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

# Annual Report 2017 on Radiation and Nuclear Safety in the Republic of Slovenia

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# Annual Report 2017 on Radiation and Nuclear Safety in the Republic of Slovenia

July 2018

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 24 May 2018.

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# SUMMARY


In 2017 there were no significant events in the field of nuclear safety and radiation protection. The Krško Nuclear Power Plant operated without any major problems. Due to technical faults, the plant had to be stopped twice for a short period of time. The annual electricity production was very high as there was no regular outage this year.

The Nuclear Power Plant signed a contract for the construction of a spent nuclear fuel dry storage facility and for the completion of the multi-annual safety upgrade project. Next to the plant a lake from the new hydroelectric plant Brežice was formed, due to which it had to adjust the system for capturing and discharging water from the Sava River.

After ten years, the Krško Nuclear Power Plant hosted an international OSART mission for the fourth time. A group of foreign experts critically reviewed all aspects of the plant's management and prepared a report with recommendations on how to improve the situation.

A similar EPREV mission visited all Slovenian institutions involved in dealing with possible nuclear or radiological accidents. Their recommendations are also useful guidelines for improvements in this area.

The Intergovernmental Slovenian-Croatian Commission for monitoring the performance of the contract on the ownership of the Krško NPP met in November 2017. At the meeting, Croatian representatives refused to participate in the project on the disposal of low- and intermediate-level radioactive waste at the Central Storage for Radioactive waste in Vrbina, as they were invited to do at the previous meeting in 2015. Therefore, a special group for negotiating the possibilities of joint disposal was formed. The Intergovernmental Slovenian-Croatian Commission also initiated the re-preparation of the renewed programme for the decommissioning and programme for the disposal of radioactive waste from the Krško NPP.

The ARAO, the Agency for Radwaste Management, has continued its activities for building a low- and intermediate-level radioactive waste disposal site in Vrbina, Krško. The environmental impact assessment procedure for the future disposal site was started. Unfortunately, all related procedures of the involved authorities have not accelerated as required, and thus the challenge remains as to how the Krško NPP will operate after 2021, when it is expected that all the storage capacities for such waste will be filled and the new disposal site will not yet be available.

At the Boršt hydrometallurgical tailings disposal site of the former uranium mine Žirovski Vrh the problems with landslide have not been solved, therefore the search for solutions continues.

In 2017 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 due to the finding of sources of ionising radiation in the field.

Mainly due to the new European directive, at the end of the year the National Assembly of the Republic of Slovenia adopted a new Ionising Radiation Protection and Nuclear Safety Act. This was a fundamental step entailing a major change in the legislation in the field of ionising radiation protection and nuclear safety.

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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 informing the general public of recent developments in the area of ionising radiation protection and nuclear safety. 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.

The preparation of this report is coordinated by the Slovenian Nuclear Safety Administration (SNSA). The content of the report is also contributed by other state bodies involved in protection against ionising radiation and nuclear safety, as well other institutions in this field. The most important contributors in 2017 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 Ministry of the Interior, the Administration of the Republic of Slovenia for Food Safety, Veterinary and Plant Protection, the Agency for Radwaste Management (ARAO), the Nuclear Insurance and Reinsurance Pool, the Krško Nuclear Power Plant (Krško NPP), Žirovski Vrh Mine, d. o. o., the Jožef Stefan Institute (JSI), the Institute of Occupational Safety (IOS) and the Fund for Financing the Decommissioning of the Krško Nuclear Power Plant and the Disposal of Radioactive Waste from the Krško NPP, and others.

The year 2017 was quiet and it can be summarised that the fundamental goal 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 contains 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 2017 the Krško NPP produced 6,285,272.3 MWh (6.3 TWh) gross electrical energy from the output of the generator, which corresponds to 5,967,826.6 MWh (6.0 TWh) net electrical energy delivered to the grid.

#### *2.1.1.1 Operation and Performance Indicators*

The most important performance indicators of the Krško NPP are shown in Tables 1 and 2, 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 2017**

| Safety and performance indicators | Year 2017 | Average (1983–2017) |
|---|---|---|
| Availability [%] | 99.40 | 87.35 |
| Capacity factor [%] | 102.29 | 86.13 |
| Forced outage factor [%] | 0.61 | 1.1 |
| Gross production [GWh] | 6,285.27 | 5,165.80 |
| Fast shutdowns – automatic [number of shutdowns] | 1 | 2.17 |
| Fast shutdowns – manual [number of shutdowns] | 0 | 0.14 |
| Unplanned normal shutdowns [number of shutdowns] | 1 | 0.71 |
| Planned normal shutdowns [number of shutdowns] | 0 | 0.80 |
| Event reports [number of reports] | 2 | 4.17 |
| Duration of the refuelling outage [days] | 0 | 49.6 |
| Fuel reliability indicator (FRI) [GBq/m$^3$] | $3.70 \cdot 10^{-5}$ | $6.34 \cdot 10^{-2}$ |

**Table 2: Time analysis of operation of the Krško NPP in 2017**

| Time analysis of operation | Hours | Percentage (%) |
|---|---|---|
| Number of hours in a year | 8,760 | 100 |
| Duration of plant operation (on grid) | 8,707 | 99.4 |
| Duration of shutdowns | 53 | 0.6 |
| Duration of the refuelling outage | 0 | 0.0 |
| Duration of planned shutdowns | 0 | 0.0 |
| Duration of unplanned shutdowns | 53 | 0.6 |

The operation of the Krško NPP in 2017 is shown in Figure 1. The plant shut down twice, once fast and automatically due to a regulator failure of the main feedwater flow control valve, and once manually with gradual power reduction due to the failure of the moisturiser and reheater relief valve. In the summer months, net energy production was lower due to the flow of the Sava River being lower and the use of cooling towers.

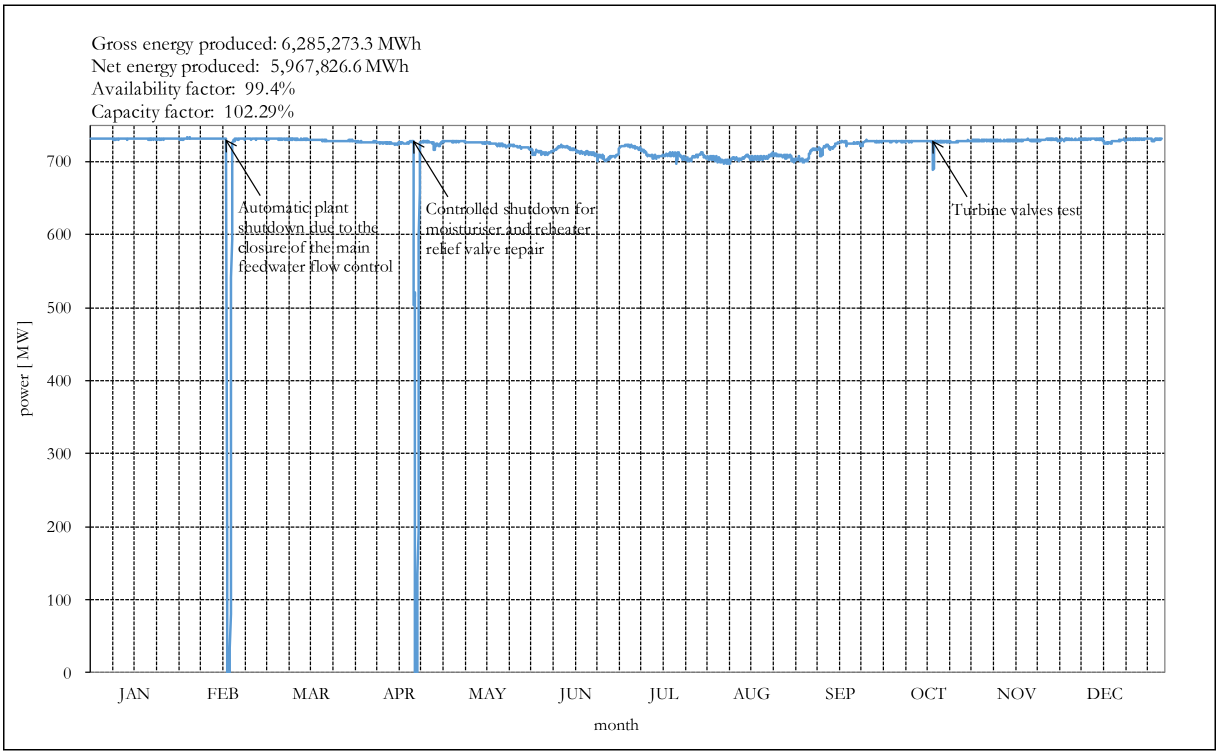


**Figure 1: Operating power diagram of the Krško NPP in 2017**

Figures 2 and 3 show the number of plant shutdowns.

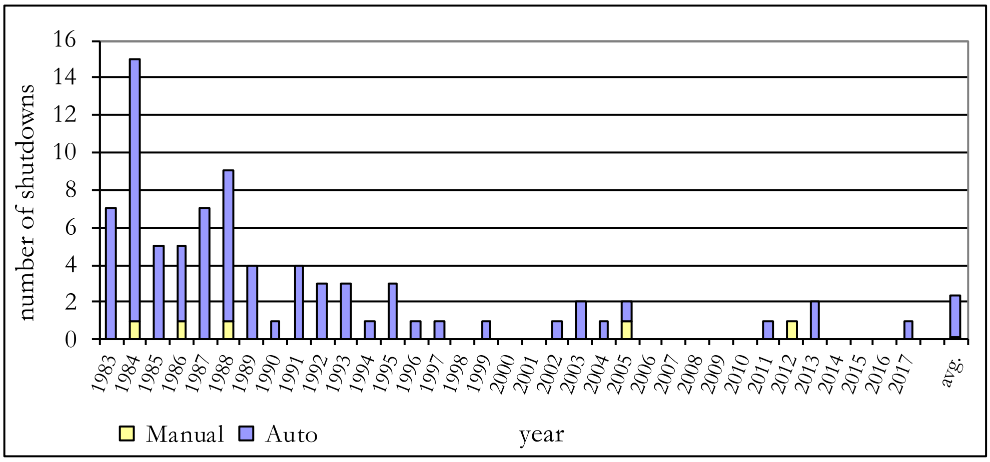


**Figure 2: Fast reactor shutdowns – manual and automatic**

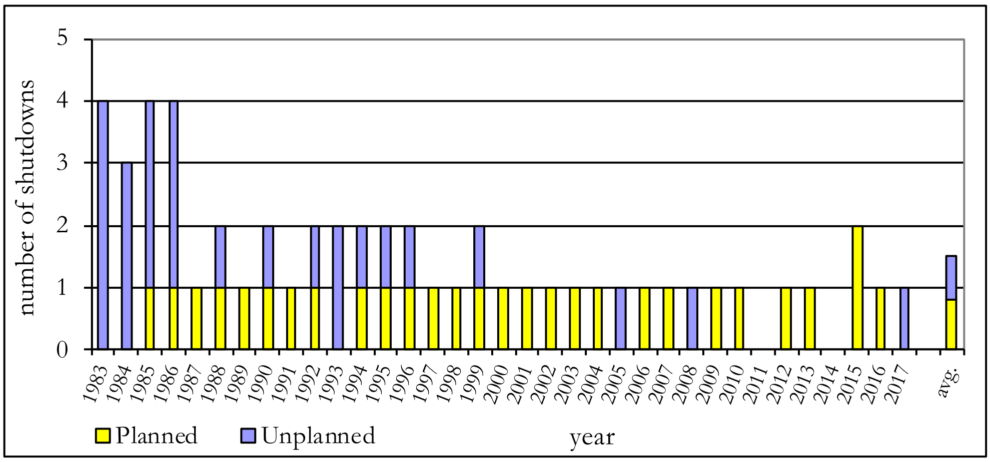


**Figure 3: Normal reactor shutdowns – planned and unplanned**

Shutdowns are divided into two groups: fast and normal. Fast shutdowns are caused by the operation of a reactor protection system that is triggered automatically or manually. With normal shutdowns, the power of the reactor is gradually reduced. These are further divided into planned and unplanned shutdowns. A normal shutdown due to fuel replacement and regular annual maintenance or outage is a special type of planned shutdown.

The gradual stabilisation of fast shutdowns can be noted (in the last 25 years less than 1 per year). In 2017 there were two shutdowns, one fast and automatic and one normal and unplanned.

Figure 4 shows the number of unplanned actuations of the high pressure injection system, which actuates automatically upon low pressure in the primary or secondary cooling system, upon high pressure in the containment, or manually. In 2017 there were no actuations of this system, thus the total number of actuations since the start of commercial operation remains 12.

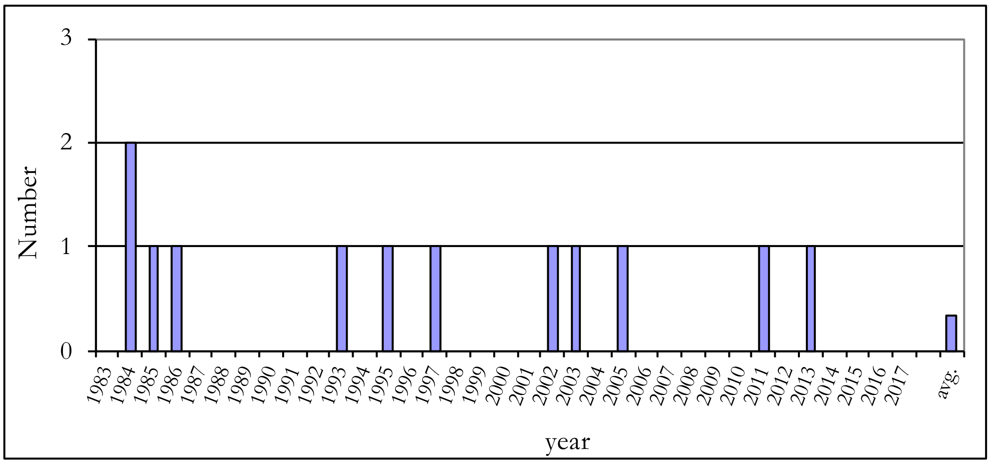


**Figure 4: Number of unplanned safety injection system actuations**

The plant availability factor is shown in Figure 5. In 2017 there was no outage, thus the availability of the plant was relatively high with a value of 99.4 %. The availability of the plant is the ratio between the number of operating generator hours (synchronised with the grid regardless of the reactor power) and the total number of hours in a year. It gives the percentage of time the plant was connected to the grid.

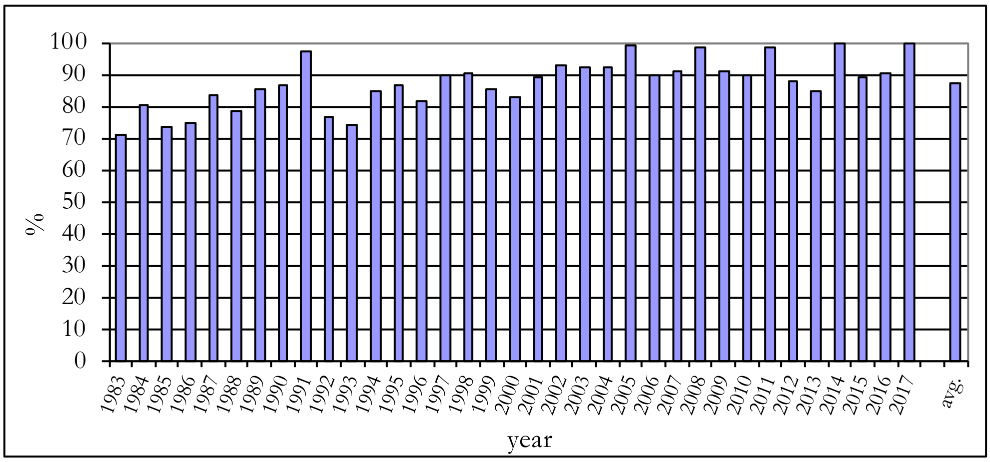


**Figure 5: Availability factor**

Figure 6 shows the produced electrical energy in the Krško NPP through all years of operation. Since there was no outage in 2017, the production of energy is appropriately high, 6.0 TWh.

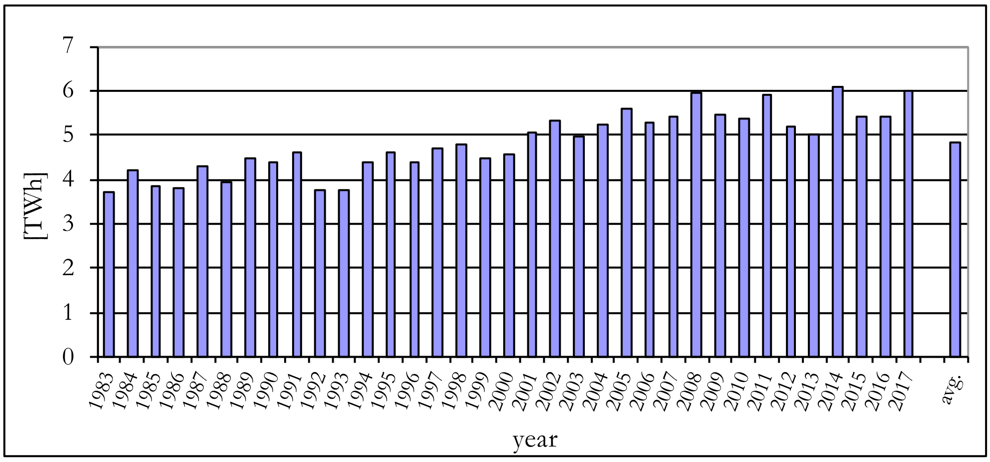


**Figure 6: Electrical energy production**

Figure 7 presents data on different means of electrical energy production in Slovenia, specifically electricity production in nuclear, hydro, thermal, and solar power plants. In 2017, the production of electrical energy was 15.3 TWh, of which 39 % was produced by the Krško NPP.

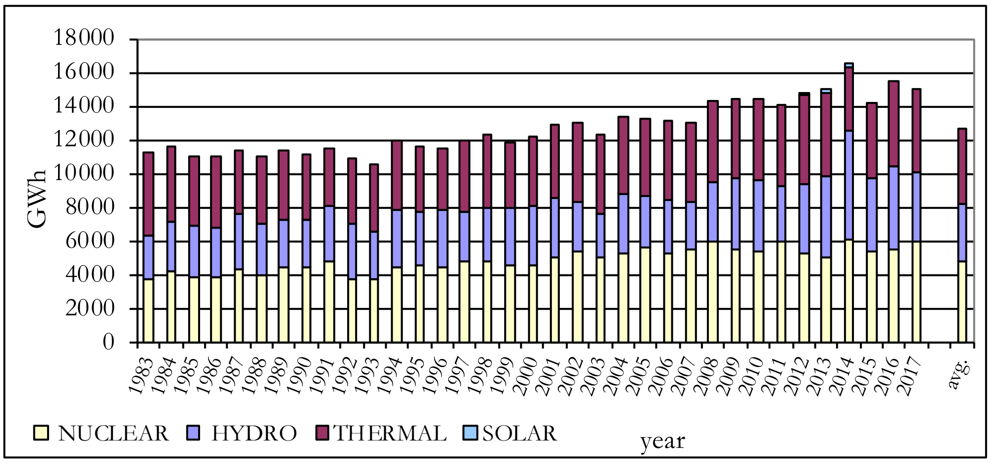


**Figure 7: Production of electrical energy in Slovenia**

The collective exposure to radiation is shown in Figure 8. The low value of this indicator shows the high effectiveness of exposure control, as well as leadership commitment to radiological protection. In 2017 there was no outage in the Krško NPP, thus the value of collective exposure, 62.6 man mSv, is comparable to other years without an outage, and it is also a record low value.

