplies was not exceeded in any sample.

In 2016 the total effective dose of an adult in Slovenia arising from the global contamination of the environment with artificial radionuclides (external radiation) was estimated at 7.4 µSv, as shown in Table 4. This is approximately 0.30% of the dose compared to the annual exposure of an adult in Slovenia received from natural radiation in the environment (2,500–2,800 µSv). In the regions with lower radioactive contamination of the soil, such as Prekmurje and the Coastal-Karst region, the corresponding dose is lower, while it is higher in the Slovenian Alpine region.

Considering all the estimated doses specified in this chapter, it should be taken into account that these values are extremely low and cannot be measured directly. The final results are calculated by using mathematical models and are based on measurable quantities of radionuclides, most of which are also low. The measurement uncertainties are therefore considerable and in some cases the results differ considerably from year to year. Most importantly, these values are far below the limit values.

**Table 4: Radiation exposure of the adult population in Slovenia due to global contamination of the environment with artificial radionuclides in 2016**

| Transfer pathway | Effective dose [µSv per year] |
|---|---|
| **Inhalation** | 0.001 |
| **Ingestion:** | |
| **drinking water** | 0.02 |
| **food** | 1.3 |
| **External radiation** | 6.1* |
| **Total (rounded)** | **7.4**** |

* This applies to central Slovenia; the value is slightly lower for the urban population and higher for the rural population.

** Radiation exposure from natural radiation is 2,500–2,800 µSv per year.

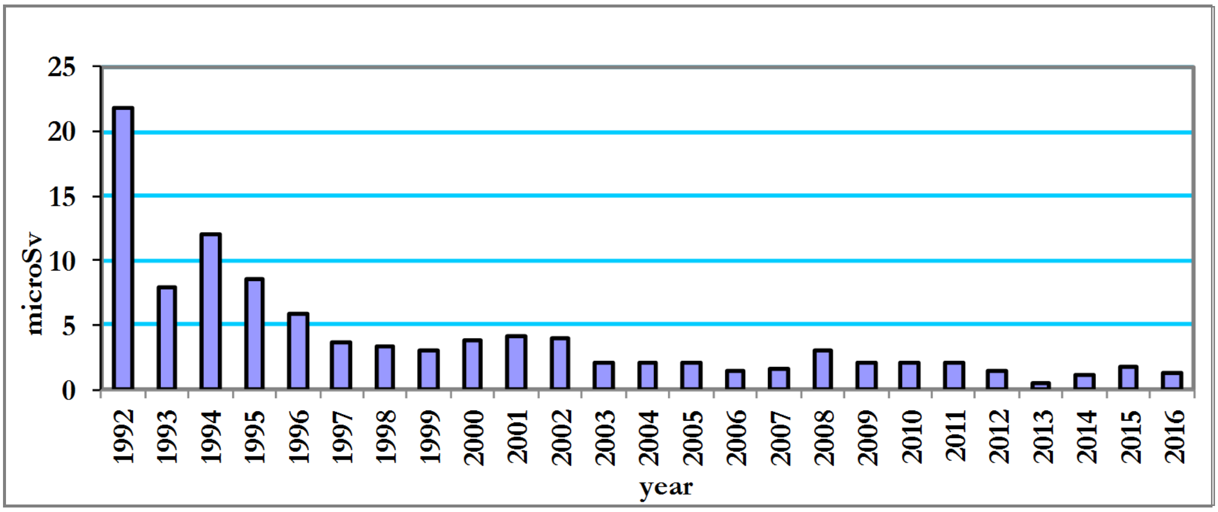


**Figure 13: Annual effective doses of members of the public received by ingestion due to global radioactive contamination of the environment with the radionuclides $^{137}$Cs and $^{90}$Sr in Slovenia**

The reason for the high value in 1992 was that game foodstuffs were taken into account when the dose estimation was calculated. Without those samples, the effective dose for that year would have been lower than 10 μSv.

## 3.3 Operational Monitoring in Nuclear and Radiation Facilities

Each installation or facility that may discharge radioactive substances into the environment is required to be subjected to regulatory control. Radioactivity measurements in the surroundings of the installations are performed already in the preoperational period, during operation, and for a certain period after the installation ceases to operate. The goal of operational monitoring is to establish whether the discharged activities are within the authorised limits, whether radioactivity concentrations in the environment are within the prescribed limits, and whether the radiation doses received by the population are lower than the prescribed dose limits.

### 3.3.1 The Krško Nuclear Power Plant

The radiological situation in the surroundings of the nuclear power plant is monitored by the continuous measurement of gaseous and liquid radioactive discharges and by carrying out radioactivity measurements of environmental samples. The measured values of the analysed radionuclides in environmental samples (in air, soil, surface and underground water, precipitation, drinking water, agriculture products, and feedstuffs) during the normal operation of the plant are low, usually considerably lower than the detection limits of analytical procedures. The impacts of the nuclear power plant on the environment are therefore evaluated only on the basis of data on gaseous and liquid discharges. These discharge data are used as an input for modelling the dispersion of radionuclides in the environment. The low results of the measurements in the environment of the nuclear power plant during normal operation confirm that radioactive discharges into the atmosphere and in aquifers were low. In the event of an emergency, the established monitoring network allows the immediate sampling and analysis of contaminated samples.

In 2016 independent monitoring confirmed that the measurements of discharges performed by the Krško NPP were fully consistent with the results of measurements carried out by the laboratories of the authorised performers of radioactivity monitoring, i.e. the Jožef Stefan Institute (JSI) and the Institute of Occupational Health (IOS).

#### 3.3.1.1 Radioactive Discharges

In 2016 the radioactive discharges from the NPP were mostly lower in comparison with 2015. The reason for this is the elimination of the problems regarding the deterioration of the integrity of the fuel, which in recent years contributed to an increase in emissions.

The activity in gaseous releases is mostly produced by noble gases. In 2016 the total activity of noble gases released into the atmosphere was 1.25 TBq, which resulted in a public exposure of 0.05 μSv, or 0.1% of the limit. Releases were lower than in the previous year, whereas their values were much lower than the prescribed limit values.

10 MBq (calculated to the equivalent of $^{131}I$) of radioactive iodine isotopes were released in 2016, representing 0.05% of the annual limit, which is an order of magnitude less than in 2015 and comparable to 2014. The activity of released radioactive dust particles also decreased and was 0.73 MBq, which is approx. 0.004% of the annual limit. Due to discharges of tritium ($^{3}H$) into the atmosphere, a slight increase in the activity of $^{3}H$ gas emissions was observed from one year to the next due to improvements in the sampling method and laboratory analysis. The release level of tritium ($^{3}H$) into the atmosphere has slowly been stabilised, as expected. The activity of $^{14}C$ corresponds to the typical values.

In liquid discharges from the plant into the Sava River, tritium ($^{3}H$) predominates, bound to water molecules. Total $^{3}H$ activity released in 2016 was slightly higher than in 2015, 19.9 TBq, which is 44.2% of the annual regulatory limit (45 TBq). This value is within the average values in the years when a refuelling outage takes place. Due to its low radiotoxicity, this radionuclide is radiologically less important in comparison to other radioactive contaminants. The activity of other radioisotopes in liquid discharges was slightly lower than in the previous year and amounted to 13.8 MBq or 0.01% of the annual limit (100 GBq). The total discharged activity of $^{14}C$ released into the Sava River in 2016 was 9.2 GBq, which is more than in 2015 and more than expected according to the estimates made on the basis of the literature and international practice. 89% of the total activity was released in the first quarter, which means that the releases in the rest of the year are comparable with previous years. The sample for the first quarter was analysed again by an accredited laboratory, which obtained the same results. However, the reasons for the increase in activity are not known. Nevertheless, the NPP still operates in accordance with its licence. The increased activity of $^{14}C$ in liquid discharges contributes negligibly to the dose received by the local population.

Figure 14 shows the activity of the released $^{3}H$ in liquid discharges from 1983 to 2016.

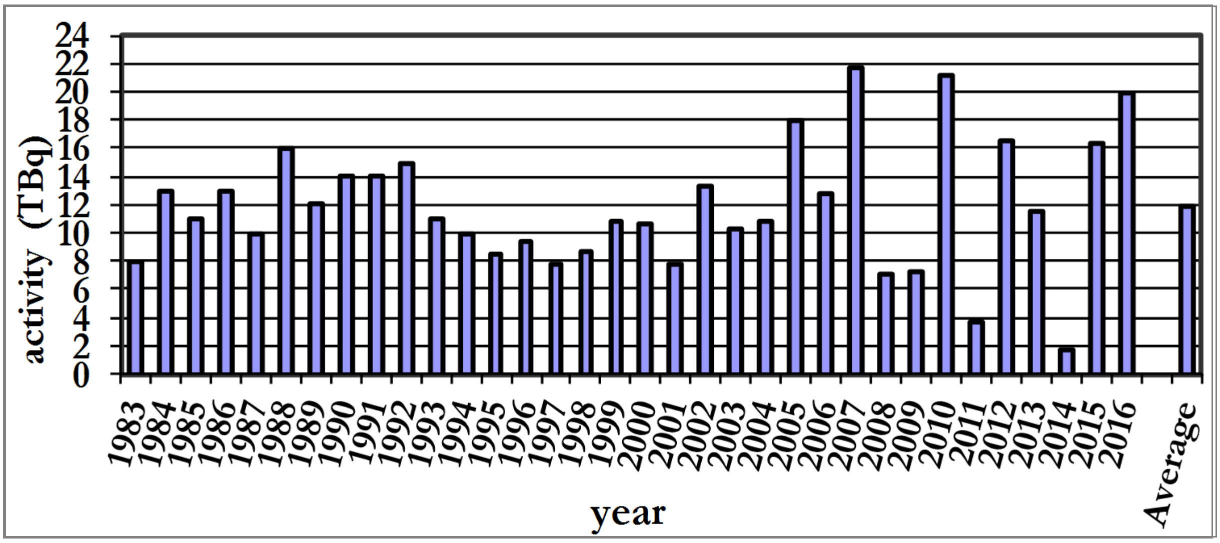


**Figure 14: Activity of the $^{3}H$ released in liquid discharges**

### 3.3.1.2 Exposure of the Public

The programme for monitoring environmental radioactivity from the above-mentioned discharges comprises the following measurements of the concentrations or contents of radionuclides in environmental samples in:

- air (aerosol and iodine filters);
- dry and wet deposition (dry and wet precipitation);
- the Sava River water, sediments and water biota (fish);
- tap water (Krško and Brežice), wells and underground water;
- food of vegetable and animal origin (including milk);
- soil on cultivated and uncultivated areas; and
- measurements of ambient dose equivalents at several locations.

Dose assessment of the public was based on model calculations made by contractors. The calculated dispersion factors for atmospheric discharges, based on realistic meteorological data, showed that the most important pathways for public exposure were the ingestion of food with $^{14}C$, external radiation from clouds and deposition, and the inhalation of air particles with $^{3}H$ and $^{14}C$. The highest annual dose was received by adult individuals due to the intake of $^{14}C$ from vegetable food (0.1 µSv), while a ten-fold lower dose (0.013 µSv) was also received due to the inhalation of $^{3}H$. The dose assessment of liquid discharges in 2016 showed the additional contribution to the population exposure, 0.27 µSv per year, which is one order of magnitude higher than in 2015. $^{14}C$ is still the largest contributor to the total dose from all contributions (97%), where the dominant pathway is the ingestion of fish. It can be noted that all modes of exposure of the population are negligible compared with the natural radiation, dose limits and authorised limits.

Table 5 shows that the estimated total effective dose of an individual who lives in the surroundings of the Krško NPP is less than 0.38 µSv per year. This value represents 0.76% of the authorised limit value (a dose constraint of 50 µSv per year), or 0.015% of the effective dose received by an average Slovenian from natural background radiation (2,500–2,800 µSv per year).

**Table 5: Assessment of the partial exposures of an adult member of the reference public group due to atmospheric and liquid radioactive discharges from the Krško NPP in 2016**

| Type of exposure | Transfer pathway | The most important radionuclides | Effective dose [µSv per year] |
|---|---|---|---|
| External radiation | Cloud immersion | Noble gasses ($^{41}Ar$, $^{133}Xe$, $^{131m}Xe$) | 0.00069 |
| | Deposition | Particulates ($^{58}Co$, $^{60}Co$, $^{137}Cs$, etc.) | 5.8E-9 |
| Inhalation | Cloud | $^{3}H$, $^{14}C$, $^{131}I$, $^{133}I$ | 0.013 |
| Ingestion (atmospheric discharges) | Vegetable food | $^{14}C$ | 0.1 |
| Ingestion (liquid discharges) | Ingestion of fish (from the Sava river) | $^{3}H$, $^{137}Cs$, $^{89}Sr$, $^{90}Sr$, $^{131}I$, $^{14}C$ | 0.27 |
| **Total Krško NPP in 2016** | | | **< 0.38*** |

* The total amount is conservative since all contributions cannot simply be summed up due to different reference groups of the population.

### 3.3.2 The TRIGA Research Reactor and the Central Storage for Radioactive Waste at Brinje

The TRIGA Research Reactor and the Central Storage for Radioactive Waste are both located at Brinje near Ljubljana. The samples irradiated in the reactor are analysed in the laboratories of the Department of Environmental Science of the Jožef Stefan Institute, which are located near the reactor building. Therefore, the radioactive discharges at this location arise from the reactor operation, the Central Storage for Radioactive Waste, and from laboratory activities. Since the operation of the facilities was stable and there were no incidents that resulted in radioactive material being released into the environment, the results of the operational monitoring for 2016 are essentially the same as for the previous year.

Environmental monitoring of the TRIGA Research Reactor comprises measurements of atmospheric and liquid discharges and measurements of radioactivity levels in the environment. The latter are carried out to determine the environmental impact of the installation and include measurements of radioactivity in the air and underground water, as well as measurements of external radiation, radioactive contamination of the soil, and the radioactivity of Sava River sediments.

Measurements of radioactive aerosol discharges into the atmosphere showed results below the detection limit. Discharges of $^{41}$Ar into the atmosphere, calculated on the basis of the reactor operation time, were estimated at 1.0 TBq in 2016, which is comparable to previous years. The measurements of specific activities in the environment showed no radioactive contamination from the operation of the reactor. The external dose due to radiation from the cloud on an individual due to $^{41}$Ar discharges was estimated, similar to previous years, at 0.02 μSv per year, under the assumption that the individual spends 65 hours per year at a distance of 100 m from the reactor when mowing grass or ploughing snow and that he or she stays in the cloud only 10% of the time. An inhabitant of the village of Pšata who lives at a distance of 500 m from the reactor receives 0.54 μSv per year. A conservative assumption was used for the dose assessment for individuals concerning liquid discharges. If river water is ingested directly from the recipient Sava River, the annual exposure is estimated at less than 0.01 μSv per year. The total annual dose for an individual, irrespective of the pathway, is still one hundred times lower than the authorised dose limit (50 μSv per year). The total annual dose of an individual from the public in 2016, irrespective of the model used, is still more than a thousand times lower than the effective dose from the natural background in Slovenia (from 2,500 to 2,800 μSv per year).

The programme for monitoring the environmental radioactivity of the Central Storage for Radioactive Waste at Brinje mainly comprised control measurements of radioactive atmospheric discharges (radon and its short-lived progeny from the storage facility, dug into the ground, coming from the stored $^{226}$Ra sources), radioactive wastewater from the drainage collector and direct external radiation on the outside parts of the storage area. Environmental concentrations of radionuclides were measured in the same way as in previous years, namely in the underground water from two wells, as external radiation at several different distances from the storage area, and as dry deposition on soil near the storage area.

The estimated average radon discharge rate in 2016 was 7 Bq/s, which is, taking into account the measurement uncertainty, similar to the discharge rates in 2009–2016 (Figure 15). The increase in radon ($^{222}$Rn) concentrations in the vicinity of the storage is not measurable and was therefore estimated by a model for average weather conditions to be around 0.37 Bq/m$^3$ at the fence of the reactor site. In the wastewater from a drainage collector, the only artificial radionuclide measured was again $^{137}$Cs, which is a consequence of global contamination and not of storage operation. Even the ground soil in the storage vicinity does not indicate the presence of other radionuclides, except the Chernobyl contaminant $^{137}Cs$ and the natural radionuclides $^{7}Be$, $^{40}K$, as well as radionuclides of the uranium-radium and thorium decay series.

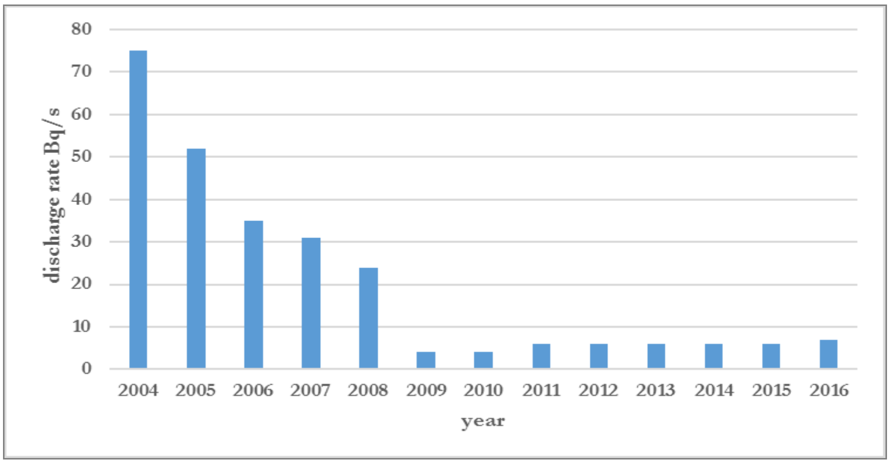


**Figure 15: Discharge rates of $^{222}Rn$ from the Central Storage for Radioactive Waste at Brinje**

For the dose assessment of the most exposed members of the public, the inhalation of radon decay products and direct external radiation from the storage facility were taken into account. The most exposed members of the reference group are the employees of the reactor centre, who could potentially be affected by radon releases from the storage area. In 2016 they received an estimated effective dose of 0.93 µSv, according to the model calculation. A security officer received 0.44 µSv per year from his or her regular rounds, while the annual dose received by a farmer adjacent to the controlled reactor area was estimated to be only about 0.02 µSv. These values are comparable with those in 2015 and are much lower than in 2008, due to lower radon releases. Moreover, they are much lower than the authorised dose limit for individuals from the reference group of the population (100 µSv per year). The annual dose collected by an individual from the natural background is 2,500–2,800 µSv.

### 3.3.3 The Former Žirovski Vrh Uranium Mine

The monitoring of environmental radioactivity consists of measuring radon releases, liquid radioactive discharges, and concentrations of the radionuclides in the environment. An integrated programme of measurements has been implemented, including the radionuclide-specific activities of the uranium-radium decay chain in the environmental samples, including the concentrations of radon and its decay products in the air, as well as external radiation. Measurement locations are set mainly in the settled areas in the valley, up to 3 km from the existing mine radiation sources, from Todraž to Gorenja Vas. For evaluation of the impact of uranium mining and milling, the relevant measurements of radionuclides of natural origin are carried out at reference points outside the influence of mine and disposal site discharges (as an approximation of natural radiation background).

The ratio of the radon concentration on the Jazbec disposal site from the period after the closure of the mine, when closing and regulatory works had not yet been started (1991−1995), and the average contribution of the mine radon in Gorenja Dobrava during this period defines the contribution of mine radon in Gorenja Dobrava in the current year.

In 2015 the Agency for Radioactive Waste Management took over the management and long-term monitoring of the Jazbec disposal site, while the Boršt repository was managed by the RŽV uranium mine. The Jazbec disposal site is no longer a radiation facility. In 2016 a monitoring programme for the Boršt repository was carried out, while the programme at the Jazbec disposal site was implemented to a limited extent, as the new programme for long-term surveillance and maintenance of the landfill has not yet been prepared or approved.