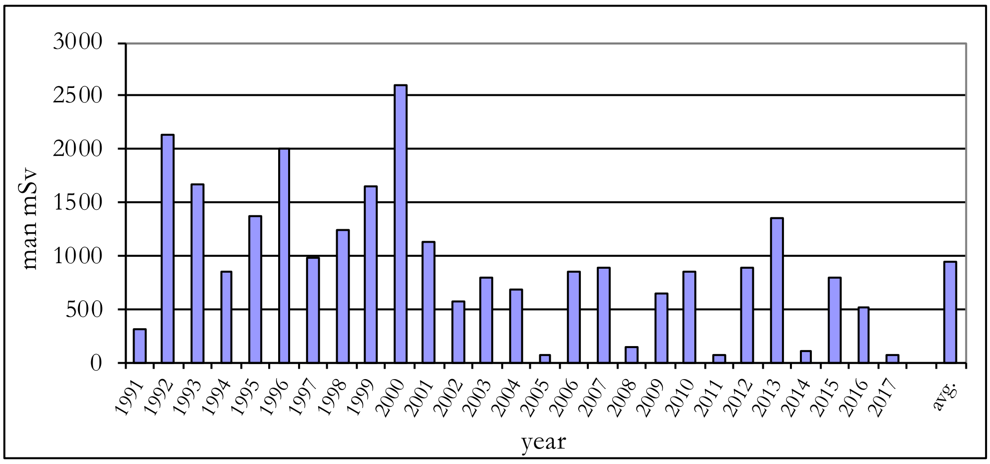


**Figure 8: Collective exposure to radiation in the Krško NPP**

Figure 9 shows the unavailability factor of the safety injection system. In 2017 the value of this factor was 0.0031, which is less than the Krško NPP's goal value (0.005). All unavailability of this system was due to planned on-line maintenance.

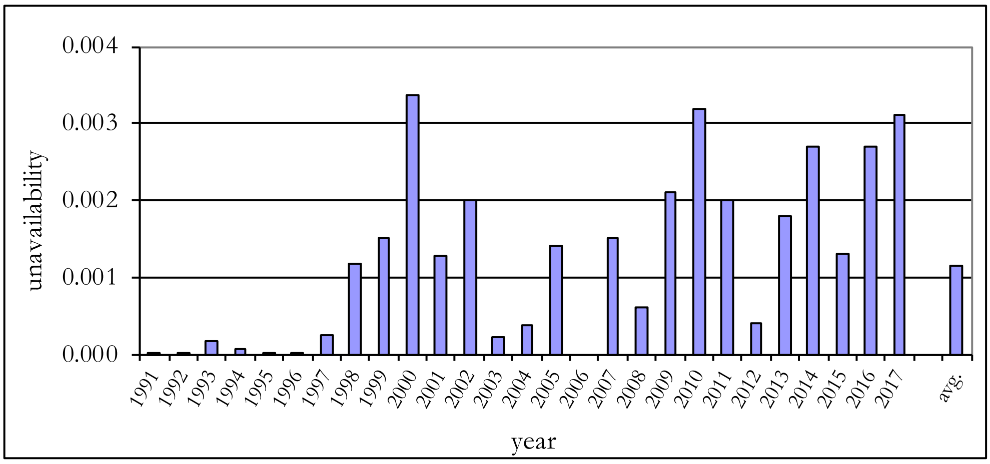


**Figure 9: The unavailability of the safety injection system**

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 2017 this system was completely available, thus the value of this factor is 0.

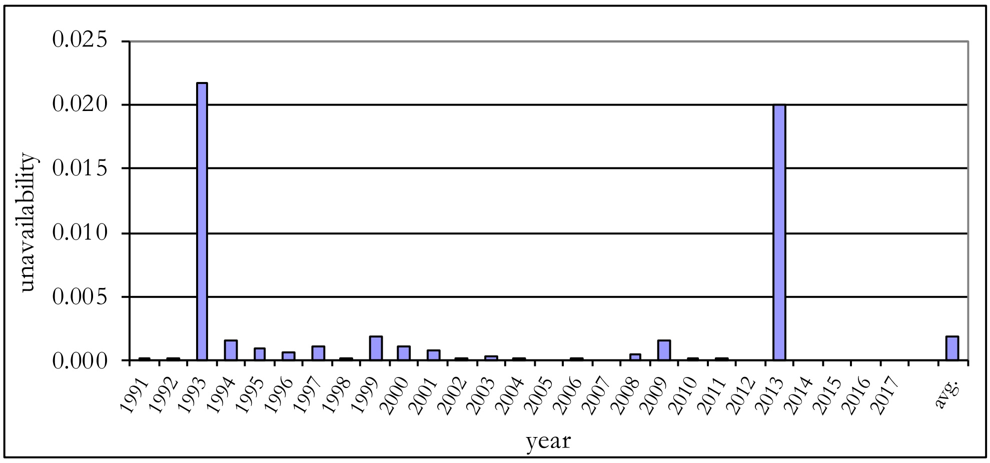


**Figure 10: The unavailability of the emergency power supply**

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 2017 the value of this indicator was 0.0009, which is below the Krško NPP's goal value (0.005). In 2017 the system was unavailable only during the planned on-line maintenance.

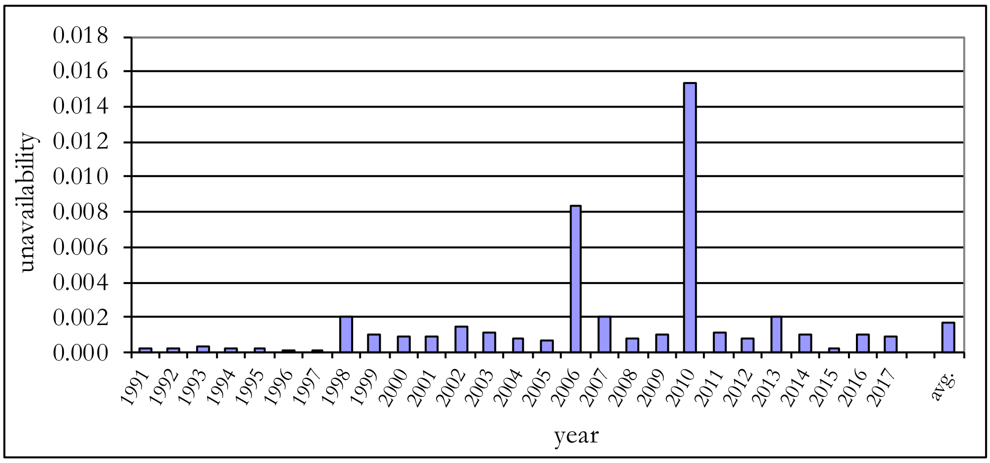


**Figure 11: The unavailability of the auxiliary feedwater system**

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

The reporting of abnormal events is determined by the Rules on the Operational Safety of Radiation and Nuclear Facilities. These Rules determine the list of events that have to be specially reported by nuclear power plant operators. The Krško NPP must also follow the additional reporting requirements prescribed in its Technical Specifications. In accordance with the Rules, the Krško NPP reported two events. In the first event, it was necessary to stop the power plant. The Krško NPP and the SNSA analysed both events. These events did not threaten nuclear and radiation safety.

**Automatic shutdown due to the closure of the main feedwater regulation valve**

On 16 February 2017, at 8:13, there was a rapid decrease in the level in steam generator No. 1 due to the undesired closure of a regulation valve (FCV551) on main feedwater line No. 1. The valve was closed despite a need for the valve to be open. The reactor operator recognised a reduction in the level in steam generator No. 1, when this was approximately 30 % of the narrow measurement range. The main operator attempted a manual shutdown, but the reactor protection function overtook the manual action. An automatic shutdown occurred when the water level in the steam generator reached 13 %. Isolation of the main steam line was carried out. At 8:52, by means of the motor-driven auxiliary feedwater pump, the power plant restored the normal water level (69 %) in steam generator No. 1. During the event all safety systems performed their function as intended.

After inspection of the regulation valve (FCV551) on feedwater line No. 1, a fault in the current/pressure converter on the regulation valve (FCV551) was discovered, which was the direct cause of the event. A detailed overview of this converter ascertained its poor quality (e.g. the soldered joints were weak, foreign objects were found, and during the inspection it was found that the converter was sensitive to shock/vibration). The Krško NPP replaced the defective position converter with a new one. The same corrective actions were preventively performed on another regulation valve (FCV552) on main feedwater line No. 2.

**Failure of the hydraulic controller during testing on diesel generator No. 2**

On 6 July 2017, at 8:30 a regular monthly test of diesel generator No. 2 was carried out. A slow start was planned at 450 rpm. After three minutes of slow-speed operation, the diesel generator accelerated to a nominal value 750 rpm.

Approximately nine seconds after accelerating, a local alarm and an alarm in the main control room sounded. The staff decided to stop the diesel generator normally. The diesel generator was declared inoperable and diesel generator No. 3 was set in automatic starting mode instead of No. 2.

During the inspection, it was noticed that the hydraulic controller did not respond to the start of motor A of diesel generator No. 2. It was found that the hydraulic controller failed due to the leakage from the electromagnetic shut-off valve despite being in a closed position.

The electromagnetic shut-off valve, which represents part of the hydraulic controller assembly, was replaced on the same day. The next day at 16:40, after successful repair and surveillance tests, diesel generator No. 2 was declared operable.

#### *2.1.1.3 Second Periodic Safety Review*

On 30 May 2014, the SNSA approved the second Periodic Safety Review (PSR2) and the resulting implementation plan. The Krško NPP reports every six months to the SNSA in accordance with the SNSA decision on the progress of the changes and improvements implementation plan of the PSR2, which includes 225 improvements. In total, by 31 December 2017, 194 actions had been completed, among them 69 out of 71 actions scheduled for completion in one year, 78 out of 84 actions scheduled for completion in three years, and 47 out of 70 actions scheduled for completion in five years. The Krško NPP must complete the implementation plan by 30 May 2019.

#### *2.1.1.4 Nuclear Fuel Integrity and Reactor Coolant Activity*

At the end of 2017 the core burnup reached 16,884.7 MWD/MTU, which corresponds to 415.8 Effective Full Power Days (EFPD).

The condition of the fuel assemblies in the reactor (fuel cladding integrity) is monitored indirectly through measurements of specific activities of the reactor coolant in conditions of stable operation and during transient events. Isotopes of xenon, krypton and iodine show fuel defects; from the measurement of specific activities of iodine isotopes, the defect size and coolant contamination can be determined. From specific activities of caesium isotopes, the burn-up of damaged fuel can be estimated. In the event of fuel rod cladding degradation, solid particles can be detected in the coolant, such as Neptunium-239 and Barium-140.

High specific activities of xenon and iodine isotopes were measured from the start of fuel cycle 29, which is a consequence of tramp fission material remaining in the primary circuit due to the open defects in fuel rods in fuel cycles 26 and 27. There were no leaking fuel assemblies in the fuel cycle 28 core. At the end of the year 2017, analyses of isotopes' specific activities showed that there were no leaking fuel rods in the cycle 29 core.

#### *2.1.1.5 The Krško NPP Safety Upgrade Programme*

In September 2011, the SNSA issued a decision for the Krško NPP in which it determined requirements for the implementation of the Krško NPP Safety Upgrade Programme (SUP). The requirements are based on Slovenian legislation and lessons learned from the Fukushima Daiichi accident in March 2011. The plant performed an analysis of the needed improvements and based thereon prepared a proposal for the SUP, which was reviewed by the SNSA and approved in February 2012.

The original deadline for the SUP was December 2016, but was later extended, first to December 2018, and then in 2017 again to December 2021 (a detailed description of the reasons for deadline extension can be found in the SNSA 2014 Annual Report).

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

Phase I, which was implemented in 2013:

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

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

- additional flood protection of the nuclear island and all the new systems, structures and components (implemented in 2015/2016);
- installation of pressuriser bypass relief valves, qualified for severe accidents (implemented in outage 2018);
- acquisition of a mobile heat exchanger, which will be located outside the nuclear island and feature provisions for quick connections to the spent fuel pool (planned for 2018);
- installation of a fixed spray system on the spent fuel pool with provisions to use mobile equipment (planned for 2018);
- 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 (planned for outage 2019);
- an upgrade of the Bunkered Building 1 (BB1) electrical power supply (with provisions to connect an additional mobile 2 MW diesel generator, seismic requalification of the 3rd emergency bus, an upgrade of the connection between the 400 V safety buses and mobile diesel generators, etc.) (implemented in outage 2018);
- replacement of the existing remote shutdown panels with the installation of an emergency control room (ECR) with capabilities to shut down the reactor and maintain the long-term safe shutdown state (the greater part of the upgrade was implemented in outage 2018, while its completion is planned for outage 2019).
- installation of additional instrumentation intended for severe accidents and featuring an independent power supply (implemented in outage 2018);

- the above-mentioned ECR will include habitability systems for ensuring a safe long-term environment for operators even in the event of severe accidents (planned for 2019); and
- an upgrade of the operational support center and technical support center (emergency centers) to ensure a safe long-term environment for operators even in the event of severe accidents (planned for 2019);

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

- installation of additional injection systems for the reactor cooling system / containment and steam generators with dedicated reservoirs for 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.

***The SNSA's Post-Fukushima Action Plan***

In December 2012 the SNSA prepared a comprehensive Action Plan based on the lessons learned from the Fukushima accident. The document was published on the SNSA's website. The Action Plan comprises all activities whose implementation would further reduce the risk due to external and other hazards that could affect the Krško NPP location.

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 eleven additional activities to improve preparedness for severe accident events. Among them are legislative changes, additional international review missions, additional studies and inspections, 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 2017 the following actions were in the process of being implemented:

- in the area of emergency preparedness, an international peer review mission, i.e. the IAEA's EPREV mission (*Emergency Preparedness REView*) was implemented, with made several recommendations for improving the emergency preparedness system in Slovenia. Part of the improvements are already being implemented, while for the rest an action plan will have to be adopted by the Government of the Republic of Slovenia;
- the IAEA's OSART mission (Operational Safety Review Team) was implemented, during which 17 international experts reviewed and evaluated all of the important processes in the Krško NPP as regards to the IAEA safety standards. The OSART mission made recommendations and suggestions for improvements and raised good practices. Based on the results, the Krško NPP will further improve its operations;
- special inspection regarding radiation monitors and readiness for severe accidents;
- upgrades of the Krško NPP's probabilistic safety assessment (PSA) – the Krško NPP developed a PSA for the spent fuel pool;
- preparations for the construction of the dry spent fuel storage on the Krško NPP site.

The updated Action Plan (December 2017) is published on the SNSA's website.

#### 2.1.1.6 *Technical improvements and modifications*

In 2017 the SNSA approved 14 modifications and agreed to 16 modifications. During the safety evaluation screening the Krško NPP did not ascertain open safety issues for 289 modifications. Therefore, the Krško NPP only informed the SNSA of those 289 modifications. As of 31 December 2017, there were 36 active temporary modifications. 40 temporary modifications were opened, and 34 were closed in 2017. Among active temporary modifications, 2 temporary modifications were approved in 2013 and 4 in 2014, which are scheduled to be closed by the end of 2018.

In 2017 the Krško NPP issued the $24^{th}$ revision of the "Updated Safety Analysis Report", which considered the changes approved up to 1 November 2017.

A list of modifications since 2000 approved by the SNSA or those of which the SNSA was informed can be found on the SNSA website.

#### 2.1.1.7 *Topical Peer Review (TPR)*

The SNSA has prepared the National Report within the Topical Peer Review (TPR) on aging management in the Krško NPP under the Euratom Directive. This work was done in cooperation with the Krško NPP, which has prepared the basis for the report. A technical support organisation also reviewed this basis and issued an independent expert opinion. The ageing management process and programme established in the Krško NPP is presented in the National Report, with an emphasis on four technical areas that are envisaged within the TPR, namely, electrical cables, concealed piping, the reactor pressure vessel, and the concrete part of the containment. The ageing management process fully complies with Slovenian regulations and is constantly being improved based on internal and external operating experiences and the results of R&D activities in the world.

The SNSA forwarded the completed and coordinated report to the European Commission in December 2017. Since then, the SNSA has been reviewing other country reports and has issued a number of questions and comments. A peer review of all country reports and a review meeting is planned for 2018 in Luxembourg.

#### 2.1.1.8 *Inspection reviews*

In 2017 the SNSA performed 67 inspections of the Krško NPP. Two inspections were reactive while all of the others were regular and planned. Four unannounced inspections are included in the total number.

The reactive inspections were related to two abnormal events, namely:

- an automatic reactor trip due to the sudden closing of the main feedwater control valve; and
- a manual shutdown due to the automatic opening of one of the relief valves.

In 2017 the SNSA introduced comprehensive and long-lasting topical inspection. The most comprehensive among them was the five-day inspection dedicated to aging management. Three two-day inspections of on-line maintenance and training were also conducted.

The SNSA inspectors monitored the management of problems with the new drives of in-core instrumentation installed in the 2015 outage. Due to the jamming of detectors, the Krško NPP operated with only two of four drives for more than half of 2017. Nevertheless, the requirements of the Technical Specifications of NPP were met at all times. The root cause analysis prepared by the drivers' supplier, namely AREVA, finally enabled the elimination of the mentioned problems in September.

Based on the performed inspections, the SNSA concluded that the Krško NPP operated safely, without causing harm to people and the environment in 2017. The identified problems were analysed and corrected within the framework of the implementation of the corrective programme. The SNSA inspection service assesses the activities of most of the organisational units of the NPP as good. The inspections identified the high level of safety culture of the majority of the NPP experts, which is reflected in the high quality of the activities carried out, where safety was always a priority.

In addition, from the radiation protection point of view, the Krško NPP is inspected by the Slovenian Radiation Protection Administration (SRPA). With no outage in 2017, the SRPA conducted no inspection of the Krško NPP.

The SRPA monitors the radiation protection of workers in the NPP. In 2017 no such inspections were performed.

#### *2.1.1.9 The OSART mission to the Krško NPP*

Following the accident at the Fukushima Nuclear Power Plant and after carrying out stress tests, the SNSA prepared an Action Plan to improve nuclear safety, which, in addition to the Safety Upgrade Plan at the Krško NPP, includes a review of operational safety with the support of the IAEA in the implementation of the OSART (*Operational Safety Assessment Review Team*) mission. A few years ago, the Republic of Slovenia invited the OSART mission to carry out a review of the operational safety of the Krško NPP in 2017.

A review of the operational safety of the Krško NPP within the framework of the OSART mission took place between 15 May and 1 June 2017. The OSART mission reviewed all aspects of the operational safety of the Krško NPP, divided into thirteen different thematic areas.

The final report of the OSART mission contains four recommendations, sixteen suggestions for improvement, and three examples of good practice. The recommendations relate to the areas of training and the qualifications of staff, operations and operational experience feedback.

The OSART suggestions for improvement (the number of suggestions are in brackets) refer to the following areas: leadership and management for safety (3), maintenance (1), technical support (1), operational experience feedback (1), radiation protection (1), chemistry (2), emergency preparedness and response (1), human technology and organisation interaction (1), long-term operation (1), and the use of probabilistic safety analyses (1).

Examples of good practice are identified in the fields of operation, maintenance and the use of probabilistic safety analyses.

In response to the reports of the OSART mission, the Krško NPP has already prepared a detailed plan for the implementation of measures by defining the measures and a timetable that envisages the implementation of the measures and solutions to open issues by the end of 2018. The mentioned plan for the implementation of the measures was submitted to the SNSA on 30 November 2017. The SNSA reviewed the draft plan for the implementation of the Krško NPP measures and prepared its own plan for monitoring the implementation of the OSART recommendations and suggestions at the Krško NPP.