According to the additional contribution to the population dose from the uranium mine in Žirovski Vrh in 2016, the most important part of the programme was measuring the radon concentration and its short-lived progeny.

The radioactivity of surface waters has slowly but steadily been decreasing in recent years. In the Brebovščica stream, where all liquid discharges flow from the mine and both disposal sites, only the uranium concentration was significantly elevated in relation to the natural background.

In 2016 the mine's contribution of radon $^{222}$Rn from other disposal sites to the natural concentrations in the environment was estimated at around 2.7 Bq/m$^3$.

The calculation of the effective dose received by the population took into account the following exposure pathways: the inhalation of long-lived radionuclides from the uranium decay series, radon and its short-lived progeny, ingestion without water contribution (the supply of the population from the public water supply), and external gamma radiation. The radiation exposure of an adult member of the public living in the vicinity of the mine was estimated at 0.059 mSv for 2016, which is slightly less than in the previous year, but still within the uncertainty of the assessment method. The exposure is low due to completed remediation at the mine disposal sites at Jazbec and Boršt and represents approximately one third of the effective dose estimated in the last decade of the 20$^{th}$ century. However, the most important radioactive contaminant in the mine environment remains radon $^{222}$Rn with its short-lived progeny, which contributed 0.057 mSv or 85% of the additional exposure in this environment (estimation for an adult member of the reference public group, see Table 6).

**Table 6: The effective dose received by an adult member of the public living in the surroundings of the former Žirovski Vrh Uranium Mine in 2016**

| Transfer pathway | Important radionuclides | Effective dose [mSv] |
|---|---|---|
| **Inhalation** | – aerosols with long-lived radionuclides (U, $^{226}$Ra, $^{210}$Pb)<br>– only $^{222}$Rn<br>– Rn – short-lived progeny | 0.00<br>0.0014<br>0.057 |
| **Ingestion** | – drinking water (U, $^{226}$Ra, $^{210}$Pb, $^{230}$Th)<br>– fish ($^{226}$Ra and $^{210}$Pb)<br>– agricultural products ($^{226}$Ra and $^{210}$Pb) | (0.0241) *<br>not estimated<br>not estimated |
| **External radiation** | – immersion in deposition (radiation from cloud and deposition)<br>– deposition of long-lived radionuclides (deposition)<br>– direct gamma radiation from disposal sites | 0.0009<br>-<br>- |
| **Total effective dose (rounded):** | | **0,059 mSv** |

* Dose due to the ingestion of water from the Brebovščica stream is not included in the dose assessment because the water is not used for drinking, watering of animals, or irrigation.

The total effective dose for an adult from the reference group amounted to less than one tenth of the general limit value for the population, which is 1 mSv per year. The estimated annual dose received by a 10-year-old child was 0.056 mSv and 0.063 mSv by a 1-year-old child. These values represent about 1% of the natural background dose due to natural background radiation exposure in the environment of Žirovski Vrh during the operation of the mine (5.5 mSv). Annual changes in effective doses due to the mine contribution are shown in Figure 16.

Measurements of the radioactivity and dose estimations for the last several years have shown that the cessation of uranium mining together with the remediation works that have already been carried out have significantly reduced the environmental impact and the exposure of the population. The estimated dose exposure is less than one third of the authorised dose limit of 0.3 mSv per year.

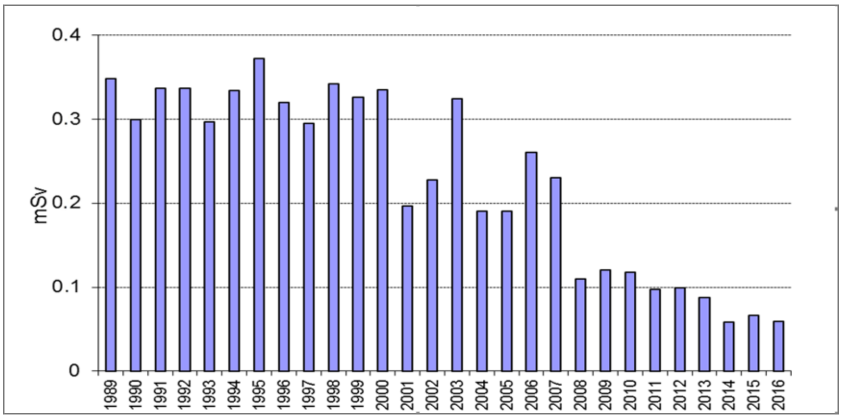


Figure 16: Annual contributions to the effective dose received by an adult member of the public due to the former Žirovski Vrh Uranium Mine in the period 1989–2016

## 3.4 Radiation Exposure of the Population in Slovenia

Every person on Earth is exposed to natural and artificial radioactivity in the environment. A great part of the population receives radiation doses from radiological examinations in medicine, while only a small part of the population is exposed occupationally due to their work in radiation fields or with radiation sources. The term 'external radiation' means that the source of radiation is located outside the body. Internal radiation occurs when radioactive material enters the body by inhalation, the ingestion of food and water, or through the skin. The data on population exposure are presented below, while occupational exposures (to artificial and natural sources), as well as medical exposures, are presented in Chapter 4.

### 3.4.1 Exposure to Natural Radiation

The average annual effective dose from natural sources received by a single individual on Earth is 2.4 mSv, varying from only 1 mSv to up to 10 mSv at some locations. The average annual dose from natural radiation sources received by an average member of the public in Slovenia is about 2.5 to 2.8 mSv. Higher values are found in areas with higher concentrations of radon in living and working environments. Based on the existing data on external radiation and radon concentrations in dwellings and outdoors, it can be estimated that most of the radiation, about 50%, comes from inhaling indoor radon and its progeny (1.2–1.5 mSv per year) in residential buildings. The annual dose from the intake of radioactivity with food and water is about 0.4mSv. The annual effective dose due to external radiation from the radioactivity of soil, building materials in dwellings and cosmic radiation together was estimated to be from 0.8 to 1.1mSv in Slovenia.

### 3.4.2 Programme of the Systematic Inspection of Industrial Activities

Systematic inspection of the working environment must mainly be ensured in areas where the increased exposure of workers or the environment may be expected due to activities involving materials or waste with an increased content of naturally occurring radioactive materials (hereinafter: NORM) or where there is an increased presence of naturally occurring radioactive substances due to technological processing.

In 2016 the measurements of external gamma radiation, specific activities of natural radionuclides in samples of raw materials and measurements of radon concentrations were performed in the working environment of the following production facilities: Lafarge Trbovlje, Knauf Insulation Škofja Loka (stone wool production) and in the factory URSA Novo Mesto (glass wool production). Measurements of the external gamma radiation and radon concentrations in the workplace and of exhibited objects were carried out also at the Slovenian Museum of Natural History and at the National Museum of Slovenia.

The measured values of external gamma radiation in factories were low and comparable to natural values. There was no need to apply additional measures to reduce exposure to natural radionuclide activities by all operators. As expected, the radon concentrations measured in all facilities, in both workplaces and production processes, were lower than the authorised levels.

Low levels of external gamma radiation were measured in the showrooms of the Museum of Natural History and the National Museum. This is due to the removal of all minerals and exhibits that contained a higher concentration of NORM a few years ago. The measurements showed that the largest part of external gamma radiation in showrooms comes from the walls. According to an authorised radiation protection expert, the reason for this lies in the use of building materials containing NORM with increased values.

In addition to these measurements, the SNSA conducted informative gamma dose rate and radon concentration measurements in the basement of the Science and Technical Faculty of the University of Ljubljana, where samples of minerals with a high concentration of NORM are stored. Although there are some sites with locally elevated levels of gamma dose rate radiation, the radiation risk to students and staff of the Faculty is negligible due to adequate radiation protection.

### 3.4.3 Measurements of Radon in Living and Working Environments

In 2016 the Slovenian Radiation Protection Administration (SRPA) continued to implement the governmental programme adopted in 2006 and updated in 2016 for systematic examination of living and working environments, as well as to raise the awareness of the population regarding measures to reduce exposure due to the presence of natural radiation sources. Again, the main focus was on determining the exposure to radon because this radioactive noble gas is generally the main source of natural radiation in living and working environments. On average, it contributes more than half of the effective dose received by individuals from all natural sources of ionising radiation. It penetrates premises mainly on the ground level through various openings, such as manholes, drains, cracks, or tears in the floor.

Through this programme, from April to October 2016 the Institute of Occupational Safety (IOS) carried out measurements using different methods: 89 basic radon measurements using nuclear track detectors for determining average radon concentrations, 11 additional continuous measurements for weekly monitoring of the timing of radon progeny and radon, and four measurements of potential radon sources originating from the soil, shafts, or openings into the rooms. A total of 48 buildings (42 schools and kindergartens, 6 other buildings) were measured. The average radon concentrations exceeded the threshold for the living environment (400 Bq/m3) in 28 rooms in kindergartens and schools out of a total of 82 and in 4 rooms in other buildings out of a total 7. The threshold for a working environment (1,000 Bq/m3) was exceeded in 3 rooms. Effective doses received by staff and children were estimated on the basis of the measurement results and the occupancy time in these buildings. Out of the total of 89 estimated annual doses, 12 exceeded the threshold of 6 mSv for members of the public. The highest estimated dose was around 34 mSv in a basement dwelling in Zdravstveni dom Ribnica due to an average radon concentration of 5,400 Bq/m3. In 19 cases the estimated annual doses were between 2 and 6 mSv, in 24 cases between 1 and 2 mSv, and in 34 cases less than 1 mSv. In some rooms and buildings with excessive levels of radon the measurements are still being performed in the framework of the available financial capabilities.

In 2016 the SRPA conducted 6 in-depth inspections of legal entities that operate facilities with increased levels of radon. A decision ordering measures to reduce radon radiation exposure was issued in 5 cases.

#### 3.4.3.1 Radiation Exposure of the Population Due to Human Activities

Higher radiation doses due to the normal operation of nuclear and radiation facilities are usually received only by the local population. The exposures of particular groups of the population that are a consequence of radioactive discharges from these facilities are described in Chapter 3.3. In Table 7, the annual individual doses are given for the maximally exposed adults from the reference groups for all objects in consideration. For comparison, an average annual dose received by individuals stemming from the global radioactive contamination of the environment (nuclear tests and the Chernobyl accident) is also shown. The highest exposures of the population are recorded for individuals living in the surroundings of the former uranium mine in Žirovski Vrh. The exposures were estimated as amounting to a maximum of 5% of the exposure from natural sources in Slovenia. The exposure of members of the public in no case exceeded the dose levels defined by the regulatory limits.

The population is exposed to radiation also due to other human activities. These exposures come mainly from deposited materials with enhanced natural radioactivity and originate from past industrial or mining activities, related mostly to the mining and processing of raw materials containing uranium or thorium. For more, see Chapter 3.4.2 above.

**Table 7: Exposures of adult individuals from the reference population group**

| Source | Annual dose [mSv] | Regulatory dose limit [mSv] |
|---|---|---|
| **Žirovski Vrh Uranium Mine** | 0.059 | 0.300* |
| **Chernobyl and nuclear weapon tests** | 0.03 | / |
| **Krško NPP** | < 0.00038 | 0.050** |
| **The TRIGA Research Reactor** | 0.00054 | 0.050 |
| **The Central Storage for Radioactive Waste** | 0.00002 | 0.100 |

* Limitation after the final remediation of the Žirovski Vrh Uranium Mine (mine pit and both disposal sites at Jazbec and Boršt).

** Due to radioactive discharges.

# 4 RADIATION PROTECTION OF WORKERS AND MEDICAL EXPOSURES

Due to occupational exposure, individuals can receive substantial doses of ionising radiation. Therefore, organisations that carry out radiation practices should optimise work activities to decrease the dose of ionising radiation to a level as low as reasonably achievable (ALARA). Exposed workers must take part in regular medical surveillance programmes and receive adequate training. Employers have to ensure that the received dose of ionising radiation is assessed for every worker performing specific activities.

The Slovenian Radiation Protection Administration (SRPA) manages the Central Records of Personal Doses (CRPD). All approved dosimetry services report monthly to the CRPD on the external exposure of all exposed workers and annually or semi-annually for internal exposures to radon.

The approved dosimetry services for 2016 were the Institute of Occupational Safety (IOS), the Jožef Stefan Institute (JSI), and the Krško Nuclear Power Plant (Krško NPP). IOS was approved for the assessment of radon exposure in mines and Karst caves. Currently, 15,319 persons have a record in the central registry, including those who have ceased to work with sources of ionising radiation. In 2016 the dosimetry service at the IOS took measurements of individual exposures for 4,247 workers, whereas the JSI monitored 1,916 radiation workers and the Krško NPP monitored 1,141 radiation workers. The Krško NPP performed individual dosimetry for 406 plant personnel and 735 external workers, who received an average dose of 0.66 mSv of ionising radiation. As for other work sectors, workers in industrial radiography received the highest average annual effective dose of 0.75 mSv from external radiation, while employees in medicine received an average of 0.21 mSv. The highest average value among these, 0.58 mSv, was recorded for workers in nuclear medicine.

In 2016 the highest collective dose from external radiation was received by workers at the Krško NPP (518 man mSv), followed by air crews (280 man mSv), workers in the medical sector (248 man mSv), industry (45 man mSv,) and other activities (29 man mSv).

Since 2010, the data on doses received by radiation workers who took part in NPP outages abroad and data on doses of Adria Airways flight personnel who are exposed to cosmic radiation have been included in the CRPD. In 2016 the collective dose for 10 workers in foreign NPPs was 30 man mSv (an average dose of 2.98 mSv). During flights, 233 workers were exposed to cosmic radiation, receiving an average dose of 1.20 mSv and a collective dose of 280 man mSv.

The highest doses are received by workers exposed to radon and its progeny. In 2016, out of 201 tourist workers, 3 workers received a dose between 15 and 20 mSv, 30 workers received a dose between 10 and 15 mSv, 35 workers received a dose between 5 and 10 mSv, 72 workers received a dose between 1 and 5 mSv, and 61 workers received a dose less than 1 mSv. The highest individual dose was 17.88 mSv. The collective dose was 913 man mSv, with an average dose of 4.5 mSv. Tourist workers in Karst caves are the category of workers most exposed to ionising radiation in Slovenia.

The findings of a study on the exposure of individuals in Karst caves, financed by the SRPA, show that the doses of tourist workers in Karst caves due to radon exposure, assessed according to the ICRP (International Commission for Radiation Protection) 65 model, are underestimated. Due to the high unattached fraction of radon progeny in the atmosphere of the Karst caves, the ICRP 32 model should be used and an approximately two-times higher dose factor should be taken into account. Therefore, received doses from radon and its progeny are assessed according to the ICRP 32 model in this report. Doses calculated in such a manner are thus twice as high as those calculated according to the ICRP 65 model.

At the Žirovski Vrh Uranium Mine, 7 workers received a collective dose of 0.62 man mSv, whereas the average individual dose was 0.09 mSv.

The distribution of workers in different work sectors by received dose interval (mSv) is shown in Table 8.

**Table 8: The number of workers in different work sectors by dose interval (mSv)**

| Sector | 0–MDL | MDL≤E<1 | 1≤E<5 | 5≤E<10 | 10≤E<15 | 15≤E<20 | 20≤E<30 | E≥30 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Krško NPP | 356 | 612 | 169 | 4 | 0 | 0 | 0 | 0 | 1,141 |
| Industry | 431 | 77 | 13 | 1 | 0 | 0 | 0 | 0 | 522 |
| Medicine and veterinary medicine | 2,817 | 1,130 | 47 | 0 | 0 | 0 | 0 | 0 | 3,994 |
| Flights | 0 | 67 | 166 | 0 | 0 | 0 | 0 | 0 | 233 |
| Other | 1,370 | 275 | 2 | 0 | 0 | 0 | 0 | 0 | 1,647 |
| Radon | 0 | 68 | 72 | 35 | 30 | 3 | 0 | 0 | 208 |
| Abroad | 0 | 3 | 4 | 3 | 0 | 0 | 0 | 0 | 10 |
| **Total** | **4,974** | **2,232** | **473** | **43** | **30** | **3** | **0** | **0** | **7,755** |

MDL – minimum detection level

E – effective dose in mSv received by an exposed worker

## Training of exposed workers using sources of radiation

The education level of workers using sources of radiation is in accordance with regulations. Minor deficiencies were found regarding the timely updating of knowledge and skills in the field of ionising radiation protection. Training, refresher courses, and tests were carried out by the approved technical support organisations, namely the IOS, d. o. o., and the JSI. In 2016 a total of 1,675 participants attended courses on ionising radiation protection.

## Targeted medical surveillance

Medical surveillance of radiation workers was performed by the physicians of five approved institutions:

- The Clinical Institute of Occupational, Traffic and Sports Medicine, Ljubljana;
- The IOS, Ljubljana;
- Aristotel, d. o. o., Krško;
- The Krško Health Centre; and
- The Škofja Loka Health Centre.

Altogether, 3,531 medical examinations were carried out. Among the examined workers, 3,043 fully fulfilled the requirements for working with sources of ionising radiation, whereas 425 fulfilled the requirements with limitations. 15 candidates temporarily did not fulfil the requirements, and 5 did not fulfil the requirements. 9 workers did not fulfil the requirements and other work was proposed for them. In 34 cases an evaluation was not possible.

**Diagnostic Reference Levels for diagnostic radiological procedures**

X-ray examinations that are implemented in accordance with good radiological practice provide a radiogram that contains all the information necessary for a correct diagnosis at the lowest exposure to patients. In 1996 the International Commission on Radiological Protection introduced the concept of the Dose Response Rate (DRR) to promote the optimisation of radiological procedures. The level of patients' exposure during an individual examination in each radiology department or when using a single X-ray device can be assessed by comparing the average exposure in this department or X-ray device to a DRR value obtained on the basis of the relevant regional or local data.

The use of DRR allows the identification of X-ray devices in which the typical exposure of patients substantially exceeds the expected values. Focusing on the optimisation of interventions on these devices leads to an improvement in radiological practices and reduces patients' exposure. The use of DRR is more efficient when national DRR values are applied. Thus, following a five-year data collection project on the exposure of patients undergoing X-ray examinations in Slovenia, DRR values for fifteen X-ray examinations were presented in 2006. Due to changes in technology and professional guidance, it is necessary to regularly review DRR. Updates provide information on the exposure of patients. Radiological companies must evaluate these data at least every five years. At the same time, these data provide a good overview of the state of optimisation of radiological procedures in Slovenia. Concurrently, Slovenia continues to participate in projects of the International Atomic Energy Agency. These projects are entitled RER-9-132 and 9-135-RER, within which the IAEA intends to establish diagnostic reference levels for paediatric patients in radiological procedures with computed tomography and participates in the development of international diagnostic reference levels for the selected interventions, with an emphasis on paediatric patients.

When issuing a license for radiation practices or a license for the use of a radiation source in medicine, the level of exposure for each X-ray device or group of such devices is compared to DRR values. If the average exposure for each examination is greater than the DRR, the SRPA requires the optimisation of that radiological procedure. Although this process is important for all radiological procedures, greater attention is devoted to procedures with high patient exposure, e.g. interventional procedures and computed tomography.

In nuclear medicine, rather than a DRR, the recommended activities of the administered radioisotope are used. Due to the small number of departments of nuclear medicine in Slovenia, developing national values is not sensible, so international recommendations, mainly the recommendations of the ENMA, the European Association of Nuclear Medicine, are used instead, taking into account the technical characteristics of each imaging device. The SRPA checks typical amounts of administered activity when approving the programmes of radiological procedures. In addition, in 2011 systematic reviews of typical values of the administered activity for all major examinations in all seven nuclear medicine departments were also conducted within the framework of the "Dose DataMed2" project.