### 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 2017 the reactor operated for 151 days and released 109.5 MWh of heat during operation. Operation was carried out according to a programme that is approved for each week by the head of the RIC and the JSI radiation protection service. The reactor operated in stationary mode and in pulse mode – 46 pulses were performed. The reactor was mostly used as a neutron source for neutron activation analysis, for the irradiation of electronic components or other materials, and for educational purposes. A total of 1,127 samples were irradiated in the carousel and the irradiation channels.

In the Hot Cell Facility (OVC), 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 2017 there were two automatic reactor shutdowns; the first one was due to sample extraction and the second one was due to the failure of a reactor building air-conditioning device. During the quick extraction of larger samples from the central or the triangular channel the reactor power varies so much that the automatic control cannot compensate for it quickly enough. Thus, the power exceeded the linear channel limiting value for a fast shutdown of the reactor and the reactor shut down. The second shutdown occurred upon morning startup on 5 December 2017, when due to the early hours the hot water supply for the heater of the reactor air conditioning device was not sufficient. The heater temperature fell below the limit of 13°C and the air conditioning device preventively shut down and thus prevented freezing and damage to the heater. The reactor automatically shut down while approaching the operational limit, which 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 2017. There were also no events in 2017 that required reporting to the SNSA and there were no events connected to fire safety or physical security.

The performance indicators regarding the doses acquired by the operating staff and the personnel conducting experiments showed values far below the regulatory limits. The collective dose in 2017 was 530 man μSv for operating staff and 1,150 man μSv for personnel carrying out work at the reactor.

In 2017 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. In 2017 there were no inspections of the fuel elements. The JSI reported on the fuel balance monthly to the EURATOM and to the SNSA by a special form. In November 2017, the EURATOM performed an inspection of the status of the nuclear material and the inspection findings showed no anomalies.

#### *2.1.2.2 Staff Training*

Two TRIGA reactor operators extended their licenses for reactor operation on 28 November 2017. Regular training of staff was performed in line with the annual programme of expert training of the TRIGA Research Reactor operators for the year 2017. Internal training was organised regarding procedures and measures in the event of emergencies and the transfer of irradiated fuel from the reactor pool to the spent fuel pool.

On 6 October 2017 an emergency exercise for the evacuation of all personnel working at the Reactor center was carried out.

#### *2.1.2.3 Modifications and Inspections of the Systems, Structures, and Components of the Nuclear Facility*

In 2017 six reactor core modifications were made for the experimental purposes of the Nuclear Physics Department and the CEA (Commissariat à l'énergie atomique).

In 2017 a modification of channel No. 6 was carried out, which will enable the neutron irradiation of larger samples. In January 2017 a protection device was installed that enables the prevention of reactor operation when the radiological shielding is removed. There were no other design changes to the reactor in 2017.

The RIC personnel, the JSI technical services, the JSI radiation protection service, and the authorised external organisations conducted periodic inspections and supervision of the safety structures, systems, and components (SSC). The inspections did not find any deficiencies.

#### *2.1.2.4 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 2017 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, 8 actions out of 14 planned were implemented, while the implementation of 6 actions was behind schedule and should be completed in 2018. In the same manner, in 2018 there are three actions scheduled for implementation in 2018 that will be completed in 2019. The implementation of the action plan for modifications and improvements should be completed by December 2019. Until the end of 2017, altogether 89 % of all planned actions had been implemented.

#### *2.1.2.5 Upgrade of the Safety Analysis Report*

In 2017 the administrative procedure for upgrade the Safety Analysis Report of the TRIGA Mark II Research Reactor was completed with the issuance of revision 7 of the Safety Analysis Report.

### 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).

Planned periodic preventive maintenance inspections and testing of CSRW structures, systems, and components (SSC) and service equipment in measuring devices were carried out as planned. The first Periodic Safety Review of the CSRW, including a final report, was carried out. The positive expert opinion from an authorised expert on nuclear and radiation safety on the final report was obtained. The approved final report on the first Periodic Safety Review will be the basis for the extension of the operating licence of the CSRW in 2018.

Records were kept of radioactive waste (RW) 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.

The acceptance of radioactive waste in the CSRW in 2017 and the inventory of the waste stored as at the end of 2017 are described in more detail in Chapter 5.4.

### 2.1.4 The Former Žirovski Vrh Uranium Mine

The excavation of uranium ore took place in the area around Žirovski Vrh 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 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. The P-10 plateau at the foot of the body of the disposal site is also included in the area of the national infrastructure facility referred to as the Jazbec disposal site due to the rupture of mining waste. The area together with the facilities that stand on the plateau has been rehabilitated and is managed by several legal entities.

For the disposal site, the year 2017 was the seventh year of the transitional period of long-term management and, in addition to regular maintenance work, the implementation of interventional drainage measures in the drainage tunnel under the landfill was also carried out. More information on the 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 required advanced notification of the intention to carry out a radiation practice or intended use of a radiation source, a mandatory licence to carry out a radiation practice and a licence for the use of a radiation source or certificates of the registration of radiation sources. In the middle of December, the new Ionising Radiation Protection and Nuclear Safety Act was adopted, which in addition to the above-mentioned, also requires the registration of a radiation practice.

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

At the end of 2017, 171 organisations in industry, research and the state administration in the Republic of Slovenia were using 339 X-ray devices, and 703 sealed sources were being used in 76 organisations. As many as 34 radioactive sources were stored at 16 organisations, which are intended to be handed over to the ARAO in the future.

In 2017, 53 licences to carry out radiation practices, 43 licences for the use of a radiation source, 4 certificates of the registration of radiation sources, 67 print-outs from the register of radiation sources, 14 approvals for external operators of radiation practices, 1 decision on the termination of the validity of licences to carry out radiation practices, 4 decisions on sealing an X-ray device and one decision on unsealing 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 21,233 ionisation smoke detectors being used at 270 organisations at the end of 2017. In addition, 305 ionisation smoke detectors were stored at the users' premises. Among them, 195 were stored at the premises of the companies, dealing with the maintenance, mounting and dismounting of ionisation smoke detectors.

**The STERIS manufacturing and storage facility for the sterilisation of medical equipment**

In 2017 the STERIS manufacturing and storage facility was built in the area of the Komenda business zone. Its investor is the international cooperative Synergy Health Holdings Limited from the United Kingdom. The sterilisation of medical equipment will be implemented in the facility. It intends to sterilise new medical equipment, which will be transported by truck from factories in East Europe to consumer centers in the West. The facility, in which there are two linear accelerators, is classified as a less important radiation facility.

In January 2017 the SNSA issued project conditions for construction affecting radiation safety and in May an approval for construction affecting radiation safety. At the same time, the SNSA also issued a decision on the status of the facility, which is classified as a less important radiation facility. In September, the SNSA issued two licences for the relevant foreign legal person that is undertaking a radiation practice for Mevex Corporation from Canada. In October, the SNSA issued an authorisation to carry out a radiation practice for the testing of linear accelerators. In December, the SNSA participated in a technical inspection of the facility.

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

In 2017 the SNSA inspection service conducted 70 inspections related to industry, research institutions, ministries, educational institutions and scrap dealers. Annual inspections related to the use of high-activity radioactive sources were performed as part of regular inspection activities in recent years. In particular, industrial radiography required special attention. As a rule, undertakings performing industrial radiography are subject to regular annual inspection not only when using high-activity radioactive sources but also when using X-ray machines. The SNSA inspectors observed an insufficient safety culture level in particular in industrial radiography where very often operators do not incorporate sufficient safety procedures into their everyday work. As industrial radiography is one of the practices involving the highest risk, the SNSA inspectors determined that annual regular inspections are necessary also in the future.

In 2017 no abandoned sources that were left when becoming disused sources, i.e. so-called orphan sources, were identified except smoke detectors using ionising radiation sources.

The inspection acknowledged the need for inspection supervision of companies that announced bankruptcy or were already bankrupt. Namely, the SNSA inspectors observed no sustainability of radiation protection knowledge related to specific sources in such companies after the radiation protection officer has left. In particular, the awareness of bankruptcy managers should be enhanced, otherwise they might unintentionally manage radioactive sources or radioactive waste without appropriate knowledge when managing a bankruptcy.

In 2017 the inspection continued the inspection programme related to the import of radiation sources. As a rule, importers do not have knowledge related to legislation associated with this activity. As a result, they often did not inform the users of sources of the conditions for the safe use of a source already issued by the producer of the source. The SNSA inspectors also inspected corrective actions required in inspection reports from previous years, e.g. complex corrective actions were conducted at the Ministry of Defence.

In 2017 the SNSA inspection conducted 17 interventions already included in the total number of inspections. The number of interventions is somewhat larger compared to the average number of interventions per year in the last five years. The majority of interventions were related to radioactive sources or radioactive waste in scrap materials, namely 11 interventions. Six times a transit cargo from Hungary or Croatia travelled through Slovenia to Italy regarding which enhanced radioactivity was measured. Such cargo was returned to the country of origin. SIJ

Acroni d. o. o. reported two instances of an enhanced dose rate measured regarding railway wagons loaded with materials from the company Dinos d. d. In addition, three times Dinos d. d. reported enhanced doses regarding wagons with scrap materials. A qualified expert, Institute of Occupational Safety (IOS), performed an investigation of the wagons and identified an enhanced concentration of natural radioactivity in materials coating the inner walls of pipes. IOS also confirmed that due to the low level of the specific concentrations of radionuclides regulatory control was not necessary.

One intervention was related to an alarm of the Early Warning Network managed by the SNSA. Namely, one detector in Ljubljana measured a radiation field that was a consequence of industrial radiography using a radiation source at a nearby construction site. The measured value of the dose rate was approximately 20 times the natural background. After this event the industrial radiography company introduced a protocol informing the SNSA in advance before performing industrial radiography that might trigger this detector's alarm.

In addition to the interventions described above, the SNSA also performed measurements of dose rates at different locations of a sand mine. Namely, the SNSA was informed of the suspicion that radioactive waste had been illegally deposited in the Municipality of Moravče. The suspicion has not been confirmed. The SNSA inspection also investigated the characteristics of a KEMIS kemični izdelki, predelava in odstranjevanje odpadkov d. o. o. (chemical products, waste recovery, and disposal, LLC) site where a fire took place in 2017. The SNSA inspection did not identify enhanced radiation fields. In 2017 one intervention was related to an enhanced occupational dose in industry. Namely, the dosimeter of one worker measured 9.75 mSv in a period of 48 days. The investigation revealed that this dose was a consequence of nuclear medical procedures. The inspection of the SNSA also took part in an emergency preparedness exercise related to explosions and fire. This exercise was organised by the Volunteer Fire Society of Ihan. Other participants were from the Agency for Radwaste Management, the Ecological Laboratory with Mobile Unit, the Jožef Stefan Institute, the Police and the Emergency First Aid Service.

The SRPA also conducts inspections related to the protection of workers against ionising radiation and thus oversees the implementation of radiation activities. In 2017 the SRPA inspection service conducted three inspections regarding training in radiation protection. Due to a report from one of the training providers, two inspections were conducted at the Milan Čopič Nuclear Training Centre and one inspection was conducted at the company Q Techna d. o. o. Eight workers did not have a valid training certificate since their training provider did not hold the valid approval. This was deemed to be an offence. Warnings were included in the inspection report. Valid training certificates were issued afterwards when the training centre obtained the appropriate approval.

Due to the already mentioned high reading of a personal dosimeter (9.75 mSv), the company TDR Legure d. o. o., Ruše, was called in to clarify the event. It turned out that the worker used the dosimeter in an inappropriate manner – for a couple of hours he lent it to a colleague who underwent an iodine $^{131}$I thyroid treatment. TDR Legure took immediate action and there have not been any high dose readings since.

### 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, 1,066 X-ray devices for medicine and veterinary medicine were installed as of the end of 2017; 112 of them were not in use, 8 required servicing, 68 were on reserve, and 36 were proposed for decommissioning. The categorisation of X-ray devices based on their purpose is given in Table 3.

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

| Purpose | Status 2016 | New | Written-off | Status 2017 |
|---|---|---|---|---|
| Dental | 565 | 46 | 53 | 558 |
| Diagnostic | 306 | 20 | 15 | 311 |
| Therapeutic | 12 | 1 | 1 | 12 |
| Simulator | 4 | 0 | 0 | 4 |
| Mammography | 34 | 5 | 5 | 34 |
| Computed Tomography CT | 29 | 5 | 3 | 31 |
| Densitometers | 46 | 0 | 1 | 45 |
| Veterinary | 66 | 6 | 1 | 71 |
| **TOTAL** | **1,062** | **83** | **79** | **1,066** |

In the field of the use of X-ray devices in medicine and veterinary medicine in 2017, the SRPA granted 75 licences to carry out a radiation practice and 230 licences to use X-ray devices.

In medicine (not including veterinary medicine), 465 X-ray devices were used in public hospitals and institutions and 530 in private dispensaries. The average age of X-ray devices was 9.8 years (9.6 years in 2016, 9.4 years in 2015, 9.6 years in 2014, 9.5 years in 2013, and 9.1 years in 2012), and in the private sector 10.0 years (10.2 years in 2016, 10.1 years in 2015, 9.9 years in 2014, 9.8 years in 2013, and 9.2 years in 2012).

In veterinary medicine, 14 X-ray devices were in use in public institutions and 57 in the private sector. The average age of X-ray devices was 15.4 years (15.5 years in 2016, 15.5 years in 2015, 14.5 years in 2014, 13.5 years in 2013, 13.8 years in 2012) in the public sector, and 8.8 years (8.7 years in 2016, 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 4.

**Table 4: 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 | 342 (81 %) | 9.6 | 110 (20 %) | 10.4 | 13 (100 %) | 7.2 | 14 (20 %) | 15.4 | 479 (45 %) | 9.9 |
| Private | 82 (19 %) | 11.6 | 448 (80 %) | 9.7 | 0 | 0 | 57 (80 %) | 8.8 | 587 (55 %) | 9.9 |
| **TOTAL** | **424** | **10.0** | **558** | **9.8** | **13** | **7.2** | **71** | **10.1** | **1,066** | **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".

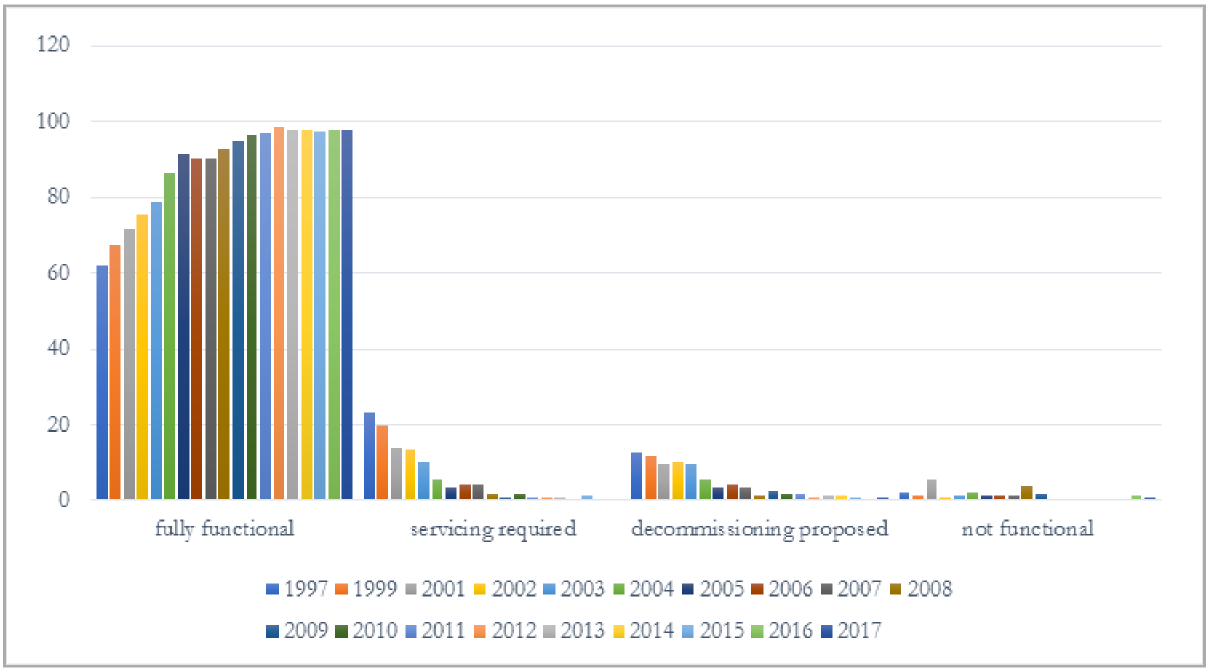


**Figure 12: Percentage of diagnostic X-ray devices according to their quality in the period 1997–2017**

In 2017 seven 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 were dedicated to the introduction of radiotherapy (the use of linear accelerators) at the University Medical Centre in Maribor, one inspection investigated an incident in radiotherapy, and four inspections were related to X-ray diagnostics. In three cases, based on the findings of the inspection, the inspection service issued a decision requiring harmonisation with the valid regulations. In one case, the inspection involved the unsealing of an X-ray machine.

An inspection was conducted at the Institute of Oncology (OI) in Ljubljana regarding the unintended exposure of a patient. On 16 March 2017 a patient, after her treatment was finished, remained in the labyrinth of the exposure room. This led to the unjustified exposure of this patient with scattered radiation. The OI conducted a careful reconstruction of the event and estimated the dose received by the patient to be 0.1 mSv. This dose is significantly lower than the dose due to scattered radiation that the patient obtained during her own treatment. The treating physician considered the dose due to the incident to be clinically negligible. Based on the results of the investigation of the event, the OI formulated protocols for closing the doors, which will prevent the occurrence of such events in the future.

Based on a review of the inspection reports on X-ray devices for medical use sent to the SRPA by approved technical support organisations, five inspections were conducted during which the SRPA requested that the user provide evidence that the noted shortcomings had been eliminated. There were 26 cases in which the user was asked to present evidence relating to the termination of the use of an X-ray device and 110 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 6708.0 GBq of isotope $^{99}Mo$, 4000.0 GBq of isotope $^{18}F$, 922.3 GBq of isotope $^{131}I$, and minor activities involving the isotopes $^{123}I$, $^{177}Lu$, $^{201}Tl$, $^{111}In$, $^{68}Ge$, $^{223}Ra$ 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, 1.26 GBq of that isotope were imported in 2017 (a bit more than in 2016, when 0.85 GBq of that isotope were imported). In October 2017 the Clinic for Nuclear Medicine of the University Medical Centre in Ljubljana introduced a new diagnostics technique involving $^{68}Ga$. This isotope emits positrons and has a half-life of 67 minutes. The generator for $^{68}Ga$ is the isotope $^{68}Ge$ with a half-life of 271 days.

Sealed sources for therapy are used at the Institute of Oncology and the Ophthalmology Clinic, 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 of up to 740 MBq are in use. The Ophthalmology Clinic uses three sources of $^{106}Ru$ with initial activities of 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 $^{137}Cs$ source with an 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.

With reference to the use of unsealed and sealed sources in medicine, one licence to carry out a radiation practice and 39 statements on the shipment of radioactive materials were issued in 2017.

Medical departments with unsealed and sealed radiation sources were surveyed (once or twice annually, depending on the source type) by approved experts in radiation protection and medical physics at the Institute of Occupational Safety (IOS). No major deficiencies were found in 2017.

Neither unsealed nor sealed radioactive sources were used in veterinary medicine in 2017.

### 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 2017 the SNSA issued one approval for multiple transport under special arrangement to the 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 2017 the SNSA did not carry out any procedures for package approval.

In 2017 the SRPA issued one licence to carry out a practice involving the transport of radioactive materials that are used in health and veterinary care.

### 2.2.5 The import/shipment into, transit, and export/shipment out 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 2017 the SRPA did not issue any permits for the import of radioactive sources from non-EU countries, but approved 27 applications of consignees of radioactive material for 44 isotopes. Each isotope from an individual producer intended for the same end user is counted separately.