## 4.1 Exposure of patients during radiological procedures

The use of ionising radiation in medicine is the main contributor to population exposure due to the use of artificial sources of ionising radiation. Slovenia assessed the contribution to the total dose received by patients in diagnostic procedures in medicine in 2010 and 2011 within the framework of the project Dose DataMed2, which was carried out under the guidance of the European Commission. The results of the study show that the average inhabitant of Slovenia receives about 0.7 mSv per year from medical procedures. The most important contribution comes from computed tomography (CT), which contributes about 60% of the total dose.

Classical X-ray diagnostics contributes about 20%, while interventional procedures and examinations in nuclear medicine contribute approximately 10%. The results show that the exposure of the population in Slovenia is slightly below the European average, which is 1 mSv per year per capita.

Due to the increasing role of X-ray diagnostics in modern medicine and on the basis of trends in other developed countries, a further increase in population exposure is expected due to medical use of ionising radiation. Therefore, the SRPA carries out activities to improve the application of the principles of justification and optimisation, with particular attention devoted to examinations with computed tomography and interventional procedures. In the scope thereof, the SRPA actively takes part in establishing the Clinical Institute of Radiology at the University Medical Centre in Ljubljana as an international competence centre for quality in diagnostic and interventional radiology with the aim of operating as a reference centre for other institutions in Slovenia. These activities are carried out in the framework of IAEA projects No. RER-6-028 and RER-6-032. In addition, the SRPA, together with the Clinical Institute of Radiology of the University Medical Centre in Ljubljana and the Institute of Occupational Safety, d. o. o., as an authorised institution that carries out external quality checks of X-ray devices, hosted a regional training programme in 2016 for medical physics experts entitled Regional Training Course on QA / QC and Diagnostic Radiology and the Digital Era within the framework of International Atomic Energy Agency project No. RER/6/032. The training programme was attended by 21 participants from 11 countries; 9 participants were from Slovenia. At the same time, they are also experts who have led training programmes, as foreign participants highlighted the high level of system verification and quality assurance, which was seen during the practical work at the Clinical Institute of Radiology. The experts leading the training course as well as other foreign participants acknowledged the high level of radiation protection and quality assurance demonstrated by the Clinical Institute of Radiology.

Another key principle of the use of ionising radiation in medicine is the principle of justification. Numerous international studies have shown that 30% or more of diagnostic radiological procedures may be unreasonable or inappropriate. This leads to the unnecessary exposure of patients and at the same time represents an additional economic burden on the healthcare system. The implementation of this principle has therefore increasingly been taken into account in recent years. As the most appropriate solution seems to be the use of the referral criteria, especially in conjunction with an electronic ordering system and digital systems for clinical support when directing patients. Unfortunately, the referral criteria and the mentioned support systems are not yet established in Slovenia. In order to assess the implementation level of this principle in practice, in November 2016 the SRPA carried out systematic monitoring at five Slovenian health institutions within the framework of co-ordinated action by the competent administrative authorities of many European countries. The findings suggest that at least in the case of referrals for interventions resulting in the largest doses (computerised tomography imaging and intervention procedures), all referrals should be examined by doctors before an intervention is made. The doctors can then bear the responsibility for the clinical radiological procedure. This provides a good basis for ensuring eligibility for referral, but unfortunately the inadequate clinical information provided by the referring doctors is often a serious obstacle to better implementation. These deficiencies should be eliminated with more complete fulfilment of referrals and/or a unified health information system, such as is already used by several European regions and countries.

# 5 MANAGEMENT OF RADIOACTIVE WASTE AND IRRADIATED FUEL

In Slovenia, the greatest amount of low- and intermediate-level radioactive waste (over 95%) is generated from the operations of the Krško NPP. The rest is produced in medicine, industry, and research activities. The only high-level radioactive waste (HLW) is the spent nuclear fuel (SNF) from the Krško NPP and the TRIGA Research Reactor. A special category of waste is spent sealed radioactive sources produced by small holders, which are stored in the Central Storage for Radioactive Waste in Brinje.

## 5.1 Irradiated Fuel and Radioactive Waste at the Krško NPP

### 5.1.1 Management of Low- and Intermediate-Level Waste

The total volume of waste accumulated by the end of 2016 amounted to 2,271 $m^3$, with the total gamma and alpha activity of the stored waste amounting to $1.71 \cdot 10^{13}$ Bq and $2.52 \cdot 10^{10}$ Bq, respectively. In 2016 the equivalent of 51 standard drums containing solid waste was stored. As of 31 December, the total beta-gamma and alpha activity of the stored radioactive waste was $5.79 \cdot 10^{8}$ Bq and $2.04 \cdot 10^{6}$ Bq, respectively.

Figure 17 shows the accumulation of low- and intermediate-level radioactive waste in the Krško NPP storage. Periodic volume reductions, which are a consequence of compression, super-compaction, incineration, and melting, are shown. After 1995, the accumulation of waste volume was reduced as a result of a new in-drum drying system (IDDS) for evaporator concentrate and spent ion exchange resins.

In 2006, a super-compactor was installed in the storage facility at the Krško NPP, which thus began the continuous super-compaction of its radioactive waste. In 2015 and 2016 there was no super-compacted newly generated radwaste.

Radwaste for incineration and melting is temporarily transferred to the Decontamination Building due to the lack of space in the storage facility near the super-compactor. In 2016, 260 packages of compressible waste were already stored for the next shipment to Sweden.

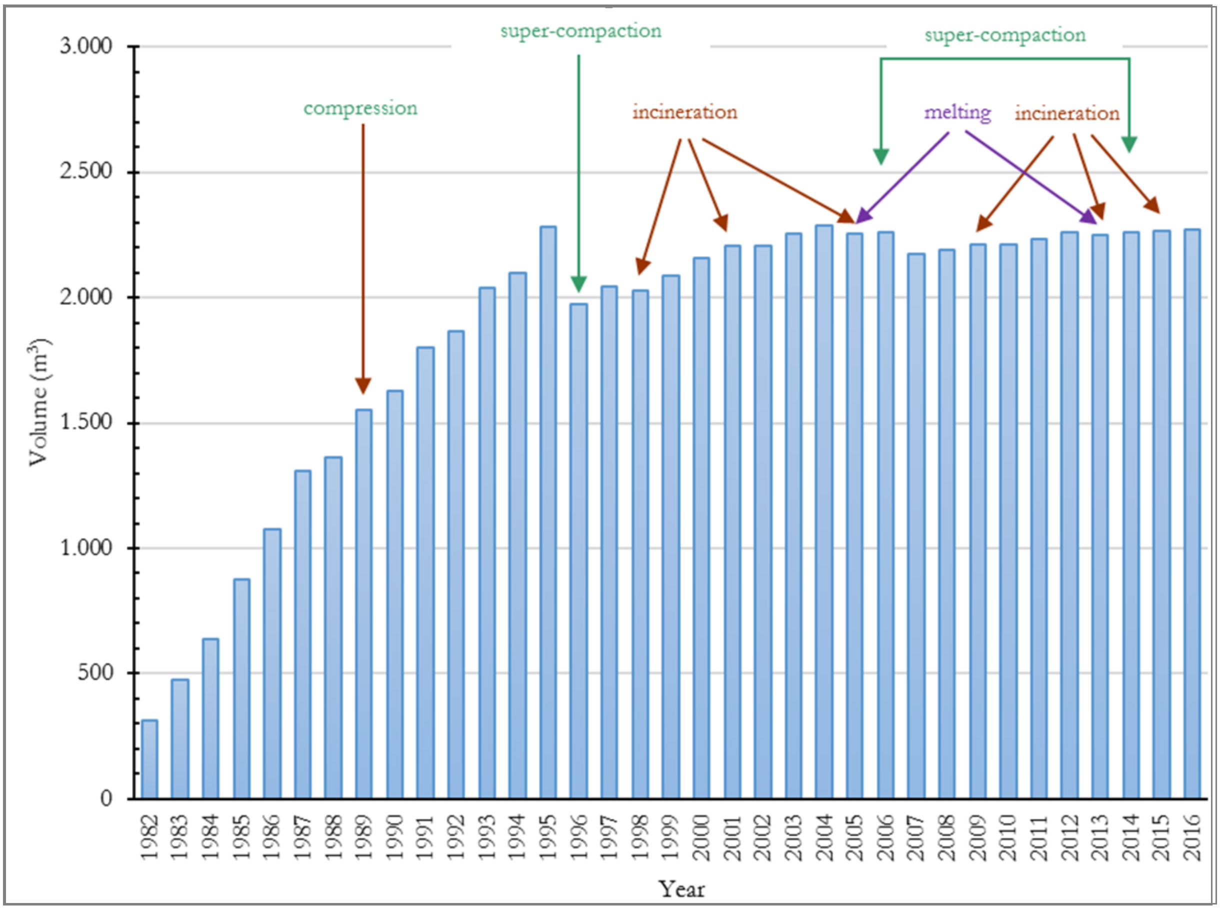


**Figure 17: The accumulation of low- and intermediate-level radioactive waste in the Krško NPP storage**

In 2013, the Krško NPP began to design a facility for handling equipment and the shipment of radioactive cargoes, as the occupancy storage of radioactive waste reached 95% of the available storage capacity in 2012. The new building will mitigate the problems caused by delays in the construction of the repository for low and intermediate level waste. The new building will ease the storage problems due to delays in the construction of the final repository for low- and intermediate-level waste.

In 2016 the construction of the first part of new building started. The new structure will enable the removal of the measuring equipment and super-compactor from handling space in the radwaste storage. This measure will result in additional space (5%), which will be reserved for emergencies. This method of reorganisation of the storage should provide the NPP with enough space for the storage of radioactive waste up to 2020. Thus, for normal operation of the NPP after 2020 it is essential that the activities regarding the construction of the repository be accelerated.

### 5.1.2 Management of Spent Fuel

All spent fuel in the Krško NPP is stored in the spent fuel pool with 1,694 cells. As of the end of 2016, the total number of spent fuel assemblies in the spent fuel pool amounted to 1,210 – including two special canisters with damaged fuel rods.

The number of annually spent fuel assemblies and the total number of such elements in the pool are shown in Figure 18.

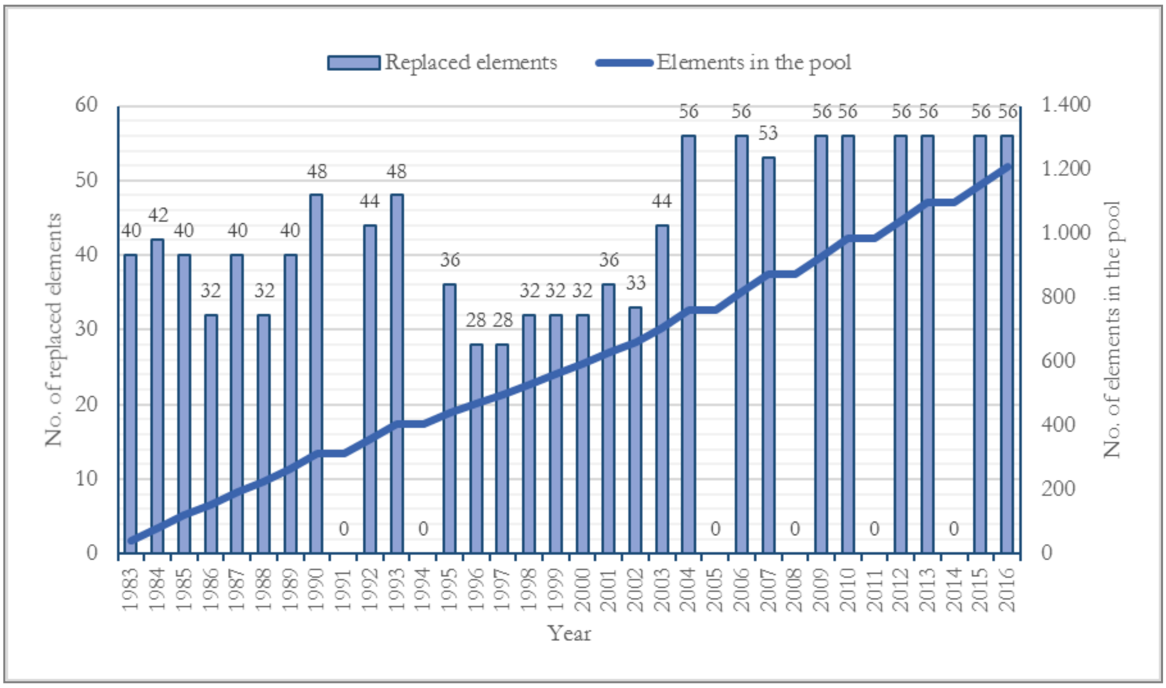


**Figure 18: The number of annually spent fuel assemblies and the total number of such elements in the pool of the NPP**

### 5.1.2.1 Dry storage of spent fuel

In December 2015, the Krško NPP prepared a document entitled "Technical Specification – Spent Fuel Dry Storage Construction", which was the officially published documentation aimed at selecting a vendor for the required equipment and an entity to carry out the project. The design of the dry storage envisaged in the specification encompasses at least 60 years of operational life. After the completion of the public procurement procedure, the Krško NPP selected the company HOLTEC (from the USA) as the most advantageous bidder. One of the non-selected bidders, i.e. the company AREVA (from France) filed a complaint with the National Review Commission for Reviewing Public Procurement Award Procedures (hereinafter: the National Review Commission).

Due to the complaint, based on doubt vis-à-vis the technical characteristics of the selected bid, the National Review Commission addressed technical-expert questions to the SNSA in mid July 2016. The SNSA was not able to be involved in the described process because it had not collaborated during the procedure for the selection of the equipment vendor; the SNSA would only be able to participate in the process as an independent regulator for nuclear and radiation safety in the later phases, concerning the licensing for the projected facility. The SNSA was only able to send a list of certified experts in nuclear and radiation safety who assess various technical questions through their expertise. The procedure at the National Review Commission had not finished by the end of 2016. It was finished in the first months of 2017.

The whole entanglement due to the complaint in the public procurement process lasted approximately eight months and for at least this amount of time the foreseen construction and beginning of operation of the dry storage for spent fuel at the Krško NPP were postponed. As dry storage is safer than storing spent fuel in a pool, such delays also indirectly influence nuclear safety, either diminishing it or affecting its further improvement.

## 5.2 Radioactive Waste at the Jožef Stefan Institute

Approximately 40 litres of spent ion exchange resins, 200 litres of activated or contaminated experimental and protective equipment and 100 litres of aluminium irradiation containers are produced yearly during the operation of the reactor, as well as from the work in the hot cell and controlled areas of the Department of Environmental Sciences. The Radiation Protection Unit of the Institute collects spent radioactive material in the temporary storage in the hot cell facility. After repacking, treatment (compression), and detailed characterisation, the material is declared radioactive waste. Jožef Stefan Institute annually produces about 2 drums (< 0.5 $m^3$) of solid radioactive waste.

In 2016 the Radiation Protection Unit of the Institute handed over to the Central Storage Facility at Brinje 8 packages of radioactive waste with a total volume of 0.7 $m^3$ and a total mass of 266 kg. The waste originated mostly from the activities of the past years.

There are 7 drums of metal and wood contaminated with naturally occurring radioactive material (NORM) temporarily stored at the location of the Reactor Centre in Brinje. The waste material was produced during the decontamination and decommissioning of buildings used for the processing of uranium ore, which took place from 2005 until 2007.

## 5.3 Radioactive Waste in Medicine

The Institute of Oncology in Ljubljana has appropriate holding tanks to decrease the activity of waste liquids through decay. The tanks are emptied every four months after approved radiation protection experts carry out preliminary measurements of specific activities. Adequate temporary storage of radioactive waste has also been arranged in the new building of the Institute of Oncology. The Clinic for Nuclear Medicine at the University Medical Centre in Ljubljana has not built a system for holding liquid waste, but, according to IAEA doctrine, such systems are not considered to be justified due to the minimal influence the liquid waste has on the health of the population and the environment. In other hospitals in Slovenia only daily treatments are applied and thus systems for holding liquid waste are not necessary.

Disused sealed radioactive sources are returned to the producer or transferred to the Agency for Radwaste Management. Radioactive waste with short-lived radionuclides are stored in a special storage until clearance levels are reached and then disposed of as normal waste.

## 5.4 The Commercial Public Service of Radioactive Waste Management

The Agency for Radwaste Management (ARAO) is responsible for providing the public service of radioactive waste management.

Within the public service of the management of radioactive waste from small producers, in 2016 the ARAO ensured regular and smooth collection of radioactive waste at its place of origin, its transport, treatment, and preparation for storage and disposal, and management of the Central Storage Facility, as described in Chapter 2.1.3.

For processing radioactive waste, the ARAO can independently use the premises of the hot cell facility which is part of the Triga Mark II Research Reactor at the Jožef Stefan Institute.

In 2016 the ARAO accepted 155 packages of radioactive waste from 95 producers, namely 17 packages of solid waste, 11 packages of sealed radiation sources and 127 packages of ionisation smoke detectors. The total volume of the stored radioactive waste was 4 $m^3$. As of the end of 2016, there were 832 packages stored as follows:

- 463 packages of radioactive waste (solid waste, sorted according to compressibility, combustibility, shape and size);
- 223 packages of sealed radiation sources; and
- 146 packages of ionisation smoke detectors.

The total activity of 92.9 $m^3$ of stored radioactive waste as of the end of 2016 was estimated to be 2.8 TBq, with a total weight of 52.6 tonnes.

In 2016 4,518 pieces of ionising smoke detectors, mostly with the radionuclide $^{241}Am$, were transported from the CSRW into the hot cell facility. The ionisation smoke detectors were disassembled into radioactive and non-radioactive parts. The contaminated housing of such smoke detectors were packed in the standard manner and accepted in the CSRW. Non-radioactive components that meet the conditions for unconditional clearance of radioactive substances were handed over to waste management companies.

At the beginning of 2016, the ARAO accepted in the CSRW four drums (210 litre drums) of solidified radioactive waste with radionuclide $^{3}H$ originated from the solidification of liquid radioactive waste accepted in December 2015. One of the drums of previously solidified waste was supplemented with solidified liquid waste with radionuclide $^{14}C$, which was accepted in December 2016 and solidified in 2016. The barrel also contains contaminated glass waste.

A licence for the implementation of the long-term monitoring and maintenance of the Jazbec mine waste pile was issued to the ARAO on June 3, 2015. At the end of 2015, the ARAO began the public service of management, implementing long-term surveillance and maintenance of the area of the piles of mine waste and hydrometallurgical tailings produced by the extraction of nuclear mineral raw materials. In connection therewith, the Regulation on the Method, Objective and Conditions of the Mandatory Public Service of Long-term Monitoring and Maintenance of the Repository of the Waste Pile and Mill Tailings Produced by the Extraction of Nuclear Mineral Raw Materials was adopted on 9 October 2015.

In 2016 the ARAO carried out monitoring of the Jazbec mine tailings disposal site (overlay, drainage ditches, flow of water below the landfill) and minor maintenance, such as cleaning drains, and cleaning undergrowth next to the fence of the repository. The mowing of the vegetative cover on the Jazbec mine tailings disposal site was carried out, and the grass was collected in order to maintain a green cover and consequently the integrity of the repository overlays.

The Safety Report for the Jazbec mine tailings disposal site provides long-term monitoring and maintenance after the five-year transitional period. Monitoring is carried out in order to detect any changes in the repository. It includes radiological, physicochemical, and geodetic measurements.

Geodetic measurements after the five-year transitional period on the Jazbec mine tailings disposal site showed adequate stability and minimal movement in the horizontal direction. For this reason, geodetic measurements in accordance with the Safety Report in the context of long-term surveillance are not carried out every year and in 2016 were not performed.

## 5.5 Disposal of Radioactive Waste

The work programme and the ARAO financial plan for 2016 were approved by the Government in May 2016, while a contract with the Krško NPP Fund was concluded in July 2016. In 2016 work on activities related to the preparation of documents for obtaining approvals and permissions for the repository for low- and intermediate-level radioactive waste (LILW) took place in all areas. The project documentation concept for the environmental impact assessment process was completed in early 2016. Revision of the project documentation for the construction and creation of reference documents for the draft safety report for the LILW repository was carried out as well. The environmental impact report was reviewed; therefore, the environmental impact assessment process and obtaining environmental approvals are planned for 2017. Further details of these activities are described below.

In the design phase for the LILW repository it was confirmed that the previous studies were of sufficient quality and extent, so in 2016 additional research was not carried out. As part of the project, the research data that are to be used for potential upgrades of the hydraulic, hydrological, and geological models are being obtained for the wider area of the LILW repository.

In 2016 the project of obtaining a building permit for the LILW repository was prepared separately for the repository facilities, the preparatory work (fills and dykes), and the infrastructure facilities. A review of the project documentation required to obtain the building permit was carried out. Opinions regarding the revision of the project documentation required to obtain the building permit for the LILW repository were written. This revision process has not yet been completed since additional experts are needed to review the strength calculations. Tender and implementation documentation for the preparatory work was prepared. The project documentation for the implementation was appropriately reviewed in accordance with the regulatory requirements and internal regulations and submitted in final form. In parallel with the preparation of the project documentation for the repository, all necessary activities for the certification of the concrete container for packaging waste are being carried out. Construction of the first prototype of a container intended for testing and calibrating computational models of the container was prepared at the end of 2016.

In 2016 work on the project for preparing safety analyses and acceptance criteria continued. A new revision of certain reports regarding operational safety and security following the closure of the repository was prepared.

Within the framework of the multi-phase project Safety Analysis (SA) and Waste Acceptance Criteria (WAC) preparation for Low- and Intermediate-Level Waste Repository in Slovenia, work to complement the existing acceptance criteria in relation to the development of the project for the LILW repository was continued. A new revision report on the inventory of radioactive waste in Slovenia and an assessment report providing for the possibility of the repositioning of the planned inventory were prepared.

The design basis for the draft safety report, which is in the final stage of preparation, was prepared and reviewed. The basis for the selection of an approved person for the acquisition of professional opinions was prepared. The environmental impact assessment report was reviewed and harmonised; it will be completed with the draft safety report.

In 2016 the project for the realisation of preparatory works for the LILW repository was prepared. This comprises construction of the reinforcement dyke on which the repository facilities are to stand. Due to the delay in the preparation of the necessary documentation, a tender for carrying out preparatory works for the LILW repository was published at the end of 2016. Construction works will begin in 2017.

## 5.6 Remediation of the Žirovski Vrh Uranium Mine

### Hydro-metallurgical tailings at the Boršt site

The remediation of the Žirovski Vrh Uranium Mine has been in progress since 1992. Both the uranium processing plant and the mine, together with the various accompanying objects, have been successfully decommissioned.

The majority of remediation work on the Boršt hydrometallurgical tailings was successfully concluded, but a non-stable landslide beneath the Boršt disposal site has prevented its final closure. 2016 was the 6$^{th}$, additional, year of the envisaged five-year transitional period for the Boršt hydrometallurgical tailings disposal site. Sampling, measurements, control of the overall state, maintenance, collecting and storing information, record keeping, the preparation of reports for the authorities, etc., were carried out. An assessment of the overall state of the remediated mine facilities was performed and even intensified at the request of the mine inspectorate because the rock base of the Boršt disposal site is still moving. In 2016 the reconstruction of the passageway of the tunnel under the landfill was carried out, in addition, a portion of specific interventional drainage measures were executed and will continue in 2017.

An inspection of the concrete lining of the passageway of the tunnel, the shotcrete lining of the entrance of the tunnel, and the landslide beneath the Boršt disposal site was carried out. In addition, the functioning of the drainage wells was assessed and the movement of the landslide was measured by a special extensometer placed in a tunnel. The situation has even worsened. In the area of thrust out distance of the landslide the deformations of the lining continued, as was the case also regarding the floor panels and the spacing between the injection-moulded concrete coverings.

In 2015 the contractor Geotrias, d. o. o., prepared a study entitled "Spread modelling of the hydrometallurgical tailings of the Boršt disposal site in the event of a complete collapse of the disposal site". In the study, the distribution of tailings in the event of an extraordinary event (e.g. intensive rain or an earthquake) was assessed. On the basis of the study, the Ministry of the Environment and Spatial Planning (MESP) ordered an additional study on the radiation exposure of residents and the workers who would carry out remediation of the deposited material on the riverbeds of the Todražica, Brebovščica, and Poljanska Sora Rivers, which was prepared by INKO svetovanje, d. o. o. On the basis of the results of both studies, the Ministry of the Environment and Spatial Planning decided to implement the emergency drainage measures proposed by the professional project board.

In June 2016, the external contractor GRO – Inženiring started to carry out remediation work in the passageway of the tunnel under the hydrometallurgical tailings of the Boršt site. First, remediation of the damage to the passageway of the tunnel passing through the sliding surface was carried out. Subsequently, the remediation of the damaged lining of the passageway of a tunnel was also carried out. The work was completed in July 2016.

In August 2016, the external contractor Pavčnik, d. o. o., started to implement emergency drainage measures in the passageway of the tunnel under the hydrometallurgical tailings of the Boršt site. First, the external contractor made three boring chambers for the needs of drainage wells. 17 drainage wells will be executed with a total length of 1,455 metres. This work entails emergency drainage measures and is based on the proposal of the professional project board and was requested by the Commission for Technical Inspection.

Monitoring the stability of the Boršt disposal site is an important task of the transitional five-year and long-term period. After the final settlement of the Boršt disposal site and the end of remediation activities, the conditions for appropriate periodic geodetic monitoring as well as continuous online monitoring by means of a GPS system at the Boršt disposal site will be achieved.

Financing of the activities of the RŽV uranium mine from the budget was covered by a contract for the financing of the company's operations with MESP. Details of this monitoring project can be found in Chapter 3.3.3.

**Jazbec mine waste pile**

The Jazbec mine waste pile was closed in 2015. The mining rights were deleted from the mining registry for the area of the site. Since the end of 2015, the area which comprises the landfill of the disposal site has become a object of the national infrastructure and is managed by the ARAO, which gained a mandate therefor from the State. The landfill has not been a radiation facility since 2015. The closure of this disposal site is important for radiation safety due to the deposited material with raised concentrations of natural radionuclides. Therefore, the mandatory public service of long-term control and maintenance was established. The Agency for Radioactive Waste (ARAO) was determined as the operator of all plots of the Jazbec mine waste pile by the Government of the Republic of Slovenia in its decision of 23 February 2016.

Details on the implementation of the commercial public service for radioactive waste management and long-term supervision and maintenance can be found in Chapter 5.4.

## 5.7 The Fund for Financing the Decommissioning of the Krško NPP and the Disposal of Radioactive Waste from the Krško NPP

The Fund for Financing the Decommissioning of the Krško NPP and Disposal of Radioactive Waste from the Krško NPP (hereinafter: the Fund) was established pursuant to the Act on the Fund for Financing the Decommissioning of the Krško NPP and Disposal of Radioactive Waste from the Krško NPP.

The Fund is not financed from the national budget; the operational costs are covered from income from the Fund's operation. GEN energija, d. o. o., is liable to pay contributions for the decommissioning of the Krško NPP and the disposal of radioactive waste from the Krško NPP to the Fund in the amount of EUR 0.003 per kWh electrical energy produced in the NPP and sold in Slovenia.

The above-mentioned levy is based on calculations determined in the Programme of the Decommissioning of the Krško NPP (hereinafter: the Programme) prepared in 2004. According to Article 10 (3) of the Treaty between the Government of the Republic of Slovenia and the Government of the Republic of Croatia on the regulation of the status and other legal relations regarding investment in, exploitation of, and the decommissioning of the Krško Nuclear Power Plant governing the co-ownership of the Nuclear Power Plant, the Programme has to be reviewed every five years. The revision was to be completed by the end of 2009 and 2014, (every five years), but it had not been finished and approved by the end of 2016. The assumptions for the repository changed in the meantime, therefore the revision must be completed as soon as possible. The fact that the revision of the Programme has been delayed was also noted by the Court of Audit.

### 5.7.1 Proceeds from the contributions for decommissioning

In 2016 the Fund paid to the ARAO a total of EUR 1.6 million. From 1998 until the end of 2016, the Fund paid a total of EUR 38.8 million to the ARAO for the activities implemented by the ARAO. This amount includes compensation to the local municipality of Krško totalling EUR 14.9 million.

In 2015 the Decree on the criteria for determining the compensation rate due to the restricted use of areas and intervention measures in nuclear facility areas entered into force. This Decree superseded the Decree issued in 2008. The Fund is obliged to pay compensation for the limited use of land just to the Krško municipality, where the LILW repository will be located.

In 2016 the Fund paid EUR 5.7 million to the municipality of Krško as compensation for the limited use of land in the area of the nuclear facility.

Since 2004 municipalities have received EUR 37.7 million as compensation for the limited use of land.

The contribution is defined on the basis of levying half of the electrical energy produced in the Krško NPP. The company GEN energija, d. o. o., paid a total of EUR 8.14 million into the Fund in 2016. With that contribution for the decommissioning of the Krško NPP the company fully and within the agreed deadline fulfilled all its obligations to the Fund.

From 1995 to 2016 the Fund received a total of EUR 177.4 million from the Krško NPP and GEN energija, d. o. o.

Figure 19 shows the assets of the Fund as of 31 December 2016:

- EUR 195.2 million represents the financial portfolio (the data relates to the book value and does not include unallocated funds in the transactional account, interest accrued, interest purchased, and claims to dividends in the amount of EUR 1.7 million);
- Since 1995 municipalities and the ARAO have received EUR 76.5 million (assets paid to co-finance the activities of the ARAO and assets paid to municipalities as compensation for the limited use of land in the amount of EUR 69.2 million are not valorised). Payments made to the ARAO and municipalities account for 43.1% of the Fund's financial portfolio.

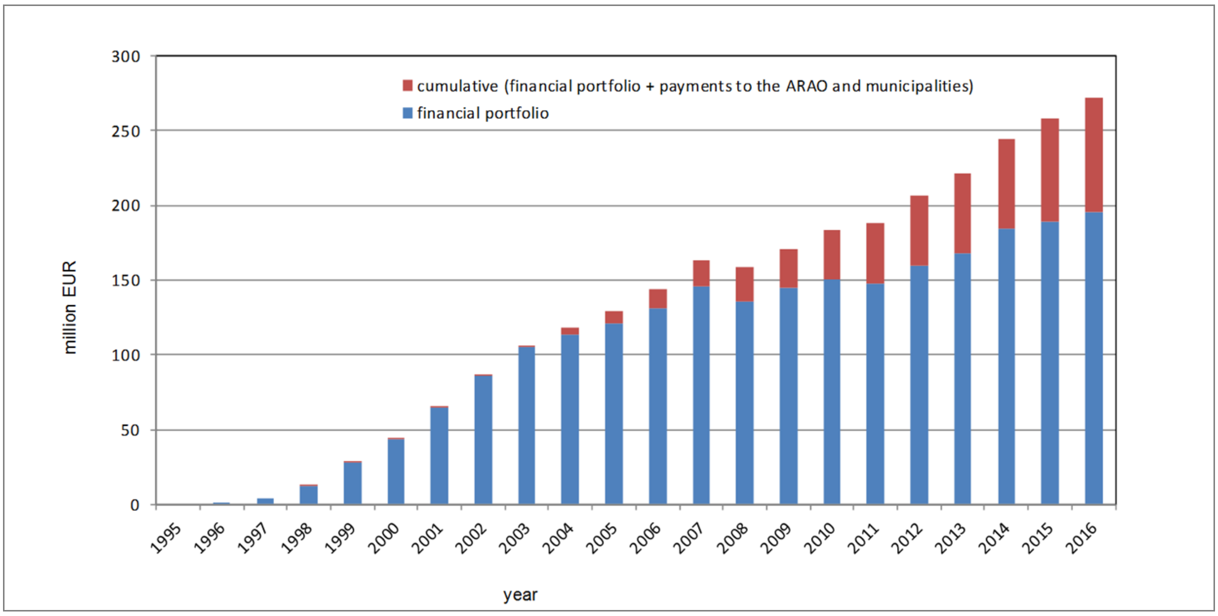


**Figure 19: Total assets of the Fund in euro millions as of 31 December 2016**

### 5.7.2 Investments and business operations in 2016

The assets of Fund increased by EUR 5.9 million (3.1%) from EUR 190.9 million as of the end of 2015 to EUR 196.9 million as of the end of 2016. Taking into account funds in the transactional account, interest accrued, interest purchased and dividends, the assets of the Fund as of the end of 2016 amounted to EUR 196.9 million. As of 31 December 2016, the Fund managed EUR 195.2 million in securities – book value. The book value does not include unallocated funds in the transactional account amounting to EUR 30,400 interest accrued, interest purchased and dividends in the amount of EUR 1.7 million. In its investment policy for 2016, the Fund mainly planned investments in safe investments grades.

The share of debt securities rose from 79.37% to 86.48%, whereas the share of equity securities decreased from 20.63% to 13.52%. The Fund decreased investments in the key investment grade of government securities, in the segment of equity mutual funds and exchange-traded funds, whereas investments in the segment money market funds, corporate bonds, and debt mutual funds increased. A significant increase in investment was recorded in the class of corporate bonds, such as in the class of bond mutual funds and ETFs.

Transactions in the segment of debt securities were a response to turbulent events in the capital markets, which led to negative interest rates on European Government Bonds. In this situation, corporate bonds were the most favourable and profitable choice. Despite good macroeconomic and microeconomic indicators, the Fund decreased its share of equity securities due to the finding that the evaluation on stock markets are significantly higher than the multi-annual average.

In 2016, due to such management, the Fund significantly reduced the risk of the portfolio. Primarily market, interest rate, and loan risks are considered. The market risk of the portfolio is evaluated by means of the value-at-risk method. As of 31 December 2015, the one-day 95% VaR was EUR 719,300, or 0.38% of the portfolio's value, and as of the end of 2016, the one-day 95% VaR was EUR 455,200, or 0.23% of the portfolio's value. The interest rate risk of the portfolio is evaluated with simulations, where changes in interest rates effect the portfolio value. For the present, we are in a period of low interest rates, which is foreseen to continue in the Euro area. Consequently, the interest rates of government bonds are low. In 2016 the yield of 5-year bonds significantly decreased. An average increase in interest rates of 1.0% (100 basis points) would lower the value of the portfolio by 2.0%, whereas an average decrease in interest rates of 0.5% would lead to a 1.06% increase in the value of the portfolio. In managing the loan risk, the credit ratings of the leading global credit rating agencies (Moody's and Standard & Poor's) are used. In accordance with the investment policy, the Fund invests in investments of investment fund class.

In 2016 the Fund created EUR 12.6 million of income, which is 1% more than the previous year. In respect of income from interest and dividends, all paid interest, dividends, and other payments are included. The Fund created EUR 4.5 million of income, which is at a similar level as in 2015.

Expenses reached EUR 7.7 million, which was 18.27% lower than in 2015. The Fund had a surplus of income over expenses in the amount of EUR 4.9 million due to lower implementation of expenses. This surplus derived from lower expenses in 2016. The realisation of the surplus of income over expenses for 2016 was 60.03% higher than in 2015.

As of the end of 2016, the expenses of managing the portfolio in relation to the total value of the financial portfolio amounted to 0.21%. The share is relatively low due to the decrease in expenses from 0.44% in 2001. Notwithstanding the successfulness of managing the portfolio, the expenses of the Fund's operation are at a similar level in comparison to the financial portfolio at the end of each year.

In 2016 the Fund received EUR 154.4 million from repayments of granted loans (due investments) and assets from sold equity shares. The granted loans and the increase in equity shares amounted to EUR 159.6 million, which is EUR 5.1 million more than the received repayments of granted loans.

In 2016 the return of the portfolio, calculated on the bases of the internal rate of return (IRR), was 2.9%. The annual return of the portfolio since 2004 is shown in Figure 20. The average return of the portfolio (GEOMEAN) for the period from 2012 to 2016 is 5.2% and 3.5% for the period from 2004 to 2006. The return of the portfolio was negative two times, the first time in 2008 due to the global financial crisis and the second time in 2011 due to the restructuring of the portfolio and the European debt crisis.

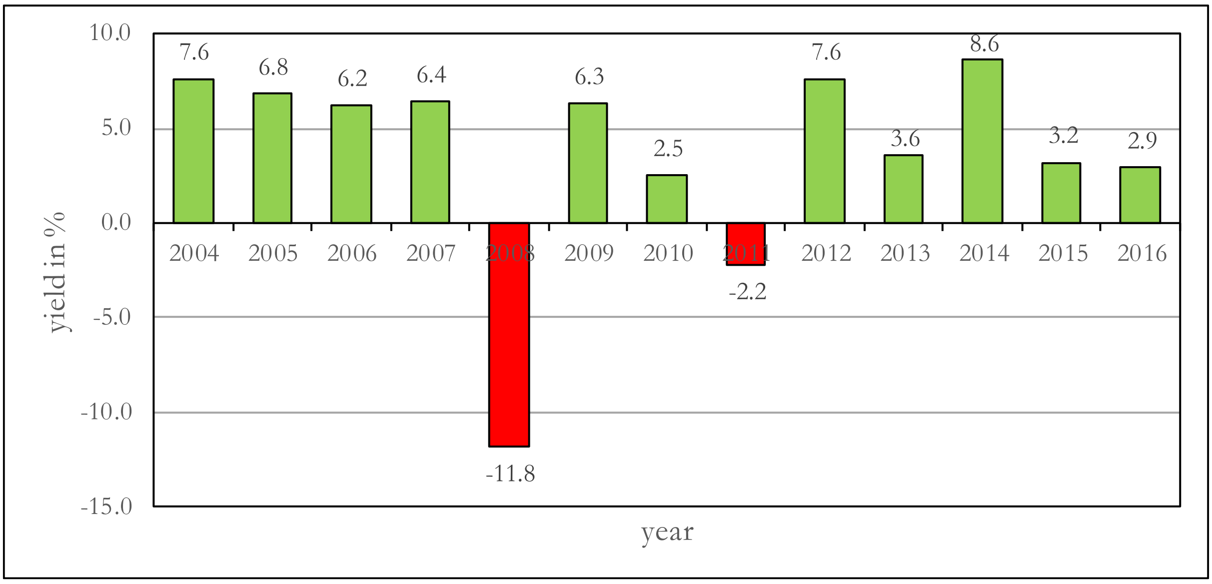


**Figure 20: The yield of the portfolio of the Fund from 2004 to 2016 in %**

In 2008 all equity securities, investments, and mutual funds that are listed on the stock exchange or whose market price is publicly available were valorised to fair value in accordance with the Accounting Act. This valorisation was in accordance with the amendments to the Rules on Breaking Down and Measuring Revenues and Expenses of Legal Entities under Public Law (Official Gazette RS, No. 120/2007). In 2010, debt securities were valorised for the first time, which was also in accordance with the above-mentioned Rules.

Primarily, the Fund must ensure the security of its assets (with a conservative investment policy), but at the same time it has to monitor the situation on the financial markets and fulfil the obligations defined by law, taking into account the following principles: safety, liquidity, diversification, and profitability. Thus, all important risks were successfully managed in 2016 as well.

## 5.8 Achieving the goals under the Resolution on the National Programme for Radioactive Waste and Spent Nuclear Fuel Management

Below there follows a summary of the implementation of the individual strategies under the *Resolution on the National Programme for Radioactive Waste and Spent Nuclear Fuel Management for the 2016–2025 Period* (ReNPRRO16–25).