In 2017 the SNSA approved seven applications of consignees of radioactive material from other EU Member States. The SNSA also issued eight permits for the import of radioactive material, one permit for multiple shipments of radioactive material between other EU Member States, two permits for the import of nuclear material, i.e. fresh fuel elements for the Krško NPP and fission chambers, and one permit for the export of radioactive material.

In 2017 the SNSA issued one approval for the shipment of radioactive waste from the Krško NPP to France for treatment. For a particular shipment France initiated a special procedure for signing an intergovernmental agreement for the return of the waste after treatment. By the end of the year 2017 the intergovernmental agreement had not yet been signed.

In 2017 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

The Resolution on Nuclear and Radiation Safety in the Republic of Slovenia for the period 2013–2023 determined the following broad-ranging goals in the field of nuclear and radiation practices:

**Goal 1**

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

**Realisation in 2017**

The main priorities that we followed in Slovenia are the following: fulfilment of the statutory requirements, continuous verification, and improvement of the nuclear safety level in all nuclear and radiation facilities and activities in Slovenia. It is evident from the previous chapters of this report that this goal was achieved.

# 3 RADIOACTIVITY IN THE ENVIRONMENT

The purpose of radioactivity monitoring in the environment is mainly to monitor the levels of general radioactive contamination, trends regarding 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, the monitoring of radioactivity in the environment and regular control of the radioactive contamination of drinking water, food and feed based on laboratory measurements.

Radioactivity released into the environment by the Krško NPP, the former uranium mine at Žirovski Vrh, the TRIGA Research Reactor and the Central Storage for Radioactive Waste, is monitored.

This chapter contains a summary of the reports on the state of environmental radioactivity on the territory of Slovenia in 2017.

The monitoring of exposure to natural sources of radiation is carried out under the governmental programme for the systematic inspection of working and living environments and raising the awareness of the population regarding 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.

## 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.

The old Early Warning System, referred to as the MZO in Slovenia, will soon be replaced by a new, advanced system, referred to as the RVO in Slovenia. The first testing of the new online tool began at the end of 2017 (Figure 13). The RVO represents a new system for collecting, archiving and displaying data on radiation in the environment. In addition, it will also display data from laboratory measurements of environmental samples (the ROKO database) and real time individual measurements made by mobile units or by SNSA co-workers.

The important novelties include the modules Exercise and Emergency Events (exercises and simulations) and Mobile Units (operators can request field measurements and display real-time data from mobile units). The new system will also allow the public insight into the state of the environment, on the same websites as was the case for the previous system (www.radioaktivnost.si/).

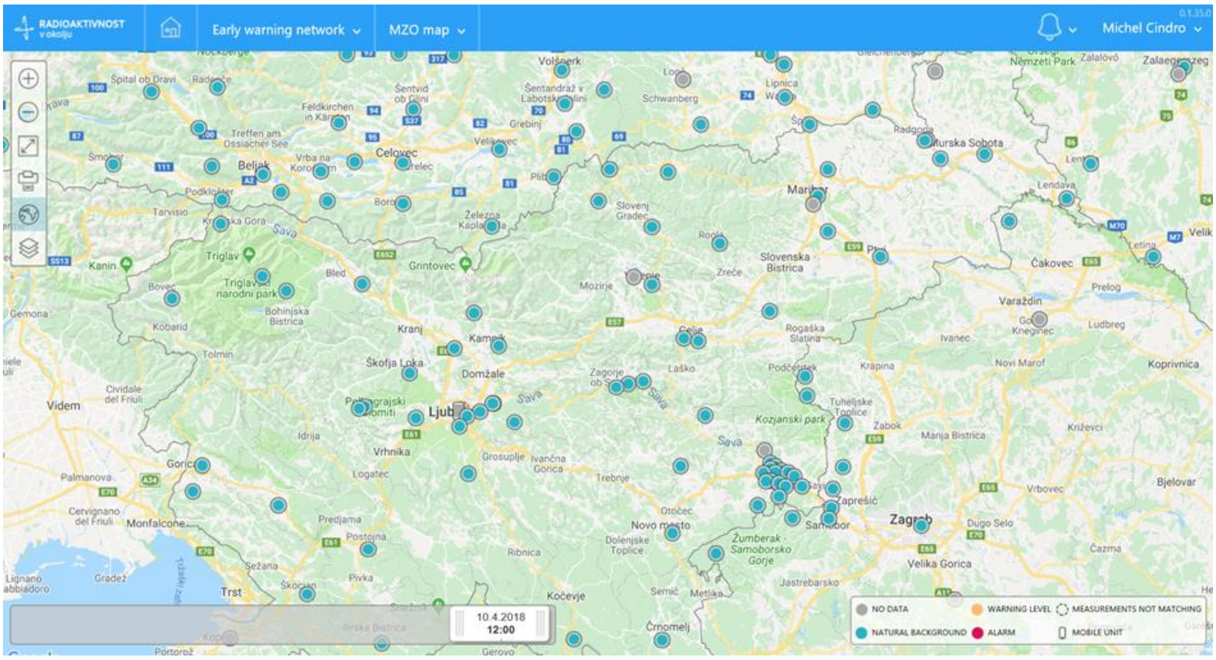


Figure 13: Basic view of the Early Warning System in Slovenia and in neighbouring countries

## 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 2017 showed that the 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. Due to the trends of seasonal deviations of the $^{137}Cs$ concentration in the air, the SNSA will conduct a study on the concentration of radionuclides in heating pellets, which will be carried out in 2018.

The biggest contribution to the radiation exposure of the public due to environmental contamination by artificial radionuclides comes from external radiation and food ingestion. The inhalation dose from aerosols with fission radionuclides is negligible. $^{90}Sr$ is the biggest contributor to the food ingestion dose and $^{137}Cs$ is the biggest contributor to the external radiation dose. In 2017 the biggest contributor to the inhalation dose was $^{106}Ru$ (see below), although it contributed only approximately 1 % to the total dose.

In 2017 the effective dose from external radiation of $^{137}Cs$ (mainly from the Chernobyl accident) was estimated at approximately 5.5 μSv, which is 0.2 % of the dose received by an average adult in Slovenia from the natural background radiation.

The annual dose from the ingestion pathway (the consumption of food and drinking water) was 3.2 μSv, which is higher than in 2016 (1.3 μSv) but the increase is still within the uncertainty of the measurement and calculation methods. Similar to the year 2008, the estimated dose 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.

In 2017 the dose was higher due to measurements of meat samples, while for other samples an increase could not be observed.

The annual contribution of the dose due to the inhalation of artificial radionuclides in 2017 was significantly higher (almost three orders of magnitude) than in previous years due to the inhalation of $^{106}Ru$ from the radioactive cloud that spread all over Europe and was estimated at 0.11 ± 0.08 µSv. The contribution of $^{137}Cs$ to the dose was similar to previous years (approximately 0.2 nSv per year). It should be emphasised that these doses are still extremely low and negligible when compared to radiation exposure from other transfer pathways.

The total effective dose received by the population from drinking water due to artificial radionuclides was also estimated. Calculations showed that on average this dose is approximately 0.03 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 2017 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 8.9 µSv, as shown in Table 5. This is approximately 0.36 % 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 5: The radiation exposure of the adult population in Slovenia due to global contamination of the environment with artificial radionuclides in 2017**

| Transfer pathway | Effective dose [µSv per year] |
|---|---|
| Inhalation | 0.11 |
| Ingestion:<br>drinking water<br>food | <br>0.03<br>3.2 |
| External radiation | 5.5* |
| **Total (rounded)** | **8.9**** |

* 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 14 shows the annual effective dose of the population due to food ingestion. In 1992 the dose rate was high due to the game meat that was included in the diet calculations. Without the inclusion of game meat, the effective dose rate for that year would be lower than 10 µSv.

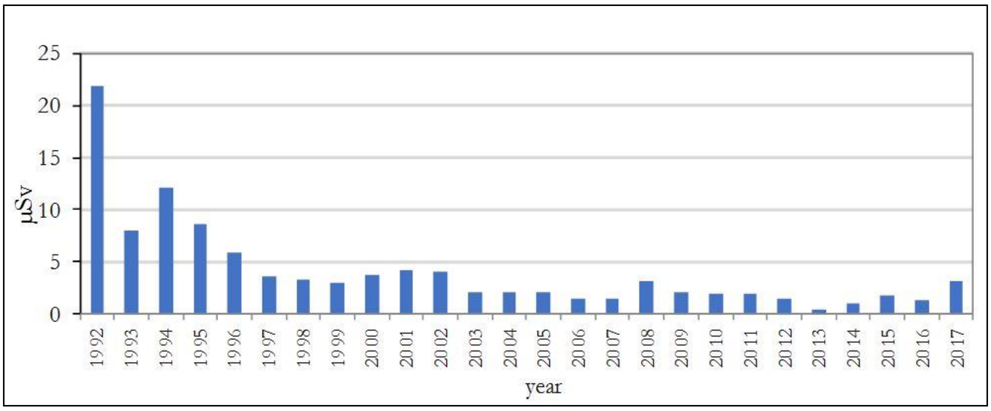


**Figure 14: Annual effective doses to the population received by ingestion due to global radioactive contamination of the environment with the radionuclides $^{137}Cs$ and $^{90}Sr$ in Slovenia**

**Occurrence of ruthenium in Europe**

At the end of September 2017, the air above southeastern Europe was contaminated with the radionuclides $^{103}Ru$ and $^{106}Ru$. In Slovenia, $^{106}Ru$ was detected, while the concentration of the radionuclide $^{103}Ru$ was too low to be measured.

Many countries of eastern and southeastern Europe reported concentrations of $^{106}Ru$ activity in the air, similar to those that were recorded in Slovenia at the end of September and at the beginning of October. In the first week of October the concentration levels of $^{106}Ru$ in the air in Ljubljana dropped below the detection limit, while at Jareninski Vrh and Predmeja, $^{106}Ru$ activity was detected until November and December.

Although the precise source of the radionuclide $^{106}Ru$ is not known, it is certain that the release did not occur due to an accident in a nuclear power plant, otherwise other radioactive fission and activation products would have been detected. All space agencies excluded the fall of a satellite with a built-in radioactive source that serves as an electrical generator for powering satellite components. The IRSN institute (France) carried out a detailed analysis; its comprehensive report shows that the only likely scenario for the release of the $^{106}Ru$ was leakage from a nuclear fuel processing plant. The estimated total released activity of $^{106}Ru$ concentration was 100-300 TBq. The release presumably occurred between 25 September and 28 September, and it did not last longer than 24 hours. By the end of 2017, an international group was established to identify the source of this ruthenium. The group has not yet finished its work.

## 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 in the pre-operational 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 the 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, food 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 NPP on the environment are therefore evaluated only based on 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 NPP 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 2017 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 Safety (IOS).

#### *3.3.1.1 Radioactive Discharges*

In 2017 the radioactive discharges from the Krško NPP were mostly lower in comparison with 2016.

The activity in gaseous releases is mostly produced by noble gases. In 2017 the total activity of noble gases released into the atmosphere was 1.33 TBq, which resulted in a public exposure of 0.046 μSv, or 0.09 %of the limit. Releases were comparable to those in the previous year, whereas their values were much lower than the prescribed limit values. 2.8 MBq (calculated to the equivalent of $^{131}I$) of radioactive iodine isotopes were released in 2017, representing 0.015 % of the annual limit, which is an order of magnitude less than in 2016. The activity of released radioactive particulates in 2017 was negligible and was 1.4 kBq, which is approx. 1,000 times less than in 2016 and approximately 8 millionths of a percent 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 2017 was expected to be lower, as there was no overhaul of the NPP, and amounted to 8.6 TBq, which is 19.2 % of the annual administrative limit (45 TBq). Due to its low radiotoxicity, this radionuclide ($^{3}H$) 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 7.2 MBq or 0.007 % of the annual limit (100 GBq). After an unexpected increase in 2016, the total activity of the released $^{14}C$ in 2017 decreased to 0.1 GBq, which is in accordance with data from the professional literature and international practice (1.8 GBq/year) and less than in 2015.

Figure 15 shows the activity of the released $^{3}H$ in liquid discharges from 1983 to 2017.

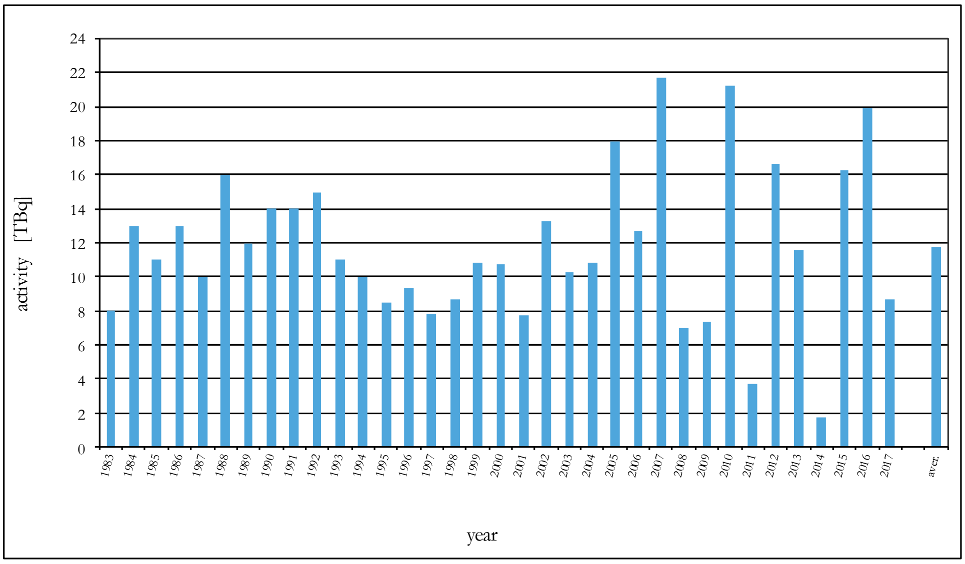


**Figure 15: Activity of the $^{3}H$ released in liquid discharges in the Krško NPP**

#### *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 food exposure were the ingestion of food due to $^{14}C$ and the inhalation of airborne particles of $^{3}H$ and $^{14}C$. The highest annual dose received by adult individuals was due to the intake of $^{14}C$ from vegetable food (0.1 μSv), while a ten-fold lower dose (0.024 μSv) was also received due to the inhalation of $^{3}H$ and $^{14}C$. Unlike 2016, liquid discharges in 2017 did not significantly contribute to the additional exposure of individuals from the population. $^{14}C$ is still the biggest contributor to the overall dose. All types of exposure of the population were negligible compared to natural radiation, the dose limits, and the authorised limits.

Table 6 shows that the estimated total effective dose of an individual who lives in the surroundings of the Krško NPP is less than 0.14 μSv per year. This value represents 0.28 % of the authorised limit value (the dose constraint is 50 μSv per year), or 0.005 % of the effective dose received by an average Slovenian from natural background radiation (2,500–2,800 μSv per year).

**Table 6: Assessment of the partial exposure of an adult member of the reference public group due to atmospheric and liquid radioactive discharges from the Krško NPP**

| Type of exposure | Transfer pathway | The most important radionuclides | Effective dose [μSv per year] |
|---|---|---|---|
| External radiation | Cloud immersion | Noble gases: ($^{41}Ar$, $^{133}Xe$, $^{131m}Xe$) | 0.00071 |
| | Deposition | Particulates: ($^{58}Co$, $^{60}Co$, $^{137}Cs$, etc.) | $1.2 \cdot 10^{-9}$ |
| Inhalation | Cloud | $^{3}H$, $^{14}C$, $^{131}I$, $^{133}I$ | 0.024 |
| Ingestion (atmospheric discharges) | Vegetable food | $^{14}C$ | 0.1 |
| Ingestion (liquid discharges) | Ingestion of fish (from the Sava River) | $^{3}H$, $^{137}Cs$, $^{14}C$ | 0.008 |
| **Total Krško NPP in 2017** | | | **< 0.14*** |

* 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 in 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 2017 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 based on the reactor operation time, were estimated at 1.2 TBq in 2017, 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 Pšata, a village at a distance of 500 m from the reactor, receives 0.63 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 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 general public in 2017, 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 2017 was 8 Bq/s, which is, taking into account the measurement uncertainty, similar to the discharge rates in previous years. 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 0.46 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.

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 center, who could potentially be affected by radon releases from the storage area. In 2017 they received an estimated effective dose of 1.16 μSv, according to the model calculation. A security officer received 0.55 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 approximately 0.02 μSv. These values are comparable with those in 2016 and are much lower than those 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 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).

In 2015, the Agency for Radwaste Management assumed the management and long-term monitoring of the Jazbec disposal site, while the Boršt disposal site is managed by Rudnik Žirovski Vrh d. o. o. The Jazbec disposal site is no longer a radiation facility. At present, both landfill operators are responsible for the implementation of the environmental monitoring programme. The SNSA issued a license for the implementation of long-term supervision and maintenance of the Jazbec disposal site. With this license, the SNSA instructed the operator of the Agency for Radwaste Management to conduct long-term supervision and maintenance under the monitoring programme and the long-term control plan, which is an integral part of the safety report of this facility in the (last) fifth year of the transitional period. Environmental monitoring, especially when speaking about the responsibility of the operator of the Jazbec disposal site, was not fully implemented. The SNSA conducted an inspection and requested regulatory action from the operators.

#### *3.3.3.1 Radioactive releases*

In 2017 it was not possible to estimate the total value of releases because no adequate measurements were made. Measurements of liquid discharges have shown that they are within the authorised limit values for the Boršt disposal site, while measurements were not fully carried out for Jazbec and the relevant mine water. Concerning gas discharges, the situation was better because, despite incomplete data, it was possible to estimate the radon discharge from the surfaces of both landfills. Both values were below the authorised limits.

#### *3.3.3.2 Exposure of the population*

In 2017 according to the values of the additional contribution to the population dose rate from the Žirovski vrh mine, the most important part of the programme was the measurement of the radon concentration. The contribution of short-term progeny can also be measured from the results.

In recent years, the radioactivity in the surface waters has slowly been decreasing. In Brebovščica, where all the liquid emissions from the mine and from both landfills are discharged, only the concentration of uranium has noticeably increased in recent years.

For the 2017, it is estimated that the contribution of $^{222}Rn$ from the remaining mining sources to the natural concentrations in the environment is around of 2.4 $Bq/m^3$.

In assessing the effective dose rates for the population, only the realistic pathways were taken into account, such as the inhalation of radon and its short-lived progeny and external gamma radiation. In 2017 the reference exposure of an adult individual of the reference group of the population was estimated at 0.053 mSv, which is lower than in the previous year, but still within the uncertainty of the assessment methods.

The low exposure is the result of the completion of the arrangement of the Jazbec and Boršt disposal sites and represents approximately one third of the effective dose values estimated in the 1990s. However, the most important source of radioactive contamination from the mine environment is $^{222}Rn$ with its short-lived progeny, which contributed 0.051 mSv of additional exposure in this area (Table 7).

**Table 7: The effective dose received by an adult member of the public living in the surroundings of the former Žirovski Vrh Uranium Mine in 2017**

| 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 live progeny | - (no longer a pathway)<br>0.0013<br>0.051 |
| Ingestion | drinking water (U, $^{226}Ra$, $^{210}Pb$, $^{230}Th$)<br>fish ($^{226}Ra$ and $^{210}Pb$)<br>agricultural products ($^{226}Ra$ and $^{210}Pb$) | (0.007)*<br>not estimated (0.002) **<br>not estimated (0.007) ** |
| External radiation | immersion and deposition (radiation from the cloud and deposition)<br>deposition of long-lived radionuclides (deposition)<br>direct gamma radiation from disposal sites | 0.0009<br>-<br>- |
| **Total effective dose rate (rounded):** | | **0.053 mSv** |

* The dose contribution 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.