**Strategy 1:** *The prime responsibility for radioactive waste management in nuclear and radiation facilities rests with the holders of operating licensees. Radioactive waste is to be managed in accordance with the approved safety analysis reports for the operation of individual nuclear facilities. Storage is to be implemented for the purpose of efficient and secure phased disposal at the LILW repository. In the field of radioactive waste management, the strategy promotes the concept of the clearance of radioactive materials from regulatory control in accordance with the prescribed criteria in order to avoid unnecessary generation of radioactive waste.*

**Achieving the goal:** The radioactive waste at the Krško NPP, the TRIGA Research Reactor, and the CSF is managed in accordance with the operating licenses and requirements of the safety analysis reports. The concept of the clearance of radioactive materials from regulatory control is applied. The building for handling equipment and radioactive waste packages at the Krško NPP is under construction.

**Strategy 2:** *After the radioactive material is no longer in use, its users are to hand it over to the SGEI provider of radioactive waste management, return it to the supplier/manufacturer, or hand it over to another contractor carrying out a radiation practice. The radioactive material can be reprocessed or reused even if it is already stored in the CSF. The use of alternative methods in activities, where this is possible, is encouraged.*

**Strategy 3:** *The users of sealed radiation sources will, as a rule, return the used devices containing sealed radiation sources to the supplier/manufacturer. Failing that, sealed radiation sources are to be delivered to the SGEI provider of radioactive waste management and stored in the CSF. The clearance of radioactive material from regulatory control is recommended in accordance with the prescribed criteria in order to avoid the generation of excessive amounts of radioactive waste. Transitional liquid radioactive waste is to be managed according to the "dilute and disperse" principle: the waste is diluted with water and dispersed into the sewerage system in accordance with the prescribed limit values for release into the environment.*

**Strategy 11:** *The discharge of radioactive waste into the environment is to be carried out in accordance with the prescribed limits for individual nuclear or radiation facilities and radiation practices, whereby the holder of the radioactive waste must ensure that the release of liquid and gaseous radioactive waste into the environment is controlled and minimised within the prescribed limits. An increase in the prescribed limits is not envisaged.*

**Achieving the goal:** Performers of radiation activities transfer the sources after they stop using them to the CSF, operated by the ARAO, or return them to the foreign supplier. The ARAO performs the state public service of radioactive waste management. The periodic safety assessment of the CSF is ongoing. Discharges of radioactive effluents into the environment were within the permitted limits. The concept of the clearance of radioactive materials from regulatory control is applied.

**Strategy 4:** *This strategy concerns the construction of the LILW repository, the disposal of the current LILW inventory in the repository as soon as possible, and the temporary closure of the repository. After the Krško NPP has ceased to operate, the repository is to be re-opened and, after all LILW has been disposed of, again closed. The conditioning of all LILW for disposal is to be carried out in the Krško NPP.*

**Achieving the goal:** These activities are performed; unfortunately, delays are accumulating and the start of operations has been shifted into the future. Details are available in Chapter 5.5.

**Strategy 5:** *Spent fuel from the Krško NPP is to be stored in the spent fuel pool and the spent fuel dry storage facility at the location of the power plant. The holder of the spent fuel is to examine the possibility of spent fuel processing. The SGEI provider of the radioactive waste management is to monitor and actively participate in international and especially European developments in the field of the treatment, reprocessing, and final disposal of spent fuel or HLW generated from spent fuel reprocessing, and implement activities for the construction of its own spent fuel and HLW repository.*

**Achieving the goal:** The storage of spent fuel in the Krško NPP is performed without any complications in the spent fuel pool, while the preparations for the construction of dry storage are ongoing. The ARAO, as the public service provider for radioactive waste management, monitors the activities and is included in international activities in this area.

**Strategy 6:** *The Programme for the Krško NPP Decommissioning and the Programme for the Disposal of LILW and Spent Nuclear Fuel are to be periodically revised in accordance with the Bilateral Slovenian-Croatian Agreement on the Krško NPP. In addition to the strategy of immediate dismantling, preparations for the revision of the decommissioning programme should also include an analysis of the possibility of a deferred dismantling strategy after the standby period following the shut-down of the Krško NPP.*

**Achieving the goal:** Unfortunately, this goal has not been achieved because there is still no agreement with the Republic of Croatia on the continuation of the preparation of both documents. Details are available in Chapter 9.5.

**Strategy 7:** *All LILW resulting from the decommissioning of the TRIGA Research Reactor will be disposed of in the LILW repository in Vrbina, Krško. The spent fuel generated by the TRIGA Research Reactor is to be either repatriated to the state of origin or managed together with the spent fuel generated by the Krško NPP.*

**Achieving the goal:** This goal will be met after the decommissioning of the TRIGA Mark II Research Reactor.

**Strategy 8:** *Slovenia is to maintain the operation of the CSF for radioactive waste that is not generated from 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 disposal of radioactive waste from the CSF in the LILW repository, the need for the continuation of the operation of the CSF is to be re-examined. After the final clearance and elimination of the need for storage, the facility is to be decontaminated and handed over for other purposes.*

**Achieving the goal:** The CSF operated without any complications.

**Strategy 9:** *The Jazbec mine tailings disposal site and the Boršt hydrometallurgical tailings disposal site are to be closed. After their closure, the two disposal sites are to be subject to long-term monitoring and maintenance by the Agency for Radioactive Waste Management (ARAO) as the provider of radioactive waste management as an SGEI.*

**Achieving the goal:** The Jazbec disposal site is closed; the ARAO assumed long-term surveillance and monitoring. At the Boršt disposal site remediation works that will enable closure and transfer to long-term surveillance in 2017 or 2018 were performed.

**Strategy 10:** *Materials that are usually not regarded as radioactive but which contain naturally occurring radionuclides are to be regularly monitored in terms of their impact on the population and the environment. If the permissible impacts are exceeded, measures are to be taken to rectify the situation. Radioactive waste containing naturally occurring radionuclides is to be managed in accordance with the established level of radioactivity and other waste properties.*

**Achieving the goal:** Activities are ongoing and described in Chapter 3.4.2 and 3.4.3.

**Strategy 12:** *The State is to maintain and update the legislative and institutional framework, ensure the research and development required for the implementation of the national programme and provide information to the public on progress in the implementation of this programme.*

**Achieving the goal:** The strategy is ongoing; the details can be found in Chapter 7.1 and 7.2.

# 6 EMERGENCY PREPAREDNESS

Emergency preparedness is an essential part of the comprehensive system for ensuring a high level of nuclear and radiation safety. During a nuclear or radiological emergency, all competent organisations in Slovenia must take appropriate actions according to emergency plans.

The response to a radiation emergency in Slovenia is defined in the National Emergency Response Plan for Nuclear and Radiological Accidents. The Administration for Civil Protection and Disaster Relief (ACPDR) has a leading role in dealing with emergencies, whereas the Slovenian Nuclear Safety Administration (SNSA) gives advice and makes recommendations.

## 6.1 The Slovenian Nuclear Safety Administration

At the SNSA, the responsibility for emergency preparedness and response falls under the Emergency Preparedness Division.

In an emergency the SNSA emergency team is activated, led by the emergency team director. There are 19 positions in the team, working in two shifts per day.

Since tasks during an emergency mostly differ from regular work, the training of the emergency team members is very important. Therefore, the SNSA conducted 50 individual and group training exercises, tests, and exercises totalling 106 hours in 2016. The SNSA also participated in the regular annual emergency exercise of the Krško NPP and in several international exercises, e.g. ConvEx.

In order to improve preparedness for nuclear and radiological emergencies, Slovenia invited the EPREV (Emergency Preparedness REView) mission, which will be carried out in November 2017. With the aim of preparing the participating organisations in Slovenia for a mission and implementing improvements before the mission itself, the SNSA, in cooperation with the ACPDR, conducted a simulation of the EPREV mission (see Chapter 6.4).

In the area of emergency preparedness, the SNSA regularly cooperates with other organisations in the country and abroad. In this manner, i.e. the transfer of lessons learned and good practices, its preparedness constantly improves.

## 6.2 Administration of the RS for Civil Protection and Disaster Relief

In accordance with its statutory powers, the Administration for Civil Protection and Disaster Relief (ACPDR) maintained and ensured preparedness and developed procedures for the effective response of the system for protection against natural and other disasters to nuclear and radiological emergencies in 2016.

In 2016 the ACPDR adopted a new Threat Assessment regarding Nuclear or Radiological Emergencies, version 2.0, drawn up together with the SNSA. The assessment consists of three parts. The first part is the Threat Assessment in the Event of an Emergency at Nuclear Facilities and due to Radioactive Substances, prepared by the SNSA in August 2016, the second part is the Criteria for the classification of municipalities and regions by threat in the event of a nuclear emergency at the Krško NPP, also prepared by the SNSA. The third part is the Criteria for the classification of municipalities by threat of radiological emergency, which were analysed in August 2015 by the SNSA in the Risk Assessment regarding nuclear and radiological emergencies in Slovenia.

The Ministry of Health, the Agency of the Republic of Slovenia for Commodity Reserves, and the Krško NPP carried out activities regarding the protective measure of ensuring iodine prophylaxis. All potassium iodide tablets, also those in the national commodity reserves, which are intended for all residents in the country, as well as those that were pre-distributed, have expired. Since the usable life of the potassium iodide tablets from the national reserves was not extended, the Institute for Commodity Reserves in 2016 began to purchase new ones. The NPP also joined in the purchase, for it also provides tablets for pre-distribution. Tablets will be purchased and then exchanged for the expired ones with all those residents who have already received tablets in accordance with the Plan for the Distribution of Potassium Iodide Tablets in the Event of a Nuclear or Radiological Emergency, probably in the first half of 2017.

The ACPDR still maintains a website, www.kalijevjodid.si, where visitors can obtain more information on tablets, the iodine thyroid blocking protective action, and pre-distribution.

In 2016 the ACPDR, together with the SNSA, conducted a simulation of the EPREV mission (see Chapter 6.4).

In parallel with the preparations for the EPREV mission, the ACPDR also participated in the revision of the National Emergency Response Plan for Nuclear and Radiological Accidents, which mostly refers to the new IAEA standard GSR Part 7 (General Safety Requirements – GSR).

## 6.3 The Krško NPP

In 2016 the activities of the Krško NPP in the area of preparedness for emergencies included the following:

- training, drills, and exercises;
- maintenance of support centres, equipment, and communications;
- updating of the document "Krško NPP Protection and Rescue Plan", procedures, and other documentation; and
- replacing staff and appointing new members to the emergency organisation.

The training of licensed personnel whose activities are related to nuclear safety, and personnel who have to refresh their knowledge in compliance with Slovenian legislation was fully performed as planned. Furthermore, the staff of the Krško NPP actively cooperated with the planners and providers of protection and rescue services at the local and national levels, as well as with the administrative authorities, namely the SNSA and the ACPDR.

## 6.4 Simulated EPREV

On the initiative of the Inter-Ministerial Commission for monitoring the implementation of the National Emergency Response Plan for Nuclear and Radiological Accidents, the Government of Slovenia invited an EPREV (Emergency Preparedness REView) mission. This is a review mission in the field of preparedness for nuclear and radiological emergencies, organised by the International Atomic Energy Agency (IAEA), which will be carried out in 2017. The mission is an important step towards improving the preparedness and response to nuclear or radiological emergencies. In order to improve the preparedness of organisations involved in the mission, the Inter-Ministerial Commission decided to simulate a mission before it is carried out officially. The results of the simulated mission in the form of an Action Plan are also a part of the Slovenian self-assessment for the mission.

The simulated EPREV mission was carried out as a two-week mission in May 2016 and was conducted according to a programme, and a review of documents, interviews, and visits, all in accordance with the guidelines of the IAEA EPREV. A total of 35 interviews, including 29 at individual locations, were carried out. 77 participants were interviewed and 14 visits to the sites were carried out.

The findings of the simulated mission, presented in a final report on the simulated EPREV mission, were the basis for an Action Plan for the improvement of the emergency preparedness and response in Slovenia issued by the Inter-Ministerial Commission and approved by the Government.

## 6.5 Achieving the Goals of the Resolution on Nuclear and Radiation Safety

**Goal 10**

*In the use of nuclear energy and radiation activities in the Republic of Slovenia, emergency preparedness and response are appropriately ensured so that in the event of such the impact on people and the environment is minimal.*

**Realisation in 2016**

From the above, it can be concluded that with regard to the use of nuclear energy and radiation-implementing activities in the Republic of Slovenia, the SNSA has appropriately addressed the issue of emergency preparedness and response. The Inter-Ministerial Commission for coordinating the implementation of the national plan meets regularly and is responsible for directing and coordinating preparedness at the national level.

# 7 SUPERVISION OF RADIATION AND NUCLEAR SAFETY

## 7.1 Education, Research, Development

In 2016 no major changes in education, research, and development regarding nuclear and radiation safety occurred.

### 7.1.1 Achieving the Goals of the Resolution on Nuclear and Radiation Safety

The objectives in education, research, and development that should be achieved in the

2013–2023 period, as foreseen in the Resolution, are the following:

**Goal 9**

*The system of authorised experts enables optimum expertise in the decision-making of regulatory bodies on radiation and nuclear safety, with the producer or applicant bearing the costs of the preparation of an expert opinion.*

**Realisation in 2016**

The SNSA regularly gathers data from major funders (leaving aside the main nuclear facilities and state authorities) on how the funds are being disbursed to Slovenian organisations, in particular, authorised experts in the field of nuclear and radiation safety. The total amount for applied projects and research studies in 2014 was nearly EUR 5 million, while in the years 2015 and 2016, the total funds jumped to more than EUR 7 million primarily due to work on the project regarding the repository for radioactive waste in Vrbina. Of this amount, approximately EUR 1.5 million per year was spent directly on research activities.

Since the average cost of one expert, 1 FTE (FTE - Full Time Equivalent) is approximately EUR 65,000 per year, the figures above indicate that the nuclear profession outside nuclear facilities and state authorities receives sufficient funds to finance around 100 professionals, of which approximately 22 directly for research activities. This level of funding contributes to the maintenance of professional competence in the country and provides assistance in making important decisions in the field of nuclear safety. Financing is now left to the market and individual contracts between investors and contract operators. In order to ensure steady and sufficient coverage of all areas of nuclear and radiation safety in the country, it would be useful to draw up a broader strategy of research and development in the field of nuclear safety, which would form the basis for the selection of research areas in tenders issued by the Slovenian Research Agency and a point of reference in concluding individual contracts for the development needs of individual clients.

Unfortunately, the appropriations in 2016 were insufficient to finance the training of authorised experts, development studies, and independent expert reviews and international cooperation, as envisaged by the Ionising Radiation Protection and Nuclear Safety Act.

**Goal 11**

*Slovenian educational institutions offer study programmes whose graduates, after gaining appropriate additional training, can secure important positions in organisations where they can ensure nuclear safety.*

**Realisation in 2016**

No major changes in this area were achieved in 2016.

At the Faculty of Mathematics and Physics of the University of Ljubljana, the Department of Physics conducted a two-stage *Nuclear Engineering* master's degree programme. In the 2016/17 school year, 6 students were enrolled in this program, who together with three 2$^{nd}$ year students are attending four modules of the Nuclear Engineering Programme, while about half of the additional credits are acquired through courses of other study programmes. Due to financial savings, lectures are only held for 8 courses and even for those only in a cyclical mode, i.e. they are carried out every second year. In 2016 four graduates successfully completed a Master's Degree in Nuclear Engineering. The study programme was carried out by teachers who are members of the Jožef Stefan Institute, the Faculty of Electrical Engineering, and the Faculty of Mechanical Engineering. All participate in the programme in the context of additional employment or contracts with the Faculty of Mathematics and Physics. No permanent position for a nuclear engineering professor was available at the University of Ljubljana.

There are 15 students in the doctoral programme *Mathematics and Physics* within the module *Nuclear Engineering*, most of them employed at the Jožef Stefan Institute. In 2016 two students finished PhD studies.

In 2016 Slovenia (i.e. the Jožef Stefan Institute) assumed the presidency of the ENEN (*European Nuclear Education Network*), which brings together the majority of European universities and institutes dealing with higher education in the field of nuclear technology and promotes the exchange of students and teachers between European institutions. In 2016 the title of *European Master of Science in Nuclear Engineering*, awarded by the ENEN, was first awarded to a student from Slovenia; this individual holds a master's degree in Nuclear Engineering from the University of Ljubljana and completed one semester of his education abroad.

It is estimated that in the current situation in Slovenia the scope of studies and the number of students roughly correspond to the needs of the profession. It should be noted that each year some engineers take up the field of nuclear technology after coming from other technical science faculties; they typically obtain an education in the nuclear field after employment.

**Goal 12**

*In the Republic of Slovenia, stable conditions for the financing and implementation of research and educational activities in the field of nuclear and radiation safety are established by which a "critical mass" of experts that can competently cover all key aspects of the safe use of nuclear energy and ionising radiation sources is ensured.*

**Realisation in 2016**

The activities carried out in this area are described under Goal 9.

## 7.2 Legislation

The most important piece of legislation in the field of nuclear and radiation safety in the Republic of Slovenia is the Ionising Radiation Protection and Nuclear Safety Act. The Act was adopted in 2002 (ZVISJV, Official Gazette RS, No. 67/02). It was amended for the first time in 2003 (Official Gazette RS, No. 24/03 – ZVISJV-A), for the second time in 2004 (Official Gazette RS, No. 46/04 – ZVISJV-B), for the third time in 2011(Official Gazette RS, No. 60/11 – ZVISJV-C) and for the fourth time in 2015 (Official Gazette RS, No. 74/15 – ZVISJV-D).

In 2016 one decree and five rules within the narrower field of nuclear and radiation safety were adopted to implement the 2016 Act, namely:

- Decree on the programme of the systematic monitoring of working and residential environments and raising awareness of measures to reduce public exposure to natural radiation sources (Official Gazette of RS, No. 19/16);
- Rules on authorised experts in radiation and nuclear safety (Official Gazette of RS, No. 50/16);
- Rules on radiation and nuclear safety factors (Official Gazette of RS, No. 74/16);
- Rules on the operational safety of radiation and nuclear facilities (Official Gazette of RS, No. 81/16);
- Rules on the method of keeping records of personal doses due to exposure to ionising radiation (Official Gazette of RS, No. 81/16); and
- Rules on the requirements and methodology of dose assessment for the radiation protection of the population and exposed workers (Official Gazette of RS, No. 83/16).

In addition to these implementing rules, which were adopted already in 2016, intensive preparations for the adoption of the Rules on activities involving radiation and the Rules on the obligations of persons performing radiation practices and holders of ionising radiation sources, which were adopted in early 2017, took place during 2016.

Despite the most recent amendments of the Act, which were adopted at the end of 2015, the SNSA and the SRPA already in 2015 started preparations for the adoption of the new Ionising Radiation Protection and Nuclear Safety Act; this preparatory work accelerated and intensified in 2016.

The reason for such intensive legislative work lies in the fact that the amended 2015 Act does not contain provisions which have to be transposed into the Slovenian legal system based on the amended Council Directive 2009/71/Euratom establishing a Community framework for the nuclear safety of nuclear installations (amended by Council Directive 2014/87/Euratom) and Council Directive 2013/59/Euratom laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, also known as the EU BSS (Basic Safety Standards). Slovenia has to adopt the legislation and administrative provisions necessary to comply with the first Directive by 15 August 2017, while the deadline for the transposition of the second Directive expires on 6 February 2018. The main developments of the two Directives were extensively reported in our Annual Report for 2014. The provisions of those two Directives will be transposed into the legal system of Slovenia through the new Ionising Radiation Protection and Nuclear Safety Act, as well as through the Decrees of the Government and Rules of the minister responsible for nuclear safety (the Ministry of the Environment) and the minister responsible for radiation protection (the Ministry of Health).

At the end of April 2016 the Resolution on the National Programme for the Management of Radioactive Waste and Spent Fuel Management for the Period 2016−2025 (ReNPROG) was adopted, which replaced a similar resolution from 2006. The SNSA widely reported on the preparation of this National Programme in its Annual Report for 2015; the main objective of the National Programme for the Management of Radioactive Waste and Spent Fuel is to ensure the safe and efficient management of radioactive waste and spent fuel in Slovenia in accordance with the principle of decision-making and action based on the latest findings of domestic and foreign research, the latest technologies and best practices, and the latest operational experience. All this must at any time ensure the safety of people and the environment, while maintaining long-term technologically modern and rational infrastructural support to users of nuclear and radiation technologies. The National Programme is also the basis for the fulfilment of Article 11 of Council Directive 2011/70/Euratom establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste, which requires each Member State to ensure the implementation of its national programme covering all types radioactive waste and spent fuel under its jurisdiction and all stages, from generation to disposal. In accordance with the eighth chapter of the Resolution, progress in the implementation of this National Programme is included in Chapter 5.8 of this Report.

### 7.2.1 Achieving the Goals of the Resolution on Nuclear and Radiation Safety

As regards the legislative and institutional framework, the resolution sets two goals.

**Goal 7**

*The Republic of Slovenia maintains its legislation in the field of nuclear safety and radiation protection in accordance with international best practices. The legislation provides for the priority of nuclear and radiation safety while enabling the main purpose of the use of nuclear energy and ionising radiation sources.*

**Realisation in 2016**

The objective was achieved; a detailed description can be found at the beginning of this chapter.

**Goal 8**

*The Republic of Slovenia shall maintain the appropriate separation and independence of the regulatory authorities responsible for the supervision of nuclear and radiation safety from those entities whose primary mission is to promote the use of nuclear energy or ionising radiation sources. The supervisory authorities shall have adequate financial resources and appropriate personnel to perform their duties.*

**Realisation in 2016**

The organisation of administrative bodies/regulatory authorities in the field of nuclear and radiation safety in the Republic of Slovenia is adequate and in 2016 there was no need for any substantive changes.

## 7.3 The Expert Council for Radiation and Nuclear Safety

The Expert Council for Radiation and Nuclear Safety provides expert advice to the Ministry of the Environment and Spatial Planning and to the Slovenian Nuclear Safety Administration in the field of radiation and nuclear safety, the physical protection of nuclear materials and facilities, safeguards, radioactivity in the environment, radiation protection of the environment, intervention measures and mitigation of the consequences of emergencies and the use of radiation sources other than those used in health and veterinary care.

The Expert Council for Radiation and Nuclear Safety convened a regular session and two correspondence sessions in 2016. In addition to the regular reporting of the SNSA Director to the Council on the status of nuclear and radiation safety, the Council considered and approved the following implementing regulations: UV1 Decree on activities involving radiation, JV3 Rules on authorised experts on radiation and nuclear safety, JV5 Rules on radiation and nuclear safety factors, and JV9 Rules on the operational safety of radiation and nuclear facilities. In the correspondence sessions the Expert Council also considered and approved the 2015 Annual Report on Radiation and Nuclear Safety in the Republic of Slovenia and the national report according to the Convention on Nuclear Safety.

## 7.4 The Slovenian Nuclear Safety Administration

The Slovenian Nuclear Safety Administration (SNSA) performs administrative and developmental tasks in the field of nuclear and radiation safety, radiation practices, and the use of radiation sources (with the exception of medicine and veterinary medicine), environmental protection against ionising radiation, the physical protection of nuclear materials and facilities, the non-proliferation and security of nuclear materials, radiation monitoring, and liability for nuclear damage; it also carries out inspection duties in the above areas and cooperates in radiological and nuclear emergency events with the State Civil Protection Headquarters to define protective measures for the population and inform the public regarding such matters.

At the beginning of 2016 the SNSA employed 41 civil servants, which is the number permitted by the human resource plan for the year 2016. During the year, four new employees were hired, of which two employees for an indefinite period as alternate employment for two colleagues who in recent years left the SNSA; there were also two employees under fixed-term employment contracts on a project that is not accounted for in the human resource plan. Thus, the total number of employees at the SNSA as of the end of 2016 amounted to 43.

The financial situation in 2016 also improved; budgetary funds provided to the SNSA were stable; extra budgetary financial resources of the SNSA obtained on the basis of its cooperation and work on various projects to assist third countries, as tendered by the International Atomic Energy Agency, in particular the EU, are strongly represented in the total amount of appropriations.

In 2016 the SNSA, as in all previous years, dedicated a great deal of attention to education and training with a view to monitoring and developing the careers of its public servants and creating conditions to improve the professional skills of all employees. In particular, a two-month course *Fundamentals of Nuclear Technology - OTJE*, which was organised and carried out by the Milan Čopič Training Centre for Nuclear Technology, and attended by seven SNSA employees, has to be underlined. All seven employees attended the first part of the course (Theory), and five also the continuing course (Systems of the Krško NPP).

Also in 2016, the SNSA strived to ensure the transparency and openness of its work. The public is informed primarily by means of the publication of information via the SNSA's websites. The information is constantly updated, wherein the content is made transparent and reader-friendly. In addition to the aforementioned websites, the SNSA also publishes two periodicals: *The Radiation News* and *Nuclear News from Slovenia*. The SNSA began publishing *The Radiation News* in 2004; in each issue a specific area of radiation protection and/or radiation safety is addressed and elaborated. *Nuclear News from Slovenia* is a publication that is primarily intended for foreign regulatory authorities in the field of nuclear and radiation safety. It is published twice a year according to a standardised form of content.

The SNSA implemented a management system in compliance with ISO 9001 and, at the same time, with the IAEA standard GS-R-3 *Management System for Facilities and Activities*.

### The Fulfilment of other Requirements in Respect of Workers Performing Duties and Tasks in Nuclear and Radiation Facilities

In 2016 the Expert Commission for the Verification of Professional Competences and Fulfilment of other Requirements in Respect of Workers Performing Duties and Tasks in Nuclear and Radiation Facilities (hereinafter: the Commission) carried out exams for Senior Reactor Operators, Reactor Operators, and Shift Engineers of the Krško NPP. The Commission also organised exams for the licensing of Reactor Operators and Reactor Shift Supervisors of the TRIGA Research Reactor.

Seven candidates acquired a Reactor Operator license for the Krško NPP for the first time. Altogether, four candidates also acquired a Senior Reactor Operator license for the first time and one candidate qualified as a Reactor Shift Engineer for the first time. Extensions of licenses were granted to three Senior Reactor Operators and two Shift Engineers. In 2016 no exams related to the extension of Reactor Operator licenses were carried out.

In 2016, two candidates received a Reactor Shift Supervisor license for the TRIGA Research Reactor for the first time. Extensions of licenses were granted to two Reactor Shift Supervisors.

No exams for a Storage Facility Manager license at the Central Radioactive Waste Storage Facility were held in 2016.

The SNSA granted the appropriate licenses to all candidates from the Krško NPP and the TRIGA Research Reactor.

## 7.5 The Slovenian Radiation Protection Administration

The Slovenian Radiation Protection Administration (SRPA), a regulatory body within the Ministry of Health, performs specialised technical, administrative, and developmental tasks, as well as inspection tasks related to carrying out activities involving radiation and the use of radiation sources in medicine and veterinary medicine; protection of public health against the harmful effects of ionising radiation; systematic surveying of exposure at workplaces and in the living environment due to the exposure of humans to natural ionising radiation sources; monitoring of radioactive contamination of foodstuffs and drinking water; control, reduction and prevention of health problems resulting from non-ionising radiation; and the auditing and approval of experts in the field of radiation protection.

As a special operational unit within the SRPA, the Inspectorate for Radiation Protection is responsible for monitoring sources of ionising radiation used in medicine and veterinary medicine and for the implementation of legislation on the protection of people against ionising radiation. In 2016 the SRPA had five employees.

The activities of the Administration were focused on performing duties in the field of radiation protection and on strengthening the system for health safety against the harmful impacts of radiation in the Republic of Slovenia. Within this framework, the activities of the SRPA comprised issuing permits and certificates as prescribed by the Act; issuing approval to radiation protection experts; performing inspections; providing information and increasing public awareness of procedures regarding health protection against the harmful effects of radiation; and cooperating with international institutions involved in radiation protection.

The SRPA supervised radiation practices in medicine and veterinary medicine and the use of radiation sources in these activities, the protection of exposed workers in nuclear and radiation facilities, and radon exposure. Altogether, 130 permits to carry out a radiation practice, 277 permits to use radiation sources, 57 certificates of received individual doses, 1 certificate of eligibility for foreign contractors involving radiation, and 39 statements of consignees of radioactive materials were confirmed. In 2016 the SRPA issued 8 approvals for the status of radiation protection expert to natural persons, approved 5 programmes of radiological procedures and 6 evaluations of the protection of exposed workers in cases for which proceedings were initiated before the amended ZVISJV entered into force in October 2015.

In 2016 the Inspectorate carried out 233 inspections. Of these, 6 were in-depth inspections of exposure to radon; the SRPA issued 5 decisions requiring a reduction in exposure. In medicine and veterinary medicine, 14 in-depth inspections were performed. A total of 5 decisions requiring the correction of established deficiencies and 2 decisions requiring the sealing of X-ray devices were issued. Eight requests to submit evidence regarding corrected authorised deficiencies, 39 requests to submit evidence regarding the termination of the use of an X-ray device, and 162 requests regarding harmonisation with the existing legislation were issued. The SRPA took action in 2 cases, when the operational monthly personal dose of 1.6 mSv was exceeded. Comprehensive control was ensured through cooperation with professional institutions that regularly monitor the situation in this field.

Thus far, the SRPA has operated with a small number of employees and modest financial resources. Despite this, a high level of radiation protection was ensured in its areas of competence. This is achieved by effectively optimising work processes and the optimal use of available resources. The SRPA does not have any internal financial or staff reserves and any further reduction of resources would mean that the SRPA would not be able to carry out its legally binding obligations and that the level of radiation safety would decrease.

As requirements for performing radiological procedures were changed by the new ZVISJV-D, dental X-ray diagnostics (with the exception of dental computed tomography) and densitometry are not considered to be practices that require radiation protection measures for exposed workers. In general, such employers no longer have to ensure evaluation of radiation protection. Workers have to undergo training for persons performing radiological procedures (the novelty introduced by ZVISJV-D) and need to be included in the personal dosimetry system.

The characteristics of dental X-ray diagnostic and densitometry and the situation in these fields were described in a report prepared by the Institute of Occupational Safety (IOS) at the request of the SRPA. Based on the report, evaluations of the radiation protection of exposed workers and on the results of individual dosimetry, the SRPA adopted a position regarding dental X-ray diagnostic and densitometry and published it on its website.

If, based on the results of individual dosimetry measurements or on regular or extraordinary radiation source checks, it is established that workers could receive doses above the dose limit for members of the public, the employer has to provide an evaluation of the radiation protection of exposed workers and ensure that the full scope of the radiation protection measures for workers are in place.

Hitherto, persons performing radiological procedures in dental care and densitometry have had to provide a programme of radiological procedures and arrange regular (annual) checks of radiation sources performed by an approved radiation protection expert.

All of the described changes are aimed at simplifying the administrative procedures in the field of radiation protection.

## 7.6 Approved experts

**Approved experts in radiation and nuclear safety**

Operators of radiation or nuclear facilities must obtain an expert opinion provided by approved experts with regard to specific interventions in the facilities. In 2016 there were no major changes in the operations of the experts in comparison to previous years. Their staff maintained the level of competence and the equipment used was well maintained and updated. The organisations established quality management programmes. The majority of them had certified programmes in compliance with the ISO 9001:2008 standard. Those approved experts who provided professional support to the Krško NPP by preparing independent reviews devoted special focus to the independence of the review of plant modifications.

Research and development activities are an important part of the work of approved experts. It can be noted that some organisations successfully participated in international research projects.

In 2016 the SNSA considered 4 submitted applications for the extension of approvals. The SNSA extended all 4 approvals regarding one or more of the expert fields. In 2016 the validity of the approval of 1 legal person expired and no new applications were submitted. In addition, no new approvals were issued.

In 2016 altogether 19 legal entities and 1 natural person were approved by the SNSA to perform the tasks of an Approved Expert in Radiation and Nuclear Safety.

The SNSA website provides information on approved experts in various fields of radiation and nuclear safety.

**Approved Radiation Protection Experts**

Approved radiation protection experts cooperate with employers in drawing up evaluations of the protection of exposed workers against radiation, provide advice on the working conditions of exposed workers, on the extent of the implementation of radiation protection measures in supervised and controlled areas, on the examination of the effectiveness thereof, on the regular calibration of measuring equipment, and on control of the usefulness of protective equipment, and carry out training of exposed workers in radiation protection. Approved radiation protection experts regularly monitor the levels of ionising radiation, the contamination of the working environment, and the working conditions in supervised and controlled areas. Approval can be granted to individuals to provide expert opinions and present topics relating to training on radiation protection, as well as to legal entities to provide expert opinions, perform control measurements and technical checks of radiation sources and protective equipment, and to carry out training regarding radiation protection for occupationally exposed workers. Individuals can obtain an approval if they have appropriate formal education, work experience, and expert skills. Legal entities can obtain an approval if they employ appropriate experts and have at their disposal appropriate measuring methods accredited according to the SIST EN ISO/IEC 17025 standard. Authorisations are limited to specific expert areas.

In 2016 the SRPA issued three approvals regarding radiation protection experts to natural persons. Authorisations were issued on the basis of the Commission's opinion. Approvals were granted on the basis of the opinion of a special commission (the Commission for Verification of the Fulfilment of the Conditions for the Performance of the Work of an Authorised Radiation Protection Expert) that assesses whether candidates fulfil the requirements. In 2016 the SRPA did not issue any approvals regarding the status of radiation protection expert to legal entities.

**Approved Dosimetry Services**

Approved dosimetry services perform tasks related to the monitoring of individual exposures to ionising radiation. An approval can only be granted to legal entities that employ appropriate experts and have at their disposal appropriate measuring methods meeting the SIST EN ISO/IEC 17025 standard.

In 2016 the SRPA did not issue any approvals for dosimetric services.

**Approved Medical Physics Experts**

Approved medical physics experts provide advice on optimisation, measurement, and evaluation of the irradiation of patients, the development, planning, and use of radiological procedures and equipment, and ensuring and verifying the quality of radiological procedures in medicine. Only natural persons can become approved medical physics experts.

In 2016 the SRPA authorised 5 medical physics experts. The granting of such approval was based on the opinion of a special commission that assessed whether the candidates fulfilled the requirements.

**Approved medical practitioners**

Approved medical practitioners carry out the medical monitoring of exposed workers. An approval is issued by the Minister of Health on the recommendation of the SRPA and the Expanded Professional Collegium of Occupational Medicine.

In 2016 the SRPA prepared 4 opinions with regard to the fulfilment of the requirements for carrying out medical monitoring of exposed workers.

## 7.7 The Nuclear Insurance and Reinsurance Pool

The Nuclear Insurance and Reinsurance Pool (hereinafter: the Nuclear Pool GIZ) insures and reinsures against nuclear threats. It has been operating since 1994, when eight members (insurance and reinsurance companies based in the Republic of Slovenia) signed a treaty establishing the Nuclear Pool GIZ.

In 2016 the following members had the largest shares: the insurance company Triglav, d.d.; the insurance company Sava, d.d.; and the reinsurance company Triglav Re, d.d.

The liability of the operator of a nuclear facility is insured in accordance with the applicable Liability for Nuclear Damage Act, which entered into force on 4 April 2011. According to this policy, the Nuclear Pool GIZ insures damages as prescribed in the Act and thereby ensures the payment of victims in the event of a nuclear accident; the costs, interest, and expenses that the policyholder is obliged to compensate the plaintiff for in respect of a nuclear incident are also covered. The insurance covers the legal liability arising from the operator's activities and its possession of the property if the damage is caused by an accident at the nuclear power plant during the period of insurance. In 2016 the Protocol to the Paris Convention (on Third Party Liability in the Field of Nuclear Energy), to which the Republic of Slovenia is a signatory, had still not entered into force. This Protocol will bring significantly higher limits of liability and a greater range of damages for which the operator of a nuclear installation is liable and which must be insured.

The Nuclear Insurance and Reinsurance Pool participates in third-party liability insurance risk up to its capacity level, while the rest of the risk is reinsured by foreign pools.

# 8 NON-PROLIFERATION AND NUCLEAR SECURITY

## 8.1 The Treaty on the Non-Proliferation of Nuclear Weapons

The main aim of the Treaty on the Non-Proliferation of Nuclear Weapons (hereinafter: NPT), which has been in force since 1970, is to curb the further proliferation of nuclear weapons, to provide security to those countries that have decided not to pursue nuclear weapon capabilities, providing for conditions for the peaceful use of nuclear energy, as well as to encourage further actions that would pave the way for the elimination of nuclear weapons.

For a number of years, the international community has devoted salient efforts to nuclear non-proliferation. During the Gulf crises and following the discovery of unauthorised activities in North Korea (DPRK), a number of violations of the NPT were brought up. A small number of countries, not being NPT signatories (India, Pakistan, Israel) or unilaterally withdrawn from the NPT (DPRK), have further pursued their nuclear weapons programmes. The past situation with the "Iranian case" gained a significant breakthrough in 2015, culminating in the Joint Comprehensive Plan of Actions (JCPoA), as well as the United Nations' Security Council Resolution 2231 (2015), and in particular in the "adoption day" (i.e. 18 October 2015) of the JCPoA. The IAEA is the inspection powerhouse ("watchdog") of the obligations under the JCPoA. So-called "implementation day" was achieved on 16 January 2016, when the Security Council adopted the IAEA's report which had confirmed that Iran had carried out a string of activities, detailed in the JCPoA.

In 2016 North Korea (DPRK) conducted two nuclear tests, the first one on 6 January and the second one on 9 September.

## 8.2 The Comprehensive Nuclear Test Ban Treaty

The Comprehensive Nuclear Test-Ban Treaty (CTBT) is one of the international instruments aimed at combating the proliferation of nuclear weapons. Slovenia ratified the treaty on 31 August 1999. Currently, there are 183 states that have signed the treaty, 166 of them have also ratified it. The CTBT will enter into force when it is ratified by the remaining 8 out of the 44 countries listed in Annex II of the Treaty (Egypt, India, Iran, Israel, China, Pakistan, North Korea, and the USA).

Slovenia's dedication to the CTBT and endeavours to curb nuclear weapons, non-proliferation, and disarmament was manifested also through it hosting an annual international NATO conference that addressed this topic from 9 to 10 May 2016 in Ljubljana. The Executive Secretary of the CTBTO, Lassina Zerbo, was the keynote speaker; in his speech he addressed endeavours regarding the entry into force of the CTBT. On the fringe of the conference, Mr Zerbo participated in a meeting with representatives from the Slovenian Ministry of Foreign Affair and the SNSA. The participants exchanged views and initiatives with regard to the topics at issue.

On the occasion of the 20$^{th}$ anniversary of the CTBT being open for signing, a high-level meeting took place in Vienna in June 2016, with Slovenian participation as well. The dedicated meeting attempted to spark the process as regards the entry into force of the CTBT and to review the implementation of its requirements.

Mrs Irena Majcen, the Minister for the Environment and Spatial Planning, held a meeting with Mr Zerbo on the fringe of the Nuclear Security Conference held in Vienna in December 2016.

Mrs Majcen also visited the CTBTO's international data centre, where the collection, collation, and analyses of data from more than 300 measuring stations occurs with the aim of detecting possible nuclear tests worldwide.

## 8.3 Nuclear Safeguards in Slovenia

At the international level, nuclear safeguards are regulated by the Treaty on the Non-Proliferation of Nuclear Weapons and the Treaty Establishing the European Atomic Energy Community. Slovenia's legal framework had to be adapted in the process of accession to the EU. Slovenia completely fulfils its obligations regarding nuclear safeguards.