** Values in brackets are calculated on the basis from the last measurement of fish and food from 2015. They were not taken into account in the assessment of the total effective dose.

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 0.050 mSv and 0.056 mSv for a 1-year-old child. These values represent approximately 1 % of the natural background dose due to natural background radiation exposure in the environment of Žirovski Vrh during the operation of the mine (estimated by the IJS in 1990, around 5.5 mSv per year). 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 fifth of the authorised dose limit of 0.3 mSv per year, which is set for all objects after the remediation (the Boršt and Jazbec disposal sites and the mine).

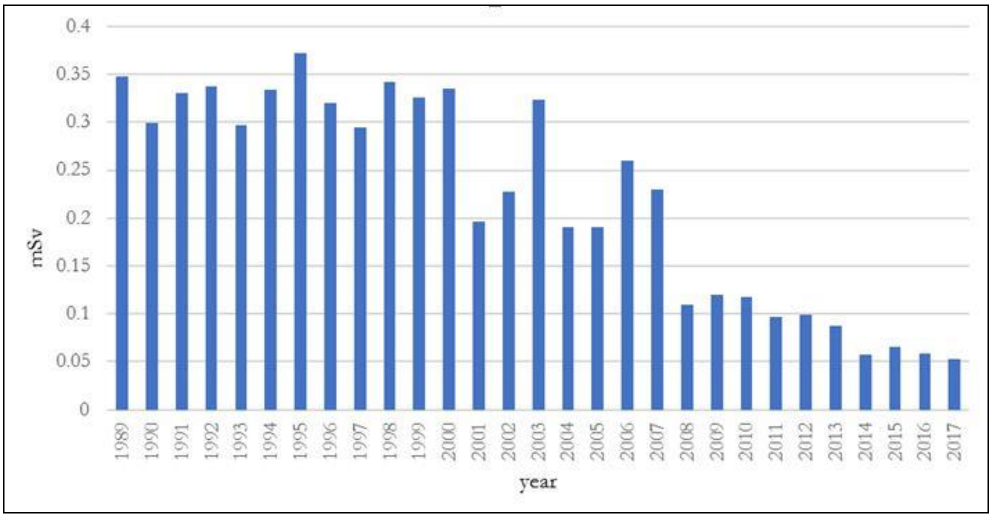


**Figure 16: Annual contributions to the effective dose received by an adult member of the public due to the former Žirovski Vrh Uranium Mine in the period 1989–2017**

## 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 (due 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 approximately 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, approximately 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 approximately 0.4 mSv. 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 1.1 mSv in Slovenia.

### 3.4.2 Programme for 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 2017 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 environments of the following production facilities: Salonit Anhovo d. d., Nafta Lendava d. o. o., Petrol Geoterm d. o. o., TKI Hrastnik d. d., Agroruše d. o. o. and EMO Frite d. o. o. The measurements were carried out by IOS (Institute for Occupational Safety) as an authorised expert.

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 the 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.

In addition to the above-mentioned measurements, the SNSA responded to a call from the People's Initiative of the Municipality of Moravče in connection with an allegedly disputable landfill of Termit d. d. in Moravče, and performed informative measurements of the ionising radiation dose rates at the landfill locations. The SNSA did not find increased dose rates and did not indicate that any further actions were needed. It was estimated that variations in the dose rate occur due to differences in the materials deposited in the landfills. The level of radiation is reduced in case of quartz sand and carbonates due to the low levels of natural radiation and is slightly increased in the case of fly ash.

In May 2017, after a fire at the company KEMIS d. o. o, in Vrhnika, the employees of the SNSA conducted informative measurements to determine the presence of radioactive substances around the KEMIS d. o. o. area. These measurements did not show elevated levels of radiation – the values only corresponded to the natural background.

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

In 2017 the Slovenian Radiation Protection Administration (SRPA) continued to implement the governmental programme adopted in 2006 and updated in 2016 for the 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. Once 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 February to October 2017, the Institute of Occupational Safety (IOS) carried out measurements using different methods: 149 basic radon measurements using nuclear track detectors for determining average radon concentrations, five additional continuous measurements for weekly monitoring of the timing of radon progeny and radon, and five measurements of potential radon sources originating from the soil, shafts, or openings into the rooms. A total of 96 buildings (87 schools and kindergartens, 9 other buildings) were measured. The average radon concentrations exceeded the threshold for the living environment (300 Bq/m$^3$) in 51 rooms in kindergartens and schools out of a total of 135 (38 %) and in 7 rooms in other buildings out of a total of 14 (50 %). A concentration of 1,000 Bq/m$^3$ was exceeded in 14 rooms.

The 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 a total of 149 estimated annual doses, 9 exceeded the threshold of 6 mSv for members of the public. The highest estimated dose was around 22 mSv due to an average radon concentration of 4300 Bq/m$^3$. In 33 cases, the estimated annual doses were between 2 and 6 mSv, in 22 cases between 1 and 2 mSv, and in 85 cases less than 1 mSv. Protection measures continue to be performed in most of the rooms with high radon concentrations.

In 2017 the SRPA conducted six 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 five cases.

In 2017 the SRPA financed the formulation of the "*Guidelines for the Radon-Safe Construction of New Buildings*", which were prepared by the Slovenian National Building and Civil Engineering Institute. The *Guidelines* are intended to ensure the economically most efficient manner of lowering radon concentrations in new buildings, together with diminishing exposure to radon. In addition, the SRPA financed the preparation of a "radon map" produced by the Jožef Stefan Institute and the Centre for Atmospheric Research of the University of Nova Gorica. The radon map is one of the bases for the national radon programme adopted by the Government of Slovenia at the beginning of 2018. In order to inform the public of the harmful effects of exposure to radon, the SRPA financed the creation of a cartoon that is printed on brochures for primary school pupils.

**Measurements of gross alpha and gross beta activities in drinking water**

In 2017 the SRPA continued to finance the measurement of gross alpha and gross beta activities in the drinking water of Slovenia. The measurements were performed by the Jožef Stefan Institute. Altogether, 132 samples were analysed, 91 from water supply systems and 10 from water filling station. The sampling covered the entire area of Slovenia, taking into account the number of inhabitants near the water supply point and the hydrogeological characteristics of the water. The gross alpha concentration values were up to 0.19 Bq/kg, with an average value of 0.025 Bq/kg. The parametric value for the alpha concentration (0.1 Bq/kg) was exceeded in four samples. Subsequent detailed analyses showed that the estimated doses were in the range of 10 % of the indicative dose (0.1 mSv per year). The values for gross beta concentrations were up to 0.65 Bq/kg with an average value of 0.1 Bq/kg. The parametric value of the beta concentration (1 Bq/kg) was not exceeded. These results are similar to the results in 2016.

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

Higher radiation doses due to the normal operation of nuclear and radiation facilities are usually only received 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 8, the annual individual doses are given for the maximally exposed adults from the reference groups for all objects in consideration. For comparison, the 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 determined 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 on this, see Chapter 3.4 above.

**Table 8: Exposures of adult individuals from the reference population group**

| Source | Annual dose [mSv] | Regulatory dose limit [mSv] |
| --- | --- | --- |
| Žirovski Vrh Uranium Mine | 0.053 | *0.300 |
| Chernobyl and nuclear weapon tests | 0.03 | / |
| Krško NPP | < 0.00014 | **0.050 |
| TRIGA Research Reactor | 0.00063 | 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. Persons carrying out a radiation practice 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 2017 were the Institute of Occupational Safety (IOS), the Jožef Stefan Institute (JSI), and the Krško Nuclear Power Plant (Krško NPP). The IOS was approved for the assessment of radon exposure in mines and Karst caves. Currently, 16,094 persons have a record in the central registry, including those who have ceased to work with sources of ionising radiation. In 2017 the dosimetry service at the IOS took measurements of individual exposures of 4,393 workers, whereas the JSI monitored 1,900 radiation workers, and the Krško NPP monitored 688 radiation workers. The Krško NPP performed individual dosimetry for 370 plant personnel and 318 external workers, who received an average dose of 0.27 mSv of ionising radiation. As for other work sectors, workers in industrial radiography received the highest average annual effective dose of 0.56 mSv from external radiation, while employees in medicine received an average of 0.19 mSv. The highest average value among these, 0.55 mSv, was recorded for workers in nuclear medicine.

In 2017 the highest collective dose from external radiation was received by air crews (342 man mSv), followed by workers in the medical sector (245 man mSv,) workers at the Krško NPP (63 man mSv in a no-outage year), workers in other activities (37 man mSv), and workers in industry (32 man mSv).

Since 2010, the data on doses received by radiation workers who took part in NPP outages abroad and data on the doses of Adria Airways flight personnel who are exposed to cosmic radiation have been included in the CRPD. In 2017 the collective dose for 20 workers in foreign NPPs was 27 man mSv (an average dose of 1.95 mSv). During flights, 252 workers were exposed to cosmic radiation, receiving an average dose of 1.41 mSv and a collective dose of 342 man mSv.

The highest doses are received by workers exposed to radon and its progeny. In 2017, out of 186 tourist workers, 3 workers received a dose between 15 and 20 mSv, 28 workers received a dose between 10 and 15 mSv, 60 workers received a dose between 5 and 10 mSv, 65 workers received a dose between 1 and 5 mSv, and 30 workers received a dose less than 1 mSv. The highest individual dose was 18.28 mSv. The collective dose was 1,014 man mSv, with an average dose of 5.5 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, the received doses from radon and its progeny are assessed according to the ICRP 32 model in this report. The 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, 8 workers received a collective dose of 1.8 man mSv, whereas the average individual dose was 0.22 mSv.

The distribution of workers in different work sectors by received dose interval (mSv) is shown in Table 9.

**Table 9: 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 | 453 | 227 | 7 | 1 | 0 | 0 | 0 | 0 | 688 |
| Industry | 448 | 78 | 10 | 0 | 0 | 0 | 0 | 0 | 536 |
| Medicine and veterinary medicine | 2,899 | 1,215 | 41 | 0 | 0 | 0 | 0 | 0 | 4,155 |
| Flights | 9 | 50 | 193 | 0 | 0 | 0 | 0 | 0 | 252 |
| Other | 1,357 | 243 | 1 | 1 | 0 | 0 | 0 | 0 | 1,602 |
| Radon | 0 | 37 | 66 | 60 | 28 | 3 | 0 | 0 | 194 |
| Abroad | 6 | 2 | 12 | 0 | 0 | 0 | 0 | 0 | 20 |
| **Total** | **5,172** | **1,852** | **330** | **62** | **28** | **3** | **0** | **0** | **7,447** |

MDL – minimum detection level

E – effective dose in mSv received by an exposed worker

### The 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 2017 a total of 1,958 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, 3,085 medical examinations were carried out. Of the examined workers, 2,684 fully fulfilled the requirements for working with sources of ionising radiation, whereas 360 fulfilled the requirements with limitations. Eight candidates temporarily did not fulfil the requirements, and four did not fulfil the requirements. Two workers did not fulfil the requirements and other work was proposed for them. In 27 cases an evaluation was not possible.

## 4.1 Exposure of the Population due to Medical Use of Radiation Sources

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 approximately 0.7 mSv per year from medical procedures. The most important contribution comes from computed tomography (CT), which contributes approximately 60 % of the total dose. Classic X-ray diagnostics contributes approximately 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. The key activities for the optimisation of radiological procedures are described in Chapter 4.2. on patient exposure.

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 unjustified 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. 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 a coordinated action by the competent administrative authorities of many European countries. The findings show that at least in the case of procedures resulting in the largest doses (computerised tomography imaging and intervention procedures), all referrals are examined by doctors qualified to bear clinical responsibility for the radiological procedure. This provides a good basis for ensuring the justification 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.

## 4.2 Exposure of Patients during Radiological Procedures

X-ray examinations 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) in order 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 such department or due to an X-ray device to a DRR value obtained on the basis of the relevant regional or local data.

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 the 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 the optimisation of radiological procedures in Slovenia. Concurrently, Slovenia continues to participate in International Atomic Energy Agency projects regarding the radiation protection of patients in radiological procedures and quality improvement in such procedures.

In 2017 the SRPA, together with the Clinical Institute for Radiology and the Clinic for Nuclear Medicine of the University Medical Centre in Ljubljana and the Institute of Occupational Safety, d. o. o., as an authorised institution carrying out external quality checks of X-ray devices, hosted a regional training programme for members of regulatory authorities competent for radiation protection in medicine, entitled "*IAEA Regional Workshop on Inspecting Medical Exposure*". The training programme was attended by six participants from six countries. The professional, carrying out the training programme , the IAEA representative and participants highlighted the efficient and professional surveillance system established by the SRPA and the high level of radiation protection in clinical environment.

In nuclear medicine, rather than the 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 applied 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 the 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.

# 5 MANAGEMENT OF RADIOACTIVE WASTE AND IRRADIATED FUEL

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

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.

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

The total volume of waste accumulated by the end of 2017 amounted to 2,284 $m^3$, with the total gamma and alpha activity of the stored waste amounting to $1.65 \cdot 10^{13}$ Bq and $2.49 \cdot 10^{10}$ Bq, respectively. In 2017 the equivalent of 159 standard drums containing solid waste was stored with a total beta-gamma and alpha activity $1.06 \cdot 10^{9}$ Bq and $2.45 \cdot 10^{6}$ 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, 2016 and 2017 there was no super-compacted newly-generated radwaste.

Radwaste for incineration and melting is temporarily transferred to the Decontamination Building due to a lack of space in the storage facility near the super-compactor. In 2017 350 packages of compressible waste were already stored for the next shipment to France or Sweden.

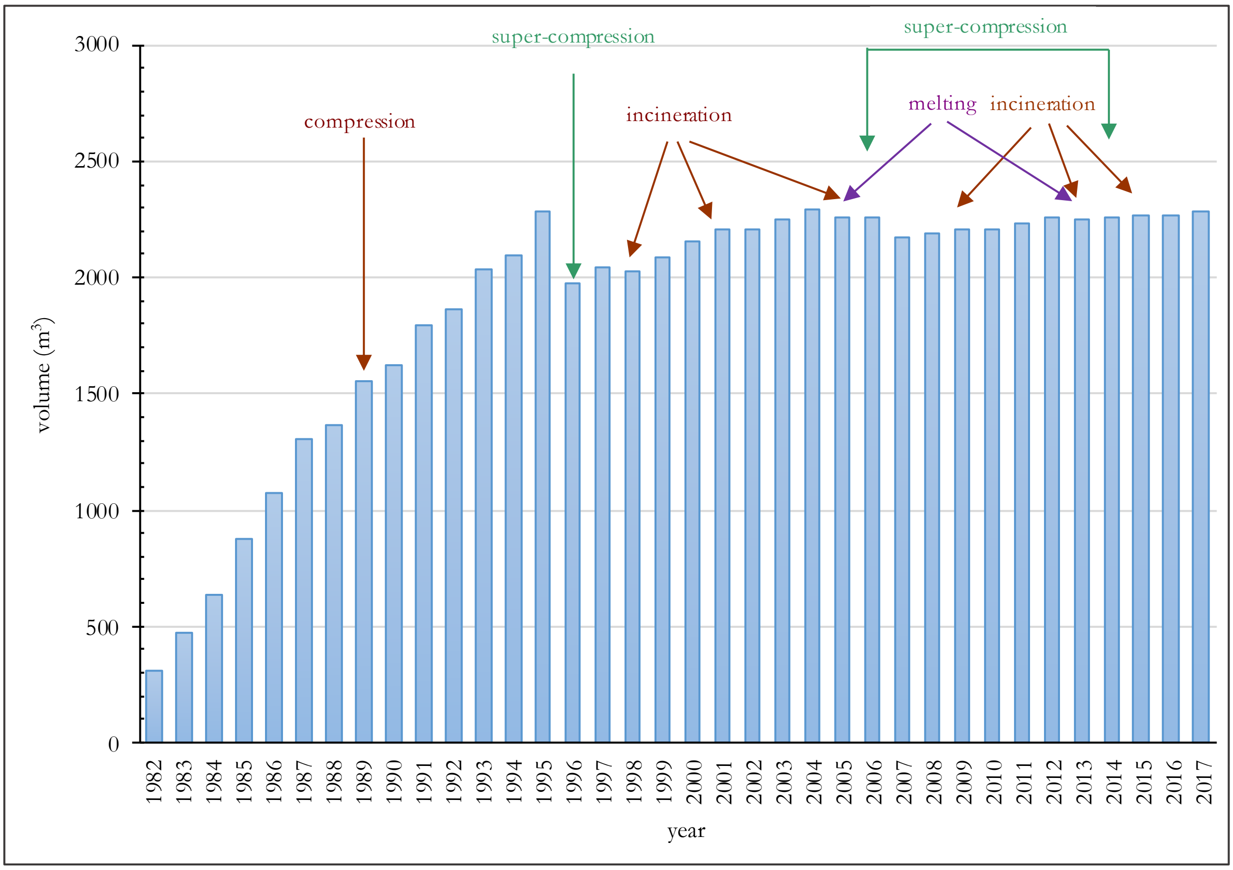


**Figure 17: The accumulation of low- and intermediate-level radioactive waste in the Krško NPP storage**

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 ease the storage problems due to delays in the construction of the final repository for low- and intermediate-level waste.

In 2017 the construction of the first part of the new building started. The new structure will enable the removal of the measuring equipment and super-compactor from the 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. At the end of 2017, 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.

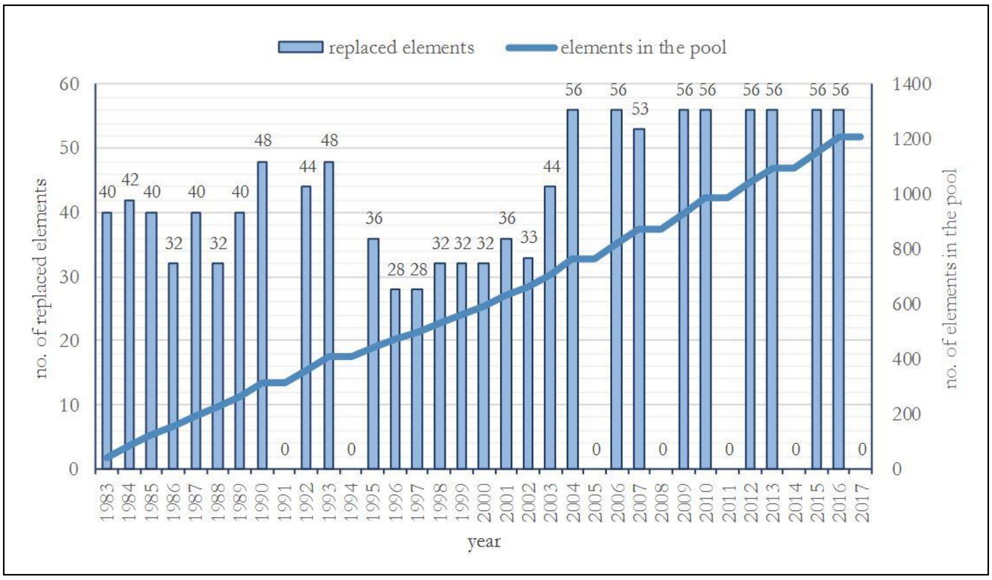


**Figure 18: The number of annually spent fuel assemblies and the total number of such elements in the pool of the NPP**

#### *5.1.2.1 Dry storage of spent fuel*

In 2011, the SNSA issued the Krško NPP a decision on the implementation of safety solutions for the prevention of severe accidents and the mitigation of their consequences, which required that the Krško NPP should verify the possibilities for reducing the risk of spent fuel (SF) management by changing the long-term fuel strategy.