In Slovenia, all nuclear material, namely the fresh and spent fuel at the Krško NPP, at the TRIGA Research Reactor, at the Central Storage for Radioactive Waste in Brinje, and at the other holders of small quantities of nuclear material, is under the supervision of international inspection.

All holders of nuclear material are obliged to report directly to the European Commission (EURATOM) with regard to the quantities and status of their nuclear material. Copies of reports are sent to the SNSA, which maintains a registry of nuclear material.

There were as many as nine IAEA/EURATOM inspections in 2016. The SNSA's staff took part in the majority of the international inspections that took place at all three domestic nuclear facilities. There were two international inspections in 2016 held on the premises of small holders of nuclear material; one of them concerned a holder who has been in the process of establishing the requested level of reporting to EURATOM on the nuclear material possessed and used in its processes. In 2016 one IAEA inspection in a nuclear facility was conducted on the basis of the so-called complementary access method (under the Additional Protocol).

## 8.4 Export Control of Dual-use Goods

The SNSA, together with the Ministry of Foreign Affairs, monitors the activities of the Nuclear Suppliers Group (NSG) and the Zangger Committee. The mission of both associations is to prevent the export of dual-use goods, i.e. goods that might be used to manufacture nuclear weapons, to those countries that wish to acquire such weapons. The annual Plenary Week of the NSG was held between 20 and 24 June 2016 in Seoul, Republic of Korea.

On the basis of the Act on Export Controls of Dual-Use Goods, a special Commission for the Export Control of Dual-Use Goods ("KNIBDR") has been functioning at the Ministry of Economic Development and Technology. Dual-use goods are goods that can be used not only for civil but also for military purposes (including nuclear weapons and other weapons of mass destruction). An exporter of dual-use goods must obtain a permit from the Ministry of Economic Development and Technology, which is issued on the basis of the Commission's opinion. In 2016 the Commission had six regular and 26 correspondence sessions. The role of the SNSA in the Commission is primarily related to the export of goods that might be used in the production of nuclear weapons or nuclear dual-use items.

In March 2016 the Slovenian stakeholders and experts from several ministries/institutions organised a seminar on the export control of dual-use goods in particular for Slovenian industrial entities.

In 2016 the Slovenian Government studied the Annual Report (covering 2015) of the above-mentioned Commission and endorsed it.

## 8.5 Physical Protection of Nuclear Material and Facilities

The operators of nuclear facilities and holders of nuclear material implemented physical protection measures in accordance with their plans on physical protection approved by the Ministry of the Interior.

The role of the Commission on the Physical Protection of Nuclear Facilities and Nuclear and Radioactive Material (hereinafter: the Commission) is to monitor and harmonise different tasks in the sphere of physical protection. The Commission provides its opinions on the threat assessment of nuclear facilities and nuclear and radioactive material, monitors and coordinates the implementation of measures for the physical protection of nuclear facilities and nuclear and radioactive material, makes suggestions to improve these measures, and makes proposals in the drafting of legislation in the area of physical protection.

In 2016 just one regular session of the Commission was held; the Commission considered proposals regarding the threat assessment of Slovenian nuclear facilities. The Commission gave its positive opinion to the Police in all cases; the threat assessments remained valid throughout 2016 or until the next revision. Additionally, the proposal was granted regarding the threat assessment regarding the transport of fresh nuclear fuel that took place from Port of Koper to Krško NPP in 2016. The Commission gave its positive opinion to the Police also in this matter.

Based upon the recent changes of the Nuclear Act (ZVISJV), the Police also drafted an annual assessment of the threat during the transport of radioactive material on roads. This will form a solid basis for the forthcoming threat assessment during the transport of radioactive material for 2017.

Stemming from the recommendations adopted after the security-related exercise "Nevtron 2014", the new system for the transmission of an alarm signal from the Krško NPP to the Krško police station and the police administration of Novo Mesto (the "operational-communication centre") was a notable achievement.

The Inspectorate of the Ministry of the Interior carried out just one inspection-supervision of a nuclear facility in 2016. This inspection addressed the Krško NPP and no security-related anomalies (i.e. non-conformities) were identified. The Krško NPP is considered to be an important part of the critical infrastructure of Slovenia; the inspector suggested that the responsible staff of the nuclear operator monitor the security situation in Slovenia and the EU, and adapt the physical protection measures to the current or evolving security.

The Service for Security Planning within the Ministry of the Interior and the Police took part in cooperation encompassing the changes and updates of the Nuclear Act (ZVISJV).

In review of 2016, no case of a threat to any of domestic nuclear facilities was considered by the Police; there were no such events connected directly to the security of the nuclear facilities. No information was collected with regard to criminal groups or individuals that would threaten the security of nuclear facilities or to persons who might attempt to access radioactive material in an unauthorised manner.

In 2016 co-operation in the field of the physical protection of nuclear facilities and nuclear and radioactive material among the Ministry of the Interior, the Police, the SNSA, and Slovenian nuclear operators was deemed to be very good.

## 8.6 Illicit trafficking in nuclear and radioactive materials

In 2016 the SNSA issued 13 approvals for measuring the radioactivity of scrap metal shipments. All 21 providers of measurements submitted annual reports, which showed that 52,267 measurements of shipments were made in Slovenia in 2016. Elevated dose levels were measured in three cases.

A duty officer at the SNSA was available to provide assistance and consultation to other state offices and scrap metal recyclers. In 2016, 18 calls to the duty officer were registered, with twelve interventions related to the identification of increased radiation when transporting radiation sources or radioactive waste. In 2016, two later suspended reports on suspicion of a threat to workers or residents with sources of ionising radiation or radioactive waste were given.

The SNSA regularly receives and to a certain extent analyses information on incidents and trafficking cases in foreign countries. The SNSA disseminates this information appropriately to other Slovenian stakeholders whose scope of responsibilities also includes (combating) illicit trafficking in nuclear and other radioactive material. In 2016 Slovenia (the SNSA) reported twice to the IAEA "Incident and Trafficking Database" (ITDB): in February regarding the discovery of a smaller quantity (30 g) of U-nitrate on the premises of a company from Vrhnika, and in November regarding the transfer of previously discovered and recorded nuclear material at an institute in Ljubljana (uranium – 76 g and thorium – 6 g).

In September 2016, representatives from the SNSA, the Customs Administration, the Market Inspectorate, the Ministry of the Interior, as well as mail/airport organisations (i.e. Pošta Slovenije, d. o. o., and Aerodrom Ljubljana, d.d.) met and reviewed the current situation in the area of illicit trafficking in nuclear and other radioactive material.

In 2016, two seminars were held in Slovenia (in Gotenica and Ljubljana) that addressed, *inter alia*, illicit trafficking, approaches to detection, nuclear security, and raising awareness; the Ministry of the Interior and the SNSA collaborated in this regard.

Mention should also be made of a multi-day exercise organised by certain Italian counterparts (a firefighting unit from Venice) wherein different firefighters and other response units from Italy, Austria, and Slovenia (Ljubljana Fire Brigade, the Ecological Lab/Mobile Unit ("ELME"), and the SNSA) participated in the exercises, which encompassed four different scenarios (a fire involving radioactive sources and casualties, a radioactive source in water, a transport accident with an injured driver, and the spillage of a radioactive substance in a lab, including injured persons).

## 8.7 Achieving the Goals under the Resolution on Nuclear and Radiation Safety

**Goal 6**

*As Slovenia does not have any intention to pursue non-peaceful use of nuclear energy, it is firmly bound by the NPT and fully respects its obligations; Slovenia is entirely open to international inspection control of the nuclear material on its territory ("safeguards").*

Slovenia has been co-operating with the international organisations in the sphere of nuclear non-proliferation and dual-use items; Slovenia in particular tries to fulfil its obligations with regard to reporting, export control of dual-use items, and – based upon its financial capabilities – contributes to global efforts to prevent the proliferation of nuclear weapons.

**Realisation in 2016**

Slovenia is committed to its obligations regarding safeguards, follows international inspections in this regard, fulfils the requirements regarding reporting events to international data bases and associations, and follows discussions in the area of dual-use goods, nuclear security, and nuclear terrorism. Based upon its human and financial resources as well as its priorities, Slovenia contributes to the global endeavours towards nuclear non-proliferation and nuclear security. As can be seen from the previous chapters, Slovenia has achieved the set goal.

**Goal 4: with regard to the part related to the international advisory missions in the area of nuclear security**

*The Republic of Slovenia will encourage the future involvement of its experts in expert engagements abroad.*

*The Ministry of the Interior has invited, within a time frame of ten years, the international advisory mission "IPPAS" (International Physical Protection Advisory Service) to review domestic measures in the area of the physical protection of nuclear facilities and activities.*

**Realisation in 2016**

A few Slovenian experts participated in the IAEA IPPAS missions in 2016; the IAEA has also established a mechanism for future "peer reviewers".

During her speech at the Nuclear Security Conference held in Vienna in December 2016, Mrs Irena Majcen, the Minister for the Environment and Spatial Planning, made reference, *inter alia*, to the last IPPAS mission in Slovenia (in 2010) and made a preliminary reference to the plan to invite the next IPPAS mission in the coming years.

# 9 INTERNATIONAL COOPERATION

This chapter presents the international framework and cooperation of nuclear and radiation safety authorities. A detailed description of all the international cooperation among individual companies and research and educational institutions would be beyond the scope of this report.

## 9.1 Cooperation with the European Union

**Working Party on Atomic Questions (WPAQ)**

During its presidency of the Working Party on Atomic Questions (WPAQ), the Netherlands focused on the PINC (Nuclear Illustrative Programme) report, on a review of the recommendations for the implementation of Article 103 of the Euratom Treaty (the transparency of national arrangements in accordance with the energy security policy within the Energy Union) and on a revision of Articles 41 to 44 of the Euratom Treaty (investment reporting).

In the second half of 2016, Slovakia assumed the Presidency and continued the Dutch programme with discussions regarding the Nuclear Illustrative Program – PINC and the revision of the aforementioned articles of the Euratom Treaty. They also discussed the EU nuclear decommissioning assistance programmes in Lithuania, Bulgaria, and Slovakia, where they, *inter alia*, dealt with the report of the European Court of Auditors regarding financial aid for this project. Furthermore, they took note of the questions and answers relating to the Euratom Report under the Convention on Nuclear Safety and the implementation of the Radioactive Waste and Spent Fuel Management Directive.

**The High-level Group on Nuclear Safety and Waste Management (ENSREG)**

The High-level Group on Nuclear Safety and Waste Management (ENSREG) is an independent expert body established in 2007 by a decision of the European Commission. It consists of prominent representatives of the regulatory bodies responsible for nuclear safety, radiation protection, and the safety of radioactive waste from all 28 Member States of the European Union. Representatives of the European Commission collaborate in the group on an equal basis.

In 2016 ENSREG devoted a great deal of time to Topical Peer Reviews. These reviews will be carried out in 2017 in all EU nuclear power plants and will address the readiness to cope with the aging of the components of operating nuclear power plants. The French regulatory authority (ASN – Autorité de Sureté nucléaire) has reported on irregularities that were detected in the Creusot Areva Forge, where the falsification of documents and doubtful forging quality were discovered in recent decades.

**Consultative Committees under the Euratom Treaty**

Within the framework of the European Treaty, which is a part of the Community acquis, at present, several technical and consultative committees are active. The SNSA complies with its obligations in three committees: the Committee under Article 31 of the Treaty, the Committee under Article 35, and the Committee under Article 37.

The Committee under Article 31 makes recommendations to the European Commission related to radiation protection and public health. In 2016 the Committee dealt with a wide variety of areas, such as the following: the implementation of the Directive for the Responsible and Safe Management of Spent Fuel and Radioactive Waste, natural radioactive substances, maximum levels of food and feed contamination, verification of radioactive releases, results of international missions, improper handling of radioactive sources, etc.

According to the Euratom Treaty, the EU Member States are required to establish a system of radiation monitoring in the government and to regularly report to the European Commission on the results under Article 35. The Commission has the right to verify whether such a system is in place and in line with the established requirements (Article 36). In 2016 they dealt with a document concerning the control of radioactive releases into the environment, which also contains good practices. In addition, they reviewed the verification programme.

The Consultative Committee under Article 37 mainly works on a correspondence basis in cases when the European Commission's opinion is needed on major reconstruction works or the construction of new nuclear facilities.

### 9.1.1 Cooperation in EU projects

The SNSA cooperates in three EU projects:

- In the project Enhancing the Capacity and Effectiveness of the Thai Regulatory Body and Developing a National Waste Management Strategy, the SNSA cooperates in the consortium consisting of the company Enconet from Austria and two Belgian companies, BEL-V and IRE-Elit. This project contains eight different tasks. In 2016 the following tasks were completed: an inspection and assessment including a safety analysis report, formulation of a human resource development plan, a strategy regarding radioactive waste and spent fuel management, as well as a task concerning naturally occurring radioactive materials. The four remaining tasks will be continued in 2017.
- In the project Training and Tutoring for Nuclear Safety Regulatory Bodies' Experts and their Technical Support Organisations and their Technical Competences, the SNSA cooperates with the consortium led by the Italian company ITER. The SNSA provides mentoring for the nuclear and radiation safety regulatory bodies' personnel from partner countries. On a case-by-case basis, the SNSA experts take part in workshops and courses. In 2016 the SNSA experts lectured at a course entitled Safety of Research Reactors.
- Within the project Further Enhancement of the Technical Capacity of the Nuclear Regulatory Bodies of the West Balkans, in 2016 the SNSA cooperated in the transposition of the EU acquis in the legal framework of the beneficiary countries, the drafting of the procedures of regulatory bodies (instructions and guides), formulating the concept of the training plan for the beneficiary regulatory bodies, and in the application of the management system, including the strategy of regulatory bodies. In this project the SRPA is also one of the consortium partners and its activities are focused on radiation protection and the use of radiation in medicine and veterinary care.

The SRPA participates in the ENATRAP III project, which is aimed at harmonising training on radiation protection and mutual recognition of the qualifications of skilled workers and experts at the EU level, and in the working group dealing with the medical use of ionising radiation, which dealt with the transposition of the medical articles of Directive 2013/59 and with the realisation of an action week of control over the implementation of the principle of the eligibility of radiological procedures.

## 9.2 The International Atomic Energy Agency

Slovenia successfully continued its cooperation with the International Atomic Energy Agency (IAEA). In September 2016, Slovenia became a member of the Board of Governors for the next two years. The Board of Governors is the IAEA's highest body directing its work between the two sessions of the General Conference. The Slovenian delegation in September 2016 also attended the regular annual session of the General Conference. At the end of 2016 the Republic of Slovenia, after several years of inability to pay its financial obligations to the IAEA regular budget and technical cooperation fund, paid its past and regular financial obligations in full and on time. Slovenia closely cooperated with the IAEA in these areas:

- In 2016, 14 training requests were implemented as well as four training application requests that were received already in 2015.
- The Jožef Stefan Institute, the Department of Nuclear Medicine, the Department of Neurology, the Institute of Biomedical Informatics of the University of Ljubljana, the Institute of Civil Engineering, and the Institute of Oncology Ljubljana actively participated in coordinated research projects. They were involved in fourteen research projects, which had already been launched in 2015. Three coordinated research projects were successfully completed in 2016.
- In 2016 two new national projects began operation: the ARAO project SLO/9/017 “Supporting Radioactive Waste Management Activities for the Implementing Organisation” and the SNSA project SLO/9/018 “Enhancing the Regulatory Oversight of the Nuclear Safety Administration”. The national projects of the Jožef Stefan Institute entitled SLO/1/006 “Feasibility Study and Installation of a Thermal Neutron Driven 14 MeV Neutron Converter in the TRIGA Research Reactor”, of the ARAO entitled SLO/9/016 “Supporting Radioactive Waste and Spent Fuel Management for the Implementing Organisation” and of the SNSA entitled SLO/9/015 “Strengthening the Regulatory Capabilities of the Nuclear Safety Administration” were all completed.
- In 2016 Slovenia organised four regional training course and workshops of the IAEA.
- The participation of Slovenian specialists and their involvement as experts in various IAEA committees, missions, and workshops abroad is important as well.

In early 2016, assignments of a new interregional project on further sustaining cradle-to-grave control of radioactive sources started. Representatives of the ARAO and the SNSA have been actively involved in the project. Last year Slovenian representatives also successfully and actively participated particularly in the work of the regional projects on the enhancement and strengthening of the utilisation and safety of research reactors, the strengthening of nuclear power plant lifetime management for long-term operation, the inspection capabilities of the regulatory authority, quality assurance and quality control in diagnostic X-rays, radiation protection of patients and medical exposure control, the management of fruit flies in the Balkans and the Eastern Mediterranean, capabilities for radionuclide measurement in the environment and the QA/QC system for environmental radioactivity monitoring, the capacities of the veterinary services in the event of a nuclear or radiological accident, and enhancement of nuclear safety in accordance with the IAEA’s Action Plan.

The SRPA collaborates in a project on upgrading quality assurance and quality control in diagnostic X-rays and in a project intended to improve the radiation protection of patients and medical exposure control. Slovenia provided valuable input in the establishment of the latter project by providing data on diagnostic reference levels with an emphasis on paediatric patients and interventions in interventional radiology.

## 9.3 The Nuclear Energy Agency (NEA) of the OECD

Since 2011, Slovenia has been a full member of the Nuclear Energy Agency (NEA) of the Organisation for Economic Cooperation and Development (OECD). The mission of the NEA is to assist its member states in maintaining and further developing the scientific, technological, and legal bases required for the safe, environmentally friendly and economical use of nuclear energy for peaceful purposes.

In 2016 Slovenia actively participated in five standing committees, namely the Radioactive Waste Management Committee, the Committee on Radiation Protection and Public Health, the Committee on the Safety of Nuclear Installations, the Committee on Nuclear Regulatory Activities, and the Nuclear Law Committee. The representatives of the Nuclear Science Committee and Committee for Technical and Economic Studies on Nuclear Energy Development and the Fuel Cycle did not attend last year's meetings. Slovenian representatives also participate in working groups of the standing committees, namely the Working Group on Risk Assessment, the Working Group on the Integrity and Ageing of Components and Structures, the Working Group on the Analysis and Management of Accidents and the Working Group on Operating Experience. In 2016 the NEA finalised a new strategic plan for the period 2017−2022. In the NEA there was a new systematisation and reorganisation of departments. The nuclear division was divided into two sectors, while some changes were also made in the radiological safety division.

Slovenian institutions (the NPP, the SNSA, and the SRPA) continue to participate in the International System of Occupational Exposure – ISOE. ISOE is an information system on occupational exposure to ionising radiation in nuclear power plants, supported by the OECD/NEA and the IAEA. The Information System is maintained by technical centres with the support and cooperation of both of the organisations mentioned, nuclear power plants, and regulatory bodies.

## 9.4 Cooperation with Other Associations

**The Western European Nuclear Regulators Association (WENRA)**

WENRA (The Western European Nuclear Regulators Association) is an informal association consisting of representatives of nuclear regulatory authorities from European countries with nuclear power plants. The main objective of WENRA is to develop a common approach to nuclear safety, the provision of independent reviews of nuclear safety in the candidate countries for accession to the EU, and the exchange of experiences in the field of nuclear safety.

In 2016 Slovenian representatives participated in two regular WENRA meetings and meetings of two working groups RHWG (RHWG − Reactor Harmonisation Working Group) and WGWD (WGWD − Working Group on Waste and Decommissioning). At the regular WENRA meetings member states dealt with the impact of electricity prices on nuclear safety, which differs from one European country to another. They became acquainted with the work of both working groups, with the conduct of the IRRS missions, and with the activities of similar organisation in the field of nuclear safeguards - ENSRA. In 2016 representatives of the Canadian and Japanese regulatory authorities attended the meetings as observers. RHWG had two main tasks: to continue the review of compliance with the new post-Fukushima WENRA requirements in the national legislation of each country and to prepare the specifications for a Topical Peer Review of nuclear power plants under the Nuclear Safety Directive. WGWD dealt mainly with the study of how countries meet the requirements for waste disposal and with the harmonisation of national action plans for disposal and decommissioning with the corresponding reference levels.