From the "*Evaluation of Spent Nuclear Fuel Storage Options*" analysis, considering accidents beyond the project bases, the current capacity of the spent fuel pool will not be sufficient for normal operation beyond 2023. The Krško NPP, according to various solutions regarding the long-term strategy for the storage of spent fuel, chose the option of storage in a dry storage facility, which increases nuclear safety without major interferences with the national programme for the treatment of RAO and IG, in which the dry storage of IG is already envisaged.

The Krško NPP intends to transfer spent fuel elements stored in the spent fuel pool into dry fuel storage facility, which is a transition from an active to a passive storage solution. Such storage is technically safer and is accepted in the world as the most appropriate and extended way of temporary storage of IG.

The construction of a dry storage facility is envisaged in the third phase of the Krško NPP Safety Upgrade Programme. The Krško NPP intends to build a dry storage facility by 2019, and operation is planned in 2021. In 2017 the procedure for obtaining permits for the construction of a dry storage facility already began. In September, the SNSA issued the design conditions for construction consent, and in the next phase it is expected to issue consent for the construction thereof.

## 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 annually 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. The Jožef Stefan Institute annually produces approximately 2 drums (< 0.5 m3) of solid radioactive waste.

In 2017 the JSI did not hand over to the Central Storage Facility at Brinje any packages of radioactive waste.

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 facility 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 2017 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 that is part of the TRIGA Mark II Research Reactor at the Jožef Stefan Institute.

In 2017 the ARAO accepted 125 packages of radioactive waste from 95 producers, namely 8 packages of solid waste, 10 packages of sealed radiation sources, and 107 packages of ionisation smoke detectors. The total volume of the stored radioactive waste was 1.45 $m^3$. As of the end of 2017, there were 685 packages stored as follows:

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

The total activity of 90.4 $m^3$ of stored radioactive waste as of the end of 2017 was estimated to be 3.4 TBq, with a total weight of 50 tonnes.

In 2017 the dismantling of ionising fire detectors and other devices containing closed radiation sources of categories 3-5 was carried out in the hot cell facility. The workers disposed of 2,375 pieces of ionising fire detectors, mostly with radionuclide $^{241}Am$. In 2017 the ARAO workers were trained in the framework of the IAEA project for the dismantling of various industrial radiation devices containing closed sources of radiation of these categories. After the training, the ARAO workers also started to independently dismantle devices such as lightning rods, level, density, and moisture meters, etc. In total, 84 devices were dismantled. The disseminated radiation sources were inserted into 8 capsules, and the capsules were placed in dedicated containers that ensure safe storage. In order to optimise the storage space, the repackaging of small packages of nuclear materials, especially chemicals with an elevated level of natural radionuclides, was carried out. This concerned combining smaller packages into larger packages. In total, 28 packages were repackaged.

Due to such activities, the volume of radioactive waste in the warehouse decreased by approximately 4 $m^3$; the rest was uncontaminated casings. Radioactive sources were properly packaged and accepted in the CSRW. Uncontaminated waste material was handed over to the organisations for the management of nonradioactive waste material.

In 2017 the ARAO ensured the monitoring of the Jazbec disposal site (overlay, drainage ditches, the passage of water below the disposal site) and minor maintenance, such as cleaning drains, cleaning the undergrowth next to the fence of the disposal site, etc. Mowing of the surface of the Jazbec disposal site and removal of the mowed grass was also ensured, thus preserving the grass and the integrity of the landfill cover.

The safety report on the Jazbec disposal site provides for long term monitoring and maintenance after a five-year transitional period. Monitoring is carried out in order to detect any changes in the repository. It includes radiological, physical, chemical, and geodetic measurements.

Changes to the Jazbec disposal site are monitored by two inclinometers. These measurements have been carried out since 2009. The measurements in 2017 did not show any changes, which means that the landfill is stable.

## 5.5 Disposal of Radioactive Waste

In 2017 work on activities related to the preparation of documents necessary to obtain approvals and permissions for the repository for low- and intermediate-level radioactive waste (LILW) were carried out in parallel with the work on the project documentation. The environmental impact assessment report was coordinated with the draft safety report; the upgrading of the safety analyses was completed to the extent necessary for the environmental impact assessment and the draft safety report was prepared. The submission of an application for environmental consent was carried out in May 2017, while the conclusion of the tender for the selection of the approved experts in radiation and nuclear safety, the start of obtaining opinions, and the successful execution of preparatory works with the arrangement of the dyke for the construction of the repository all feature amongst the important achievements of the LILW repository project in 2017.

In 2017 works began in the field of securing easements and the disposal of land for the needs of infrastructure construction (infrastructure connections and road regulation) on the basis of the prepared project documentation for obtaining a building permit.

In 2017 except for the monitoring of groundwater, no additional research was carried out. The obtained data were used to upgrade the hydrogeological study of the wider area of the LILW repository.

Activities related to the production of project and other documentation and consultancy services in the area of design and construction continued. A building permit project 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 were submitted to the designer on a regular basis. Additional experts were engaged to review the strength calculations. The tender and implementation documentation for the preparatory work was prepared. 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 were carried out. Container prototypes were constructed, as well as all testing and calibration of computational models of the container.

Work on the project for preparing the safety analyses and acceptance criteria continued in 2017.

Within the framework of the multi-phase project "Safety Analysis (SA) and Waste Acceptance Criteria (WAC) for the preparation of a Low- and Intermediate-Level Waste Repository in Slovenia", work to complement the existing acceptance criteria 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. Work on safety analyses and the development of acceptance criteria for the phase of acquiring a construction permit and the preparation of the Safety Report continued.

The design basis for the draft safety report and the draft safety report were prepared, which were, in addition to the environmental impact assessment report, submitted to the approved expert in radiation and nuclear safety for a review. Extensive reference documentation for the draft safety report was prepared. The documents for the environmental impact assessment procedure and other documents were submitted to the authorised person in order to obtain the first expert opinion. A preliminary expert opinion was obtained. The preparation of the environmental impact assessment report continued in 2017. After complying with the draft safety report, the document was prepared and, along with the draft safety report and project basis, attached to the application for obtaining environmental consent.

Preparatory works for the LILW repository were carried out at the site, where a reinforcement dyke was created, which is the basis for the construction of the plateau to the final level of the repository. The works were conducted smoothly and were completed in August 2017 in line with the schedule.

In 2017 the ARAO submitted an application for the approval of an application to distribute the content necessary to prove compliance with the conditions for obtaining consent to the construction of a radioactive waste repository as regards individual content-based thematic sections. This option was given to the investor of the nuclear facility on the basis of Article 77 of the Nuclear Act (ZVISJV), and in accordance with the new ZVISJV-1, this is regulated by its Article 107. The SNSA issued a decision on 20 March 2017. By this decision, the content necessary to prove the fulfilment of the conditions was divided into individual thematic sections, which will be reviewed by the SNSA and separate opinions will be issued on the basis thereof. The decision also specifies the deadlines for the delivery of documentation and for issuing individual opinions and consents to such construction. The purpose of this procedure is that, notwithstanding the fact that all documentation and a complete application for granting consent to the construction are not prepared by the ARAO, the SNSA may review already prepared individual thematic sections earlier and issue a positive opinion, and thus reduce the total time required to approve the construction of a nuclear facility.

## 5.6 Remediation of the Žirovski Vrh Uranium Mine

### Hydro-metallurgical tailings at the Boršt site

The remediation of the Žirovski Vrh Uranium Mine (RŽV) 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. The year 2017 was the 7th year (the second additional year) of the envisaged five-year transitional period for the Boršt disposal site. Sampling, measurements, control of the overall state, maintenance, collecting and storing information, record keeping, the preparation of reports for the relevant 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. The velocity of the movement of the control point on the Boršt disposal site is approximately 2 cm per year.

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. In the area of the landslide toe, the deformations of the lining continued.

In winter 2010/2011 six drainage wells at the intersection of the main access of the passageway of the tunnel and the two passageways were drilled (the first part of the intervention measures). The three wells constantly drain water and the other three drain water during more intense precipitation. Of the 17 drainage holes drilled in 2016 and 2017, the most active drainage wells in the event of precipitation are in chamber 2, while the drainage holes in chambers 1 and 3 are less active, as was expected. In 2017, the RŽV monitored the outflows of wells with manual measurements and continuous flow meters on individual drainage outflows. The assessment of the effectiveness of the drainage wells can be assessed by continuous monitoring of the flow and by observing the stability of the landslide base in the following years. The Expert Project Council was again convened to carry out a geotechnical and hydrogeological interpretation of the effects of the measures taken to reduce the effects of groundwater on the stability of the Boršt disposal site.

Monitoring the stability of the Boršt disposal site is an important task of the transitional five-year period 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 the GPS system at the Boršt disposal site will be achieved.

The surface movements of the Boršt disposal site were continuously monitored by the GPS system. The measured movement of the GMX1 at the weather station and GMX2 at the disposal site in the direction of the displacement vector was 20 mm in 2017. Precise geodetic measurements of the stability on the Boršt geodetic network were performed. The movement tracking data from geodetic surveys and the GPS system fit perfectly.

Financing the activities of the RŽV uranium mine from the budget was covered by a contract for the financing of the company's operations with the Ministry of the Environment and Spatial Planning (MOP). Details of this monitoring project can be found in Chapter 3.3.3.

In accordance with the requirements of the MOP in connection with the closing activities of the disposal, the RŽV has begun to prepare a revision of the safety case regarding the hydro-metallurgical tailings at the Boršt site.

## 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 the 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 the 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 contribution is determined on the basis of levying half of the electrical energy produced by the Krško NPP.

The above-mentioned levy is based on calculations determined in the Programme for 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 regulating the status and other legal relations regarding investment in and the exploitation and 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 2017. Since 2004 the basic assumptions and parameters have significantly changed, 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.

The book value of the financial portfolio of the Fund as of 31 December 2017 was EUR 198.2 million. The data does not include unallocated funds in the transactional account, interest accrued, interest purchased and claims to dividends in the amount of EUR 1.8 million. Considering this, the Fund's financial assets as of 31 December 2017 were EUR 200.0 million.

### 5.7.1 Proceeds from the contributions for decommissioning

The company GEN energija, d. o. o., paid a total of EUR 8.95 million into the Fund in 2017. With that contribution for the decommissioning of the Krško NPP the company fully and within the agreed deadline fulfilled all of its obligations to the Fund. From 1995 to 2017 the Fund received a total of EUR 186.3 million from the Krško NPP and GEN energija, d. o. o.

In 2017 the Fund paid to the ARAO a total of EUR 3.0 million. From 1998 until the end of 2017, the Fund paid a total of EUR 41.8 million to the ARAO for the activities implemented by the ARAO. This amount includes compensation paid by the ARAO 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 Municipality of Krško, where the LILW repository will be located. In 2017 the Fund paid EUR 5.8 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 43.5 million as compensation for the limited use of land.

Since 1995 municipalities and the ARAO have received EUR 85.3 million (assets paid to co-finance the activities of the ARAO and assets paid to municipalities as compensation for the limited use of land are not valorised). Payments made to the ARAO and municipalities account for 43.0 % of the Fund's financial portfolio, which as of 31 December 2017 was EUR 198.2 million. Figure 19 shows the book value of the financial portfolio of the Fund as of 31 December 2017, increased by the cumulative amount of payments to the ARAO and municipalities.

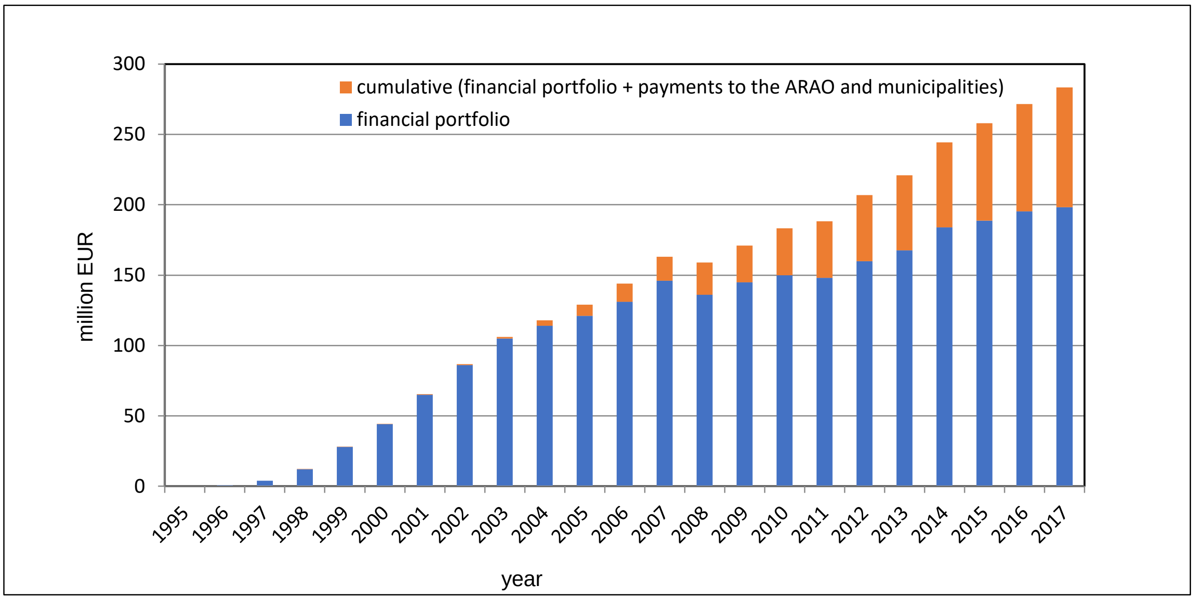


**Figure 19: Total financial portfolio of the Fund, increased by the amount of payments to the ARAO and municipalities, in euro millions, at the end of the year, for the period of 1995–2017**

### 5.7.2 Investments and business operations in 2017

The financial assets of Fund increased by EUR 3.1 million (1.6 %) from EUR 196.9 million as of the end of 2016 to EUR 200.0 million as of the end of 2017. As of 31 December 2017, the Fund managed EUR 198.2 million in securities (book value), unallocated funds in the transactional account amounting to EUR 10,500, interest accrued, interest purchased and dividends in the amount of EUR 1.8 million.

In its investment policy for 2017, the Fund mainly planned investments in safe investment-grade debt securities (sovereign and corporate bonds). The share of debt securities rose from 86.48 % to 87.30 %, whereas the share of equity securities decreased from 13.52 % to 12.70 %. The Fund decreased investments in the segment of cash and cash equivalents, whereas investments in the corporate bonds and government securities segment increased.

The main generator of investment activities in the debt securities segment was the negative yield to maturity of European Governmental Bonds, mainly long-term, interest rate risk due to extremely low interest rates for long-term bonds, the activities of major central banks, and macroeconomic and sectoral indicators. On average, the bond markets were still characterised by a negative yield to maturity. In this situation, corporate bonds and governmental bonds of peripheral countries e.g. Italy, Spain, Bulgaria and Hungary, were the most favourable and profitable choice. In 2017 the investment activities were carried out in accordance with the Fund's investment policy and within the framework of the investments policy goals.

In 2017 the Fund reduced its exposure to the equity securities segment. The main reason for the decrease in the share of equity securities was the extremely high valuation of stocks, measured by the PE ratio, which, despite good macroeconomic and microeconomic indicators, are nearly above the multiannual average in all markets.

In 2017, due to such management, the Fund continued to reduce the risk of the portfolio, but with lower intensity than in 2016. The most important risks are market, interest rate, and loan risks, while in 2017 due to the increased scope of corporate bonds, the Fund began to closely monitor the spread risk. The market risk of the portfolio is evaluated by the so-called ratio value-at-risk (VaR) method. As of 31 December 2016, the one-day 95 % VaR was EUR 466,200, or 0.23 % of the portfolio's value, and, as of the end of 2017, the one-day 95 % VaR was EUR 331,800 or 0.17 % 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 are foreseen to rise in the future. An average increase in interest rates by 50 basis points would lower the value of the portfolio by 1.0 %, whereas an average increase in interest rates by 1 percentage point (100 basis points) would lead to a 2.0 % decrease 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 2017 the Fund created EUR 12.6 million of income, which is at the level of the previous year. The Fund created EUR 3.7 million of income in 2017 and EUR 4.5 million of income in 2016. All paid interest, dividends, and other payments are included in income, but accrued interest is excluded. The lower income is due to bank interest rates still being low (even negative). The result is lower interest income.

In 2017 expenses reached EUR 9.3 million, which was 20.62 % higher than in 2016. The Fund had a surplus of income over expenses in the amount of EUR 3.3 million. The realisation of the surplus of income over expenses for 2017 was 32.11 % lower than in 2016 due to higher implementation of expenses in 2017.

In 2017 the Fund received EUR 133.8 million from due investments and assets from the sale of equity shares. The assets placed in new investments amounted to EUR 137.1 million, which is EUR 3.3 million more than due investments and assets acquired from the sale of equity shares.

In 2017 the return of the portfolio, calculated on the bases of the internal rate of return (IRR), was 1.78 %. The portfolio outperformed the benchmark, which grew by 1.56 % in 2017, as well as the minimum guaranteed return of the portfolio for 2017, which is calculated each year and determined by the Ministry of Finance, and for 2017 was 0.57 %. In the period from 2004 to 2017 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. Even though we have been faced with extremely difficult conditions in the last three years, especially in bond markets characterised by very low interest rates (even negative), the average annual return (CAGR – compounded annual rate of return) of the Fund's financial portfolio over the long term is quite positive. After the global financial crisis, in the period from 2009 to 2017 the average return of the portfolio was 3.76 %, in the period between 2012 to 2017 it was 4.58 %. The average return of the portfolio for the period from 2004 to 2017 was 3.40 %. The annual return of the portfolio since 2004 is shown in Figure 20. When operating with the average return of the portfolio in the specified period, it should be taken into account that before 2010 a part of the debt investments was valorised upon the purchase value (HTM, Hold to Maturity) and since 2010 all investments have been valorised upon the market value.

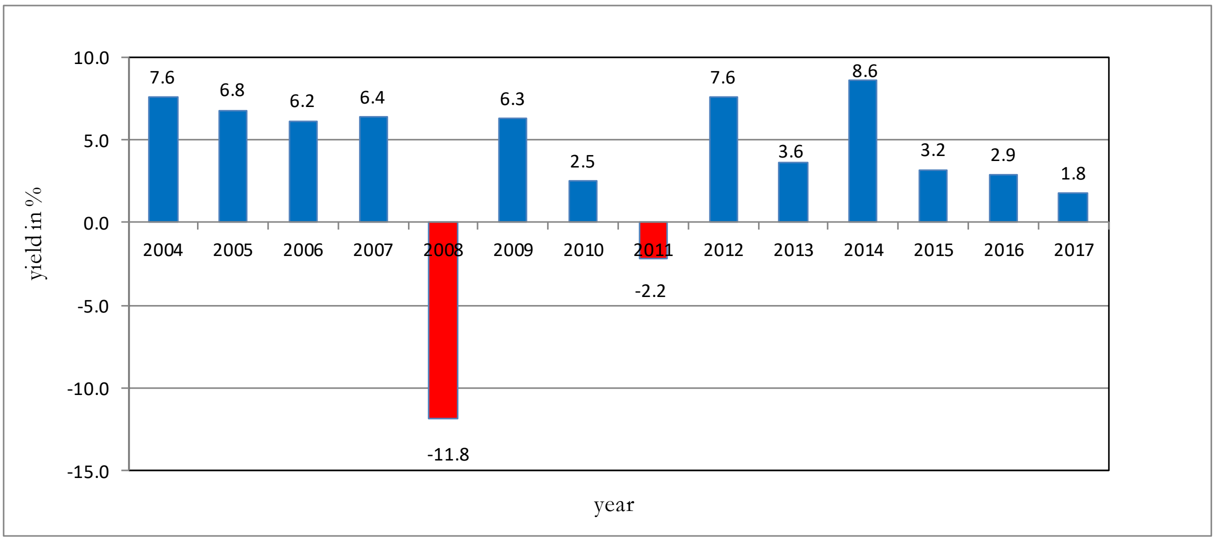


**Figure 20: The annual yield of the financial portfolio of the Fund from 2004 to 2017 in %**[1]

The primary investment goal pursued by the Fund is to preserve the value of its financial portfolio. Since 2004 the Fund has endeavoured to achieve an average annual yield of the portfolio of 4.29 %, in accordance with its investment goals and the Decommissioning Programme.

The Fund is responsible for ensuring the security of its assets. The Fund implements a conservative investment policy, but at the same time it has to monitor the situation on the financial markets and fulfil the obligations determined by law, taking into account the following principles: safety, liquidity, diversification, and profitability. Thus, all important risks were successfully managed in 2017 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

[1] 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 the 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.

applied. A building for handling equipment and radioactive waste packages at the Krško NPP is under construction. The construction started in 2016 and was finished by the end of 2017. Some minor finalisation works are still being carried out.

**Strategy 2**: *After 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 national public service of radioactive waste management. The periodic safety assessment was finished in October 2017 when the final report was prepared. 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 but unfortunately some 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 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 spent fuel pool in the Krško NPP is performed without any complications, while the preparations for the construction of a dry storage facility are ongoing. For this purpose, the SNSA issued project conditions in 2017. The ARAO, as the public service provider of radioactive waste management, monitors the activities and is included in international activities in this area.

**Strategy 6**: *The Programme for the Decommissioning of the Krško NPP 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 (BHRNEK). 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, but in 2017 the Interstate Commission for monitoring the implementation of the Treaty between the Government of the Republic of Slovenia and the Government of the Republic of Croatia on regulating the status and other legal relations regarding investment in, the exploitation of, and the decommissioning of the Krško Nuclear Power Plant (the Interstate Commission), at its 11th session in November 2017, requested that the ARAO and the Fund for Financing the Decommissioning of the Krško NPP and the Disposal of Radioactive Waste from the Krško NPP from Croatia (the Croatian Fund), in cooperation with the Krško NPP, prepare a new revision of the Programme for the Disposal of RAW and SF from the Krško NPP by the end of November 2018 in accordance with the BHRNEK. The ARAO and the Croatian Fund have prepared and assigned project tasks for the preparation of supporting studies, harmonised the work programme for the project and the agreement on joint public procurement and prepared appropriate documentation for public procurement of the envisaged support studies for the preparation of the RAW and SF disposal programme. At the same session, the Interstate Commission commissioned the Krško NPP to develop a programme for the decommissioning of the Krško NPP in cooperation with the ARAO and the Croatian Fund by October 2018. 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 Radwaste Management (ARAO) as the SGEI provider of radioactive waste management.*

Achieving the goal: The Jazbec disposal site is closed; the ARAO assumed long-term surveillance and monitoring. At the Boršt disposal site, remediation works are mostly finished; unfortunately the landslide in the wider area of the disposal site has prevented its closure. The assessment of the effectiveness of the intervention measures carried out in 2017, namely the construction of additional drainage wells, will be assessed by continuous monitoring of the flow and observing the stability of the disposal site base in the following years.

**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 determined by 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) provides 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, and is led by the emergency team director. Since tasks during an emergency mostly differ from regular work, the training of the emergency team members is very important. Therefore, the SNSA conducted 53 individual and group training exercises, tests, and exercises totalling 133 hours in 2017. The SNSA also participated in two regular annual emergency exercises of the Krško NPP, a radiological emergency field exercise, and in several international exercises, including the largest international exercise ConvEx-3, which at the same time also served as the annual emergency exercise of EU Member States in this area ("*ECUREX*"). ConvEx-3 are full-scale exercises designed to evaluate international emergency response arrangements and capabilities for a severe nuclear or radiological emergency over several days, regardless of the cause. The 2017 exercise was hosted by Hungary, which served as an excellent opportunity for Slovenia as a neighbouring state to evaluate cross-border impacts and protective measures and to test communication channels between the states.

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 2017.

In 2017 the ACPDR adopted a new Threat Assessment regarding Nuclear or Radiological Emergencies, version 2.1. The second part of the assessment was amended – the Threat Assessment in the Event of an Emergency at Nuclear Facilities and due to Radioactive Substances, edition 6, prepared by the SNSA based on the sEPREV Action Plan. The amendment includes a threat assessment of a combination of a nuclear emergency with other conventional emergencies, security aspects, and nuclear-powered vessels.

In 2017 activities regarding the protective measure of ensuring iodine prophylaxis continued. Since the usable life of the previously distributed potassium iodide tablets has expired, the Krško NPP purchased new ones. The ACPDR, in collaboration with the Ministry of Health, the Police, the Fire Fighting Association of Slovenia, and municipalities, replaced the expired tablets with new ones in accordance with the Plan for the Distribution of Potassium Iodide Tablets in the Event of a Nuclear or Radiological Emergency. The population within a 10 km-circle around the Krško NPP is entitled to exchange or obtain new tablets in the determined pharmacies.

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

The ACPDR, together with the SNSA, the lead organisation of the EPREV mission, conducted the mission from 5 to 16 November 2017 (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 EU basic safety standards for radiation protection (Council Directive 2013/59/Euratom of 5 December 2013). On the basis of the new Directive's requirements as to the content of emergency response plans, the ACPDR prepared a Draft Amendment of the Decree on the Content and Elaboration of Protection and Rescue Plans.

## 6.3 The Krško NPP

In 2017 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
- the replacement of staff and the appointment of new members to the emergency organisation (three persons passed the initial training for emergency team members).

In 2017 the Krško NPP conducted a set of training, tests, and exercises with a total of 586 participants from the Krško NPP and 164 participants from supporting organisations. The Krško NPP conducted two annual emergency exercises with 506 participants from the Krško NPP. In total, emergency staff consist of 360 persons, including security and operating personnel.

Furthermore, in 2017 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 EPREV Mission

An EPREV mission is one of services of the International Atomic Energy Agency (IAEA) for its Member States in the fields of the peaceful use of nuclear energy and nuclear and radiation safety. Within the United Nations system, the International Atomic Energy Agency (IAEA) has the statutory function of establishing safety standards for the protection of health against exposure to ionising radiation and ensuring the application of these standards. In addition, under the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (Assistance Convention), the IAEA is tasked, if requested, with assisting Member States in preparing emergency arrangements for responding to nuclear accidents and radiological emergencies.

EPREV ("*Emergency Preparedness REView*") missions are designed to provide a peer review of emergency preparedness and response (EPR) arrangements in a country based on the IAEA Safety Standards.

The Government of Slovenia sent the request for the mission through the Slovenian Nuclear Safety Administration (SNSA) on 10 April 2015. The second step in the process was a self-assessment, which included the preparation of a self-assessment report and the translation of all relevant documentation (legislation, regulations, plans, procedures, etc.). Within this phase the SNSA and Administration for Civil Protection and Disaster Relief conducted a simulated EPREV mission, which revealed a number of possibilities for the improvement of EPR arrangements before the start of the mission. Based on the simulated mission, the Government of Slovenia adopted an action plan to be fulfilled before the start of the mission.

A preparatory meeting for the EPREV was conducted from 4-5 April 2017, where the scope of the mission and some organisational and logistical arrangements were discussed. The discussions resulted in an agreement on the scope of the EPREV mission (full scope mission) and all relevant aspects were included in the agreed Terms of Reference.

The key objectives of this mission were to enhance nuclear and radiation safety and emergency preparedness and response, namely the following:

- to provide Slovenia with an opportunity for self-assessment of its activities with respect to the IAEA Safety Standards;
- to provide Slovenia with a review of its emergency preparedness and response arrangements;
- to provide Slovenia with an objective evaluation of its emergency preparedness and response arrangements with respect to the IAEA Safety Standards and guidelines;
- to contribute to the harmonisation of emergency preparedness and response approaches among IAEA Member States;
- to promote the sharing of experiences and the exchange of lessons learned;
- to provide reviewers from IAEA Member States and the IAEA staff with opportunities to broaden their experience and knowledge of the EPR;
- to provide key staff with an opportunity to discuss their practices with reviewers who have experience with different practices in the same field;
- to provide Slovenia with recommendations and suggestions for improvement; and
- to provide other States with information regarding good practices identified in the course of the review.

The mission was undertaken from 4-16 November 2017. The EPREV mission team consisted of international EPR experts from IAEA Member States as well as a team coordinator and deputy team coordinator from the IAEA Secretariat. Within the two-week appraisal the mission team reviewed the entire national EPR framework, including legislation, regulations, plans, and procedures on all levels, as well as staffing and technical capabilities to respond properly in the event of a nuclear or radiological emergency. The mission team conducted site visits or interviews with 35 different stakeholders involved in the response system on all levels. At the end of the mission the team presented its findings and the draft report of the mission, while the final report was submitted on 8 January 2018.

The mission report serves as the basis for the Slovenian action plan for the implementation of the recommendations and suggestions in the report and improvement of the EPR system in the next few years. Subsequently, Slovenia will invite the IAEA for an EPREV Follow-Up Mission to review the implementation. The final goal of the whole mission process is the improved preparedness of Slovenia for nuclear and radiological emergencies.

In general, the mission team commended the preparedness of Slovenia and, *inter alia*, highlighted the excellent cooperation between all the stakeholders and response organisations during the mission and during detailed discussions regarding the EPR arrangements in the country.

The team also noted a number of specific good practices. The first such good practice is the MKSID communication and coordination system, which enables the rapid sharing of technical and operational information across a wide range of national and international response organisations. The second is the GIS system of regional emergency notification centres, which includes the location of all high-activity sealed sources in the country, which ensures a rapid assessment of the hazard and an appropriate emergency response. The third good practice was the conducting of a simulated EPREV mission, which provided a good basis for improving EPR arrangements in the country and updating the national self-assessment.

The mission team also noted some areas where improvements could be made. The report of the mission includes 19 recommendations and 12 suggestions for improvements based on the IAEA Safety Standards. Based on these findings, an action plan with 31 actions was drafted for adoption by the Government of Slovenia. Each action includes the mission's observation and findings, the action to be taken, the leading and participating organisations, and deadlines for implementation. The main areas where improvements are to be made include the finalisation of the revision of the national plan such that it fully reflects the international safety standards, in particular for the development of a protection strategy for taking protective actions and other response actions during an emergency, especially arrangements for the later phases of an emergency response, the preparation of the concept of operations for a nuclear or radiological emergency, the preparation of a comprehensive monitoring strategy as part of the overall protection strategy, a detailed assessment of needs and available resources, and overall training and exercise programmes for all response organisations. The Inter-ministerial Commission for Monitoring the Implementation of the National Emergency Plan for Nuclear and Radiological Accidents is to monitor the implementation of the action plan and report to 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 2017**

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 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

Once again in 2017, the field of education, research and development regarding nuclear and radiation safety was stable.

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

The objectives to be achieved in the field of education, research and development in the period 2013–2023, as envisaged by the Resolution, are as follows:

**Goal 9**

*The system of authorised experts enables optimum professional support in the decision-making of the regulatory bodies on nuclear and radiation safety, while ensuring that the producer or the applicant covers the costs of preparing an expert opinion.*

**Realisation in 2017**

The Slovenian system of authorised experts provides optimum professional support in the decision-making of the regulatory bodies on nuclear and radiation safety. In 2017 the amended Act on Protection Against Ionising Radiation and Nuclear Safety (ZVISJV-1) maintained the same solution as applied in the past: the party that initiated an administrative procedure in which the expert opinion of an authorised expert for radiation and nuclear safety is necessary bears the cost of preparing such expert opinion. At the end of 2017, 12 experts from the Republic of Slovenia were authorised to cover all areas of nuclear and radiation safety. Furthermore, the Act also allows the authorisation of foreign professional organisations (in 2017 there were two from Austria and five from Croatia), which ensures greater coverage of professional areas. The Act furthermore contains provisions on ensuring the independence of authorised experts from nuclear or radiation facility operators or persons carrying out a radiation practices.

Apart from the direct financing of the preparation of expert opinions, authorised experts are also financed through research and development projects, as described below in the achievement of Goal 12.

**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 2017**

There were no major changes in this area in 2017.

At the Faculty of Mathematics and Physics of the University of Ljubljana, within the framework of the Department of Physics, the two-stage Master's Degree programme "Nuclear Engineering" is being carried out. In the school year 2017/18, four students enrolled in the programme, who, together with five students in the 2$^{nd}$ year, attend four modules of the Nuclear Engineering Programme, while approximately half of the additional credits are received through courses from other study programmes. For reason of financial savings, lectures are only held for eight courses and even for those only in a cyclical mode, i.e. they are carried out every second year. In the year 2017, three graduates finished their 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. Everyone in the programme is involved in 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 were 17 students in the "Mathematics and Physics" Doctoral Programme within the module Nuclear Engineering; in 2017 two students enrolled in the first year. Most of them are employed at the Jožef Stefan Institute. In 2017, one student finished PhD studies. In 2016, Slovenia (the Jožef Stefan Institute) assumed the presidency of the European Nuclear Education Network (ENEN), which brings together a majority of European universities and institutes dealing with higher education in the field of nuclear technology, and encourages the exchange of students and teachers among European institutions.

We estimate that in the current circumstances in Slovenia the scope of studies and the number of students approximately correspond to the needs of the profession. It should be noted that in the field of nuclear engineering, there are also some engineers from other technical and natural science faculties that acquire nuclear knowledge outside faculties by means of post-employment training.

**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 2017**

The SNSA regularly gathers data from major funders (leaving aside the main nuclear facilities and state authorities) on how the funds are disbursed to Slovenian organisations and 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 increased to more than EUR 7 million primarily due to work on the project regarding the repository for radioactive waste in Vrbina. In 2017 the total amount was approximately EUR 6.2 million. For the past several years, of this amount approximately EUR 1.5 million per year was spent directly on research activities, while in 2017 this sum increased to EUR 1.8 million.

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 28 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.

## 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) and 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).

Following the series of amendments to the 2002 Act, it is now necessary to regulate the area on a new basis, especially due to the need to transpose the requirements of Council Directive 2013/59 / Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers of ionising radiation, which is more familiar to the professional public as the "EU BSS Directive" (Basic Safety Standards). Since the required changes in the field of radiation protection are rather extensive and the chapters that regulate these areas constitute an important part of the Act, the Slovenian Nuclear Safety Administration, in cooperation with the Slovenian Radiation Protection Administration, has decided to prepare a new Act and not another amendment to the existing one from 2002.

Already in mid October 2016, the Slovenian Nuclear Safety Administration informed the interested and general public of the drafting of a new Act, published the draft Act on its website, and invited the public to submit their proposals, comments and opinions.

Upon the completion of the public hearing, the Slovenian Nuclear Safety Administration and the Slovenian Radiation Protection Administration collected all the proposals, comments and opinions received into a single document and published it, again on the SNSA's website, with its comments.

After several months of coordination with ministries and the Government Office for Legislation, the Slovenian Nuclear Safety Administration sent a draft of the new Act (ZVISJV-1) for consideration and approval to the Government of the Republic of Slovenia, which determined the text of the proposal of the ZVISJV-1 and sent it, based on the regular procedure, to the National Assembly of the Republic of Slovenia for consideration and adoption.

The National Assembly adopted the new Act on 12 December 2017; ZVISJV-1 was published in the Official Gazette of the Republic of Slovenia, No. 76/17 of 22 December 2017, and entered into force on 6 January 2018.

The year 2017 was also very intensive regarding the drafting of secondary legislation in the field of nuclear and radiation safety; in fact only two implementing regulations were adopted, i.e. the Decree on Radiation Activities (Official Gazette of the Republic of Slovenia, No. 8/17) and the Rules on the Requirements and Methodology of Dose Assessment for the Radiation Protection of the Population and Exposed Workers (Official Gazette of the Republic of Slovenia, No. 3/17), but both as implementing regulations of the latest amendments of the 2002 Act (ZVISJV-D). At the end of 2017 a number of implementing regulations (decrees) were in the final stage of preparation, all prepared by the Slovenian Nuclear Safety Administration and/or by the Slovenian Radiation Protection Administration, such as the Decree on Radiation Activities, the Decree on Dose Limits, Reference Levels and Radioactive Contamination, the Decree on the National Radon Program Regulation, the Decree on the Reduction of Exposure due to Natural Radionuclides and Existing Exposure Situations, and the Decree on Performing a Compulsory Public Service for Radioactive Waste Management.

Furthermore, both regulatory bodies have also been preparing many implementing rules, such as the Rules on the Use of Radiation Sources and Activities Involving Radiation, the Rules on the Criteria for Using Ionising Radiation Sources for Medical Purposes and Practices Involving Non-

Medical Imaging Exposure, the Rules on Special Radiation Protection Requirements and the Method of Dose Assessment, the Rules on Approving Experts Performing Professional Tasks in the Field of Ionising Radiation and the Rules on the Obligations of Persons Carrying out a Radiation Practice and Persons Possessing an Ionising Radiation Source.

All listed decrees and rules, once adopted and in force, will represent the implementing regulations of the new Act – ZVISJV-1.

A more detailed overview of already adopted implementing regulations and those in preparation is provided on the Slovenian Nuclear Safety Administration's website.

Already in 2014, the Slovenian Nuclear Safety Administration encouraged all major stakeholders (the Ministry of Finance, the Krško Nuclear Power Plant, the Nuclear Insurance and Reinsurance Pool, the Ministry of Infrastructure, and the Ministry of Foreign Affairs) to prepare common positions on the entry into force of the 2004 Protocol to Amend the Convention on Third Party Liability in the Field of Nuclear Energy (the so-called Protocol to the Paris Convention) and the 2004 Protocol to Amend the Convention of 31 January 1963 Supplementary to the Paris Convention (the so-called Protocol to the Brussels Supplementary Convention) and the beginning of the full application of the Act on Liability for Nuclear Damage (ZOJed-1), as well as related open issues regarding the following:

- state aid in the case of those State Parties to the Paris Convention that, in the part of unsecured risks, enter into the insurance scheme with the so-called state premium insurance or guarantee;
- the possible failure to comply with the requirement of the Council Decision of 2004 on the simultaneous submission of the instruments of ratification to the depositary;
- the elements of the contract concluded by the Ministry of Finance with the Krško NPP, pursuant to Article 23 of the ZZOJed-1, for the regulation of relationships arising from the insurance of the Republic of Slovenia for "rejected" insurance coverage;
- the methodology for calculating the premium that the State would charge for the Krško NPP; and
- other outstanding issues.

Two meetings were held (3 July 2017 and 19 December 2017), but unfortunately no substantive progress in resolving the outstanding issues has been achieved.

### 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 2017**

As described above, in the field of nuclear and radiation safety legislation, the Republic of Slovenia regularly transposes the EU acquis (directives), maintains its domestic regulations in line with accepted WENRA standards, and duly fulfils its commitments under all relevant international treaties to which the State is party. This is proven by both informal and formal responses received in this area from comparable regulatory bodies around the world and reviews received within the framework of regular reporting based on various international treaties and/or membership in different organisations and associations.