**ENSRA**

The European Nuclear Security Regulators Association (ENSRA) is an association consisting of representatives of nuclear regulatory authorities that cover nuclear security. It was established in 2004. Slovenia joined the ENSRA in 2008. The main objectives of the ENSRA are to exchange information on nuclear security, current security issues and events regarding the development of a comprehensive understanding of the fundamental principles of physical protection, and to promote common security principles in Europe.

In October 2016 France hosted ENSRA's plenary meeting. The main topics were the exchange of information on current security challenges, the exchange of information on legislation and the accession of members, cooperation with the IAEA and WENRA, and a seminar on inspection approaches.

### INLA

The International Nuclear Law Association (INLA) is an international association of legal and other experts in the field of the peaceful use of nuclear energy. The objectives of the INLA are to support and promote the knowledge and development of legal issues and research related to this field, the exchange of information among its members, and cooperation with similar associations and institutions. The INLA has approximately 500 members from more than 50 countries and international organisations.

In November 2016 the INLA held its congress in New Delhi, India. The Congress is normally organised every two years. Slovenian representative did not attend the meeting in 2016.

### CAMP (NRC)

The research development programme CAMP (Code Application and Maintenance Programme), directed by the US NRC (the US Nuclear Safety Regulator), enables cooperation in the maintenance and application of software in the field of accident prevention and the management of accidents, incidents, and unusual events in nuclear power plants. The Krško NPP, the Jožef Stefan Institute, and the SNSA are involved in the programme. The Slovenian National Coordinator of the CAMP programme is the Jožef Stefan Institute, which regularly monitors and reports on the activities of CAMP and actively cooperates and contributes to the development and use of computer programmes.

### Association of the Heads of European Radiological Protection Competent Authorities (HERCA)

A representative of the SRPA is a member of the Association of the Heads of European Radiological Protection Competent Authorities – HERCA. In 2016 the Association organised a "week of inspections" in which 15 countries conducted simultaneous inspections of the justification of radiological procedures. HERCA, along with WENRA, is also very active in the field of the harmonisation of responses to possible nuclear accident with transboundary impacts in the EU Member States.

### The European ALARA Network

As one of 20 European countries, Slovenia participates in the European ALARA Network (EAN). The EAN is dedicated to optimising radiation protection and sharing good ALARA practices in industry, research, and medicine. In the framework of the EAN, international workshops on specific fields are organised. In addition, the EAN issues a newsletter on practical implementation of the ALARA principle, examples of good practices, and other news on radiation protection. The EAN has an active role in studies conducted by the European Commission and other international organisations in the field of radiation protection. The network is also involved in other aspects of implementing the ALARA principle in practice. There are several sub-networks within the framework of the EAN. The SRPA is active in the ERPAN (the European Radiation Protection Authorities Network), which is dedicated to the exchange of operational information on surveillance and measures in radiation protection.

**International cooperation in the field of the management of radioactive waste and spent fuel**

Slovenia is included in two international associations in the field of the development and approach to international solutions for the disposal of radioactive waste. The ARAO has been involved in a working group of the European Repository Development Organisation Working Group (ERDO-WG), which develops and promotes the concept of a common repository. Slovenia also participates in the IFNEC – the International Framework for Nuclear Energy Cooperation, an association in the field of nuclear energy also dealing with the issue of an international repository.

The ARAO also participated in some of the activities of various European technology platforms, namely Implementing Geological Disposal of Radioactive Waste–Technology Platform (IGD-TP), which is aimed at enhancing knowledge and competencies to develop a geological repository for spent fuel and high-level radioactive waste, which is planned to be built in one of the EU Member States by 2025. In addition to its involvement in associations and platforms, the ARAO also maintains permanent contacts with similar European organisations for the management of radioactive waste. It collaborates with Sogin from Italy, COVRA from the Netherlands, ANDRA from France, and with the Croatian Fund for the Decommissioning of the Krško NPP. The ARAO has established contacts with many other organisations, such as NDA (the United Kingdom), ENRESA (Spain), and SURAO (the Czech Republic).

## 9.5 Agreement on the Co-ownership and Management of the Krško NPP

In order to monitor the implementation of the Agreement between the Government of the Republic of Slovenia and the Government of the Republic of Croatia on regulating the status and other legal relations as regards investments in the Nuclear Power Plant, and its exploitation and decommissioning (hereinafter: the Bilateral Agreement), an Intergovernmental Commission was established.

The Intergovernmental Commission monitors the implementation of the Bilateral Agreement, confirms the Programme on Radioactive Waste and Spent Fuel Management and the Krško NPP Decommissioning Programme. It also deals with open questions that refer to the relationship covered by the Bilateral Agreement.

At the latest session held in July 2015, the Interstate Commission decided that the expert organisations together with the Krško Nuclear Power Plant would prepare a project proposal for a new revision of the "The Krško Nuclear Power Plant Decommissioning Programme and the Disposal of Low and Intermediate Level Radioactive Waste and Spent Fuel".

In 2015 the Government of the Republic of Slovenia appointed the Agency for Radwaste Management as the expert organisation.

Due to the multiple elections and changes of the Croatian government and the Croatian officials responsible for the issues of the Intergovernmental Commission for the Krško NPP and due to the fact that the expert organisations have not yet agreed on the contents of the project proposals, which should be discussed by the Intergovernmental Commission, the Intergovernmental Commission has not convened since July 2015. Preparations for the next session of the Intergovernmental Commission in the Slovenian organisation are already underway.

## 9.6 Cooperation within the Framework of International Agreements

In May a regular annual meeting of the nuclear regulatory bodies of the Czech Republic, Hungary, Slovakia, and Slovenia, which all have bilateral agreements with each other, the so-called Quadrilateral Meeting, was held in Hnanice in southern Moravia. The meeting was aimed at the mutual exchange of information in the field of nuclear safety and international review missions, implementation of post-Fukushima measures, non-proliferation, and security and legislative challenges. Operating events in the respective countries were also reported.

In October, representatives of Austria and Slovenia convened at their annual meeting in Celovec in Austria. Both sides informed each other of major developments regarding legislation, radiation monitoring, emergency preparedness, waste management, changes, and important events in the Slovenian nuclear programme.

Also in October, a bilateral meeting between Slovenia and Italy was held in Trieste. Representatives of the Italian and Slovenian nuclear safety authorities met for the first time since the conclusion of the Agreement for Early Exchange of Information in the Event of a Radiological Emergency, signed in 2010. Discussion topics were related to legislation, the programme for the decommissioning of nuclear power plants, seismic safety and measures to manage these risks, implementation of the post-Fukushima safety upgrade programme, emergency response, and the organisation of a simulated Emergency Preparedness Review mission (EPREV − Emergency Preparedness REView).

In November 2016 a bilateral meeting under the Agreement between the Republic of Slovenia and the Republic of Croatia for the Early Exchange of Information in the Event of a Radiological Emergency took place. During the bilateral meeting both sides described their main developments in the field of legislation, waste management, and emergency preparedness. An important part of the meeting was related to the realisation of the HERCA−WENRA approach to cross-border cooperation in the event of a nuclear or radiological emergency.

### 9.6.1 Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management

A Joint Convention Topical Meeting on "Challenges and Responsibilities of Multinational Radioactive Waste Disposal Facilities" was held from 5 to 7 September 2016 in Vienna. The meeting was chaired by the SNSA's director, Dr. Andrej Stritar. Seventy-eight representatives of the Contracting Parties to the Joint Convention participated in the meeting. From Slovenia, there were representatives from the SNSA, the Ministry of Infrastructure, and the Agency for Radwaste Management.

The purpose of the meeting was to discuss different aspects of multinational disposal, which are important for radioactive waste disposal facilities with radioactive waste from different countries. Existing international practices and international initiatives were presented. The participants highlighted the legal framework, siting, regulatory control, liability and safety issues, liability for nuclear damage, public acceptance, research activities and security. It was concluded that the Joint Convention and other international acts do not prohibit such facilities, but on the other hand, they determine the conditions and requirements for the transfer of radioactive waste between countries. There is no experience regarding the joint disposal of radioactive waste from NPPs. The meeting was a small contribution to seeking a solution, which is important in particular for small countries with small nuclear programmes, such as Slovenia.

## 9.7 Achieving the goals of the Resolution on Nuclear and Radiation Safety

Slovenia successfully and rationally strives to achieve the goals set out in the Resolution.

**Goal 2**

*In principle, the Republic of Slovenia joins international conventions, agreements, contracts, or other modes of cooperation enabling the fast and equitable exchange of information and mutual assistance in ensuring nuclear and radiation safety and reducing risks to humans and the environment both in the territory of the Republic of Slovenia as well as elsewhere.*

**Goal Implementation in 2016**

The Slovenian authorities and other organisations in the field of nuclear and radiation safety and physical protection were actively involved in international associations in line with the needs and benefits of such membership in organisations such as WENRA, ENSRA, HERCA, and CAMP, as well as in their working groups. Cooperation in the framework of bilateral agreements was conducted as planned.

Besides the activities of state authorities described in this chapter, entities such as operators of nuclear installations and other expert and research organisations actively take part in international cooperation.

**Goal 3**

*The Republic of Slovenia will continue to actively participate in all activities within the EU where its presence is mandatory and where Slovenia can meet its specific long-term interests.*

**Goal Implementation in 2016**

The Republic of Slovenia was active in the Working Party on Atomic Questions of the Council of the EU in the group established by Articles 31, 35, 36, and 37 of the Euratom Treaty. The Slovenian representatives attended and actively participated in ENSREG meetings. They also cooperated in the implementation of assistance to third countries, which is supported by the European Commission.

**Goal 4**

*The Republic of Slovenia is and remains an active member of the IAEA. As a member of this Agency, it contributes a mandatory membership fee. In accordance with its capabilities, it also provides human and financial resources, in particular in the areas where its direct or indirect interests can be served.*

**Goal Implementation in 2016**

As described in Chapter 9.2, Slovenia has continued its intensive and active cooperation with the IAEA.

**Goal 5**

*The Republic of Slovenia remains an active member of the OECD Nuclear Energy Agency (NEA). For its collaboration, Slovenia contributes the agreed amount of the membership fee. In line with its human and financial resources, Slovenia participates in the work of NEA committees, the NEA Data Bank, and those subcommittees and working groups that are important for ensuring a high level of nuclear and radiation safety.*

**Goal Implementation in 2016**

The Slovenian representatives are actively involved in the work of the committees and working groups of the NEA, in particular in committees and working groups dealing with regulatory issues, the safety of nuclear installations, radiation protection, radioactive waste and spent fuel management, and nuclear law, as well as regarding research projects.

# 10 USE OF NUCLEAR ENERGY IN THE WORLD

As of the end of 2016, there were 449 nuclear reactors for electricity production operating in 30 countries. There are 60 nuclear reactors under construction. There were five new grid connections, all in China. Only one reactor was permanently shut down, unit Itaka-1 in Japan.

In Europe, there are nuclear power plants under construction in Finland, Slovakia, France, Russia, Ukraine, and Belarus. Most new reactors are planned in the Asian region. Nuclear power capacity worldwide is increasing steadily, mostly due to plant upgrading and licence renewals granting plants a life extension. Detailed data on the number of reactors by country and their installed power is presented in Table 9 (data source: PRIS database, IAEA).

**Table 9: The number of reactors by country and their installed power**

| Country | Operational | | Under construction | |
|---|---|---|---|---|
| | No. | Power [MW] | No. | Power [MW] |
| Belarus | | | 2 | 2,218 |
| Belgium | 7 | 5,913 | | |
| Bulgaria | 2 | 1,926 | | |
| Czech Republic | 6 | 3,930 | | |
| Finland | 4 | 2,764 | 1 | 1,600 |
| France | 58 | 63,130 | 1 | 1,630 |
| Hungary | 4 | 1,889 | | |
| Germany | 8 | 10,799 | | |
| Netherlands | 1 | 482 | | |
| Romania | 2 | 1,300 | | |
| Russia | 35 | 26,111 | 7 | 5,520 |
| Slovakia | 4 | 1,814 | 2 | 880 |
| Slovenia | 1 | 688 | | |
| Spain | 7 | 7,121 | | |
| Sweden | 10 | 9,740 | | |
| Switzerland | 5 | 3,333 | | |
| Ukraine | 15 | 13,107 | 2 | 2,070 |
| United Kingdom | 15 | 8,918 | | |
| **Europe total** | **184** | **162,965** | **15** | **13,918** |
| Argentina | 3 | 1,632 | 1 | 25 |
| Brazil | 2 | 1,884 | 1 | 1,245 |
| Canada | 19 | 13,554 | | |
| Mexico | 2 | 1,552 | | |
| USA | 99 | 99,869 | 4 | 4,468 |
| **Americas total** | **125** | **118,491** | **6** | **5,738** |
| Armenia | 1 | 375 | | |

| Country | Operational | | Under construction | |
|---|---|---|---|---|
| | No. | Power [MW] | No. | Power [MW] |
| India | 22 | 6,240 | 5 | 2,990 |
| Iran | 1 | 915 | | |
| Japan | 42 | 39,752 | 2 | 2,653 |
| China | 37 | 32,384 | 20 | 20,622 |
| Korea, Republic of | 25 | 23,007 | 3 | 4,020 |
| Pakistan | 4 | 1,005 | 3 | 2,343 |
| Taiwan | 6 | 5,052 | 2 | 2,600 |
| United Arab Emirates | | | 4 | 5,380 |
| **Asia and Middle East total:** | **138** | **108,800** | **39** | **38,008** |
| South Africa | 2 | 1,860 | | |
| **World total** | **449** | **392,116** | **60** | **60,264** |

# 11 RADIATION PROTECTION AND NUCLEAR SAFETY WORLDWIDE

The International Nuclear and Radiological Event Scale (INES) is used worldwide as a tool for ensuring consistent reporting to the public on the safety significance of nuclear and radiological events. International reporting on events is performed for more significant events rated at level 2 or higher and for events that have attracted the interest of the international public. The INES reports are published on the web-based communication system NEWS and the INES reports of events in Slovenia are published on the SNSA website.

**INES events in the year 2016**

In 2016, 16 event reports were published via the NEWS system. The reports were divided into the following groups: 1 event in a NPP, 1 event concerning the release of radioactive water from the Fukushima Daiichi NPP, 1 event at a research reactor, 1 event at an accelerator facility, 1 event at a facility for fuel assembly production, 1 event during the transport of radioactive material, 5 events during the performance of radiography, 3 events concerning finding radioactive sources, 1 event in nuclear medicine, and 1 event during radioactive waste treatment. In 2016 there were no events rated level 3 or higher. There were 10 level-2 event reports published and 5 reports of level-1 events. For the event at the Fukushima Daiichi NPP, the INES rating was not determined. In 2016 there were no events in Slovenia that required reporting according to the INES criteria.

During an accident event at a NPP in India, a small loss of coolant occurred. The safety systems responded automatically and there were no radioactive releases into the environment. The event rating was level 1 on the INES scale.

In a research reactor an event occurred due to the release of radioactive isotopes from damaged fuel rods stored in a leaking storage container. Radioactive release was detected by radiation monitors, personnel was evacuated from the reactor hall, and the ventilation was turned off. The radioactive releases were much lower than the annual limit. Due to the small radioactive release there was no hazard to the public. The neighbouring countries reported measurements of released iodine isotopes. The event was rated as level 1 on the INES scale based on degradation of defence in depth.

A cyclotron producing short-lived isotopes for medical diagnostics was in operation with an open bunkered door that should have protected personnel from radiation. The event occurred during a study visit of medical personnel from the whole country and the visitors received an estimated dose below 0.3 mSv. The event was rated as level 2 on the INES scale based on degradation of defence in depth.

Excessive deposits were found in a scrubber and the associated ventilation ductwork of a commercial nuclear fuel fabrication facility. The deposits contained large concentrations of uranium. The total quantity of the uranium found exceeded the criticality limit, however no spontaneous criticality occurred that could result in high doses to maintenance workers. The event was rated as level 2 on the INES scale based on degradation of defence in depth.

Another level-2 event on the INES scale occurred during the transportation of a radioactive source between two African countries. A parcel was labelled as empty and was handled as general luggage during transportation on a passenger flight. Upon arrival, a dose rate of 6 mSv/h was measured on the surface and it was determined that the parcel contained a radioactive source.

A serious event occurred during the performance of industrial radiography. A category-three source $^{192}$Ir dropped from the device. The next day a member of the public picked up the source and took it to his house. The owner of the source reported the loss of the source three days later and after a search action led by the national administration for atomic energy, the source was found. A total of 20 members of the public who were exposed were referred to the hospital and the most severely exposed was the person that had found the source and received a dose of 1 Gy. The event is under investigation; therefore, the event was rated provisionally as level 2 on the INES scale.

Another report concerned an event where members of public were exposed. During repair work on a radiographic device, it was not discovered that a $^{75}$Se source with activity of 1.3 TBq (a category-three source) was damaged. This resulted in the contamination of two workers repairing the device. The contamination spread to other rooms and external areas, which required a survey of $^{75}$Se intake for more than 80 persons. Due to $^{75}$Se intake, three workers received doses between 1 and 3 mSv, while three members of the public received doses higher than the annual dose limit of 1 mSv. The event was rated as level 2 on the INES scale based on the release of radioactive materials.

One report concerned the theft of a device containing a radioactive source. The device was dropped on a sidewalk in a town and a report indicated that it might contain the stolen source. The source was intact and therefore there was no hazard to the public. Another event was reported where two density gauges with category-five sources were stolen from a mining facility. The event occurred also due to a deficient safety culture. A third event occurred during radwaste management. A worker disassembled a gauge with a category-five $^{137}$Cs source to dispose of the source as radwaste. The source was damaged and this resulted in the contamination of rooms and ventilation ducts. The worker was not contaminated internally. All of these three events were rated as level 1 on the INES scale.

Five level 2 events were reported that were rated according to the criteria of workers' exposure that exceeded the annual dose limit in activities such as radiography, X-ray imaging, work with a particle accelerator, and in the preparation of nuclear medicine isotopes. Some of these events were caused due to non-adherence to the procedures for work with such devices or to the deficient safety culture of the personnel.

**Other Internationally Interesting Events in 2016**

The IAEA website reported on 11 events in 2016 that were not reported according to the INES criteria. Some countries reported on external events that could threaten nuclear facilities. Japan reported 3 earthquakes, on 1 occasion the earthquake triggered a tsunami. No nuclear power plant was threatened due to these events. In another country, a nuclear power plant was shut down due to a hurricane and minor damage to the plant occurred. A third country reported a forest fire that approached the city. The measures taken included the evacuation of inhabitants and additional monitoring of radiation sources at the location.

Following the terrorist attacks in Brussels in March 2016, emergency conditions were declared at Belgian NPPs. All staff that were not required for the operation of the NPPs were sent home. Supplemental military personnel were stationed at the NPPs for additional protection.

In another incident, after completing radiography measures, the workers stored a gamma camera with a category-four $^{192}$Ir source in the trunk of a vehicle. Subsequently, the car was stolen, only to be found at another location with the radiographic camera missing. A search action was initiated but the gamma camera was not found. The INES rating was not reported, but according to the criteria, this would be a level-1 event.

Another report concerned the theft of radioactive isotope $^{131}$I for medical use from a vehicle transporting the source from a neighbouring country. The authorities started a search action and after 120 hours managed to recover possession of the radioactive material, while the radiation shielding was not damaged. The INES rating was not reported, but according to the criteria, this would be a level-1 event.

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