**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 2017**

The organisation of administrative bodies/regulatory authorities in the field of nuclear and radiation safety in the Republic of Slovenia is adequate and in 2017 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 fields 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 three regular sessions and one correspondence session in 2017. In addition to the regular reporting of the SNSA Director to the Council on the status of nuclear and radiation safety, the Council discussed the situation in Slovenia in the field of authorised experts for radiation and nuclear safety, the situation in the legislative field, especially the preparation of the Ionising Radiation Protection and Nuclear Safety Act and the Act on the Fund for Financing the Decommissioning of the Krško NPP and the Disposal of Radioactive Waste from the Krško NPP. The Council considered the draft of the Public Procurement Act and the impact of this Act on ensuring nuclear safety and the following implementing regulations: the Decree on Activities Involving Radiation UV1, the Decree on Dose Limits, Radioactive Contamination and Intervention Levels UV2, the Rules on the Use of Radiation Sources and on Activities Involving Radiation JV2/SV2, and the Rules on Radioactivity Monitoring JV10, Practical Guideline PS 1.06, which graphically depicts various states of different nuclear facilities. The Expert Council also considered and approved the 2016 Annual Report on Radiation and Nuclear Safety in the Republic of Slovenia. In a correspondence session the Council considered the Sixth Slovenian Report under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.

## 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 determine protective measures for the population and informs the public regarding such matters.

At the beginning of 2017, the SNSA employed 43 civil servants. 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.

At the beginning of 2017, 43 civil servants were employed by the SNSA. During the year, two employees left; one of them was employed on the basis of the regular state budget while the salary of the other was paid from project funds. At the end of 2017, the SNSA had regular full-time staffing (41) in accordance with the determined human resource plan. In reality, the total number of employees at the end of 2017 was 44, due to the employment of one trainee and two employees under fixed-term employment contracts on a project that is not accounted for in the human resource plan.

In 2017 the SNSA, as in all previous years, devoted great attention to the education and training of its employees. Over 35 different training programmes were carried out, mostly abroad, and some in Slovenia. Over 50 SNSA civil servants were involved in these training and education, with great care being taken to rationalise the costs, as almost all forms of education and training were free of charge. The vast majority of training were carried out by the International Atomic Energy Agency (IAEA), which also covered almost all of the costs of such education and training.

The most numerous were internal training programmes in the field of emergency preparedness, i.e. more than 70 in the year in 2017, which were attended by almost all of the SNSA's staff members.

The SNSA informs the public primarily through its website, which is continuously updated, with the content being made transparent and reader friendly.

The "News" section of the website is intended for current events related to the work of the administration, regarding which the SNSA strives to be fresh and informative. In 2017, there were 51 such news items, on average slightly more than four per month. The practice of publishing "Radiation News" ("*Sevalne Novice*"), which was initiated in 2004, was continued; in the year 2017 three editions (43 to 45) were prepared, which are also published on the SNSA website. For the rest of the world (and especially for foreign governing bodies in the field of nuclear and radiation safety), the SNSA also prepares the so-called "News from Nuclear Slovenia" with a standardised content concept, which is updated twice a year. Both publications, i.e. Radiation News and News from Nuclear Slovenia, are also published on the website.

The annual Report on Protection against Ionising Radiation and Nuclear Safety in the Republic of Slovenia is also an important information tool. The report for 2016 was discussed and adopted by the Government of the Republic of Slovenia in June 2017 and forwarded to the National Assembly of the Republic of Slovenia, which took note of the report in November 2017.

At the same time, the report presents the basic manner of informing the general public of the state of nuclear safety and radiation protection in the country.

The SNSA has a management system in conformity with ISO 9001 and the IAEA 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 2017 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 the operational staff of the Krško NPP, i.e. Senior Reactor Operators, Reactor Operators, and Shift Engineers of the Krško NPP.

Four candidates acquired a Reactor Operator license for the Krško NPP for the first time. In total, the Commission organised exams six times for 31 candidates who wanted to renew a license. Extensions of licenses were granted to twelve Reactor Operators, nine Senior Reactor Operators and five Shift Engineers. 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 for the TRIGA Research Reactor were granted to two Reactor Shift Supervisors.

No storage facility manager license exams were held for the staff involved in the management of the Central Radioactive Waste Storage Facility in 2017.

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; the 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 the radioactive contamination of foodstuffs and drinking water; the 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 2017 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 (ZVISJV-1); 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, 77 permits to carry out a radiation practice, 230 permits to use radiation sources, 15 certificates of received individual doses and 27 statements of consignees of radioactive materials were confirmed. In 2017 the SRPA issued 15 approvals to natural or legal persons performing professional tasks in radiation protection.

In 2017 the Inspectorate carried out 160 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, 7 in-depth inspections were performed. A total of 3 decisions required the correction of established deficiencies. One in-depth inspection of the transport of radioactive material used in health care was performed. Five requests to submit evidence regarding corrected authorised deficiencies, 26 requests to submit evidence regarding the termination of the use of an X-ray device, and 110 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.

In 2017 the SRPA financed the formulation of the Guidelines for radon-safe construction of new buildings, a "radon map", and a cartoon with information on the harmful effect of exposure to radon, which is printed on leaflets for primary school pupils.

The SRPA continued to finance the radiation monitoring of food and drinking water and the measurement of gross alpha and gross beta activities in the drinking water of Slovenia.

In 2017 the SRPA cooperated very intensively in the drafting of the legislation transposing Council Directive 2013/59/Euratom, as described in Chapter 7.2.

Thus far, the SRPA has operated with a small number of employees and modest financial resources. Despite this, a high level of radiation protection has been ensured in its areas of competence. This is achieved by effectively optimising work processes and the optimal use of available resources. The understaffing of the SRPA was noted by the EPREV mission, which pointed out that in the event of an emergency the SRPA could not respond to the event and perform its regular duties at the same time. Furthermore, the ZVISJV-1 burdens the SRPA with additional tasks in relation to protecting the population against the harmful effects of radon exposure and in the field of the health protection of patients. Accordingly, additional financial resources have been granted to the SRPA to carry out radiation protection measures in the field of the radiation protection of patients and radon exposure. The needs for additional staffing were also described in the commentary on the ZVISJV-1, which was discussed in the National Assembly of Slovenia in the process of adopting the law. The SRPA does not have any staff reserves to fulfil the additional tasks assigned to it. Additional staffing in the near future is thus a pressing requirement in order for it to fulfil its legal obligations and maintain an adequate level 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 in relation to specific interventions in such facilities. Such expert opinions must be prepared by approved experts. In 2017 there were no major changes in these activities of experts in comparison to previous years. Their staff maintained their level of competence and the equipment used was well maintained and updated. The organisations established quality management programmes. Most of them had programmes certified in compliance with the ISO 9001:2008 standard.

Approved experts also provided professional support to the Krško NPP by preparing independent reviews related to planned modifications. Special focus was devoted to ensuring independence in the reviewing process.

Research and development activities are an important part of the activities of approved experts. It should be noted that some organisations participated in international research projects with remarkable success.

Five applications for the extension of approvals were considered by the SNSA. All approvals were granted. No new applications for approval were submitted in 2017 and no new approvals were issued.

In 2017 a total of 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 2017 the SRPA issued five approvals regarding radiation protection expert to natural persons and three approvals to two legal persons. 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 2017 the SRPA performed two inspections in the Milan Čopič training centre related to training in radiation protection.

**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 that meet the SIST EN ISO/IEC 17025 standard.

In 2017 the SRPA issued three approvals to dosimetry services.

**Approved Medical Physics Experts**

Approved medical physics experts provide advice on the 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 2017 the SRPA authorised 4 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 2017 the SRPA prepared 3 opinions with regard to the fulfilment of the requirements for carrying out the 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 2017 the following members had the largest shares: the Insurance Company Triglav, d. d.; the Reinsurance 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 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 NPP during the period of insurance. In 2017 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 liability limits 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, to ensure 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.

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 that are not NPT signatories (India, Pakistan, Israel) or that have unilaterally withdrawn from the NPT (DPRK), have further pursued their nuclear weapons programmes. In 2017 the DPRK again conducted a nuclear test. 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 United Nations' Security Council Resolution 2231 (2015).

Based upon the NPT, the States are obliged by their "safeguard agreements", which were in many cases upgraded also through the Additional Protocol to such agreement.

The Slovenian stance on the subject is aligned with the EU position, and all three "pillars" of the NPT are considered; furthermore, the Middle East Nuclear Weapon Free Zone is important, together with the early entry into force of the CTBT and the universality of the NPT. The next important conference will undoubtedly be the 10$^{th}$ RevCon – Review Conference in 2020, together with three standard-format meetings in 2017, 2018, and 2019 – i.e. PrepComs - Preparatory Committees); the first PrepCom was held in Vienna in May 2017.

On 7 July 2017, the Treaty on the Prohibition of Nuclear Weapons ("Nuclear Weapon Ban Treaty") was passed; 122 states voted in favour of the treaty text, which prohibits a number of activities related to the development, testing, production, manufacturing, acquisition, possession and stockpiling of nuclear weapons or other nuclear explosive devices, as well as threats to use such weapons. Slovenia did not take part in the process of drafting the treaty. It will enter into force 90 days after ratification by at least 50 states. A solemn ceremony was held on 20 September 2017 at the United Nations upon the first signings of the treaty.

At the end of 2017, the prestigious Nobel Prize for Peace was awarded to the non-governmental organisation ICAN (International Campaign to Abolish Nuclear Weapons), which has done significant work in the whole treaty process.

## 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 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 has cooperated bilaterally and in the framework of international sessions, and actively promoted the importance of the CTBT and its entry into force and called upon the remaining countries to do so – as soon as possible. It is only in this manner that the CTBT's aim will be achieved, i.e. a total ban on nuclear tests.

In September 2017 the Executive Secretary of the CTBTO, Lassina Zerbo, participated in the Bled Strategic Forum (BFS), which has evolved into a remarkable platform for regional and global topics; the focal point of the 2017 forum was "the new reality".

On 3 September 2017 a grid of CTBTO-related monitoring stations detected unusual seismic event in the DPRK, with its assessment indicating a human factor i.e. an explosion.

## 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) regarding 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 six IAEA/EURATOM inspections in 2017 (three of which were conducted by EURATOM). The SNSA's staff participated in all of the international inspections that took place at the three nuclear facilities; at the Krško NPP, a technical meeting was also organised that was devoted to the envisaged dry storage of spent fuel and pertinent safeguard approaches. There was only one international inspection in 2017 held on the premises of a small holder of nuclear material; the relevant holder of nuclear material has established an appropriate level of reporting to EURATOM on the nuclear material is possesses and uses in its processes. In 2017 one international inspection in a nuclear facility was conducted based on so-called "complementary access" (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 in Bern (Switzerland) in June 2017.

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 10 regular and 16 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 2017 the Slovenian Government endorsed the Annual Report (covering 2016) of the above-mentioned Commission.

In December 2017 a European regulation was published that defined amended lists of dual-use goods (Commission Delegated Regulation (EU) 2017/2268 of 12 December 2017 amending Council Regulation (EC) No 428/2009 setting up a Community regime for the control of exports, transfer, brokering and transit of dual-use items).

## 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 2017 two regular sessions of the Commission were held; the Commission considered proposals regarding the threat assessment of Slovenian nuclear facilities, the future disposal of low- and intermediate-level radioactive waste, and road transports of radioactive material (all considered for 2017). The Commission also considered the proposal regarding the threat assessment of the transport of nuclear fuel, intended for early-2018 (from the Port of Koper to the Krško NPP). The Commission gave its positive opinion to the Police in all of the mentioned cases; the threat assessments remained valid throughout 2017 or until the next revision.

In 2017 the Ministry of the Interior and the Police took part in the international EPREV mission (intended to review emergency preparedness for a nuclear or radiological accident); the final report of the IAEA mission showed the solid capabilities of both institutions were such an accident to occur.

The Inspectorate of the Ministry of the Interior carried out, based upon its plan, just one inspection-supervision of a nuclear facility in 2017. This inspection addressed the Krško NPP and no security-related anomalies (i.e. non-conformities) were identified.

During 2017 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 regarding 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.

## 8.6 Illicit Trafficking in Nuclear and Radioactive Materials

In 2017 the SNSA issued 11 approvals for measuring the radioactivity of scrap metal shipments. Out of a total of 22 providers of measurements, only one did not submit an annual report (due to bankruptcy). The submitted annual reports showed that 70,579 measurements of shipments were made in Slovenia in 2017. Elevated dose levels were measured in three cases. The duty officer at the SNSA was available to provide assistance and consultation to other state offices and scrap metal recyclers. In 2017 17 calls to the duty officer were registered, with 11 interventions related to the identification of increased radiation when transporting radiation sources or radioactive waste. In 2017 there was a suspicion that there was a threat to the inhabitants (in the municipality of Moravče) with ionising radiation sources. The suspicion was later refuted.

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 2017 Slovenia (the SNSA) reported twice to the IAEA "Incident and Trafficking Database" (ITDB), namely in both cases regarding smaller quantities of U-substances that were subsequently transferred to the central storage in Brinje ("CSRAO").

In September 2017 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. The main issues of discussion were foreign good practices and the improvement of current detection capabilities at the major Slovenian nodal points.

In 2017 a seminar for police officers was held in Slovenia (in Gotenica) 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. The SNSA cooperated in a series of ITDB-related activities with the IAEA and the European Commission, through some regional efforts and the better exchange of information.

## 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 cooperating 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 2017**

Slovenia is committed to its obligations regarding safeguards, follows international inspections in this regard, fulfils the requirements regarding reporting events to international databases 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: as regards 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 2017**

Slovenian experts participated in foreign IAEA IPPAS missions in 2017; the IAEA has also established a mechanism for future "IPPAS peer reviewers".

# 9 INTERNATIONAL COOPERATION

This chapter presents the international framework and cooperation of regulatory authorities in the area of nuclear and radiation safety. A detailed description of all 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 the Maltese presidency of the Council of the EU, an agreement was reached that Slovakia would continue its presidency of the WPAQ, which it held in the second half of 2016. The WPAQ in this period did not have legislative proposals on its agenda, but rather considered different reports and preparations for the Joint Convention review meeting, which was scheduled for May 2018. The WPAQ also considered information on cooperation with Iran. In the second half of 2017, Estonia took over the presidency. The EC had a presentation on the ITER programme (a fusion reactor) and a presentation of the work plan on implementing the Memorandum of Understanding with Ukraine on a strategic partnership regarding energy. The EC also presented the international scientific and technological centre in Astana in Kazakhstan. Euratom as a party to the Joint Convention, prepared the report and presented it to the WPAQ. Another EC presentation covered nuclear power plant decommissioning projects in Bulgaria, Lithuania and Slovakia.

**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 2017 were no new legislative proposals on the ENSREG agenda. The ENSREG mainly dealt with topics related to *Topical Peer Review*, which was focused on the systematic review of ageing management in nuclear power plants in the EU.

**Consultative Committees under the Euratom Treaty**

Within the framework of the Treaty on European Union, 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 2017 the Committee dealt with the implementation of the provisions of the EU BSS Directive. The harmonisation of measures in the event of a nuclear accident was presented, as well as the new publication on radon coefficients, which is to be published in 2018. There were presentations on modelling the origin of $^{106}Ru$, which was traced in the air over Europe in 2017, carried out by the French administrative authority, a Czech study on radioactivity in houses, which was carried out during the period 1972-1980, and on the elimination of environmental contamination.

The Euratom Treaty imposes EU member States to set up a system in their territory for measuring radioactivity in the environment (Article 35) and to report on the results regularly to the European Commission. The Commission has the right to verify whether such a system is established and whether it complies with the determined requirements (Article 36). In the year 2017, a document on the control of radioactive releases into the environment, including good practices, was discussed and the verification programme was reviewed. In the year 2017 there was no meeting, as the next one is planned for 2018.

The Consultative Committee under Article 37 has correspondence meetings, as needed, when the European Commission shall provide an opinion on major reconstruction or the construction of new nuclear installations.

### 9.1.1 Cooperation in EU Projects

The SNSA cooperates in four 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. The SNSA took part in two tasks: (a) the elaboration of the strategy from the action plan and (b) the regulatory framework. The SNSA independently completed the first task, while in completing the other task the SNSA cooperated with the partner ENCO, for which the SNSA produced examples of generic legislation in the field of nuclear safety and also for all fields of radiation protection;
- In the project Training and Tutoring for Nuclear Safety Regulatory Bodies' Experts and their Technical Support Organisations and Technical Competences, the SNSA cooperates with the consortium led by the Italian company ITER. The SNSA provides mentoring and takes part in implementing training courses for the nuclear and radiation safety regulatory bodies' personnel from partner countries. In 2017 SNSA experts participated in three courses in the field of thermal-hydraulic analysis, post-Fukushima experiences, and evaluation of the NPP safety report. The SNSA provided on-the-job training to two tutees three times;
- Within the project Further Enhancement of the Technical Capacity of the Nuclear Regulatory Bodies of the West Balkans, in 2017 the SNSA took part in workshops for formulating the procedures for Kosovo and Montenegro and implemented a workshop on compliance with the EU acquis for nuclear safety directives, the radioactive waste directive, and the shipment directive in Bosnia and Herzegovina. In cooperation with the SRPA, it also carried out on-the-job training in Slovenia for representatives of the regulatory bodies from Bosnia and Herzegovina, Kosovo, and Macedonia.
- In 2017 the SNSA also began work on the European Commission's project for Enhancing the Capabilities of the Iranian Nuclear Regulatory Authority. The objective of this project is to assist the Iranian regulatory body for nuclear and radiation safety to improve the knowledge and expertise of its staff, to modernise its administrative infrastructure, which is to become aligned with international standards as much as possible, and to transfer the Western nuclear regulatory methodology, to the extent possible, to the Iranian Regulatory Authority. The SNSA participates in a consortium consisting of nuclear safety regulatory bodies from the Czech Republic, Slovakia, and Hungary, while the Austrian company ENCO is the consortium leader. In 2017 the SNSA prepared a draft feasibility study on the future Iranian nuclear safety center, which will contain various units, including a technical support organisation that is to perform all functions that are not performed by the regulatory authority.

The SRPA participates in the *ENATRAP III* project, which is aimed at harmonising radiation protection training and the 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 on supervision of the implementation of the principle of the justification 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 and directs its work between the two sessions of the General Conference. In September 2017 the Slovenian delegation also attended the regular annual session of the General Conference. In 2017 the Republic of Slovenia settled all of its financial obligations to the IAEA.

Slovenia received 15 individual applications for the training of foreign experts in Slovenia in 2017 and one group application for training. Seven training requests were implemented. Ten training application requests received already in 2016 were implemented in 2017 as well.

The Jožef Stefan Institute, Department of Nuclear Medicine, the Department of Neurology, the Institute of Biomedical Informatics of the University of Ljubljana, the National Building and Civil Engineering Institute, and the Institute of Oncology Ljubljana actively participated in coordinated research projects. They were involved in seven research projects, which had already been launched in 2016 or earlier. Three coordinated research projects were successfully completed in 2017.

In 2017 the activities of two national projects continued: 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*". In November 2017, the Board of Governors approved two new national projects in the technical cooperation cycle 2018–2019. Slovenia submitted project proposals in 2016. The joint project of the SNSA and ARAO SLO/9/019 Supporting the Regulatory Authority and the Implementing Organisation in the Enhancement of Nuclear Safety and the Implementation of Radwaste Management, and the joint project of the Institute of Oncology Ljubljana and the Department of Nuclear Medicine SLO/1/006 Improving the Safety and Quality of Radiology Services through the Development of Medical Physics Departments and Enhancing the Theranostic Nuclear Medicine Approach.

In cooperation with the IAEA, in 2017 Slovenia organised two national workshops, two regional workshops and an international meeting.

The participation of Slovenian specialists and their involvement as experts in various IAEA committees, missions and workshops abroad is important as well.

In 2017 the activities of the interregional project on further sustaining cradle-to-grave control of radioactive waste continued. Representatives of the ARAO and the SNSA have been actively involved in the project. Last year, Slovenian representatives also successfully and actively participated in the work of regional projects, particularly in that of regional projects on enhancing and strengthening 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, capabilities for radionuclide measurement in the environment and the QA/QC system for environmental radioactivity monitoring, the capacities of 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.

The SRPA participated in two IAEA project related to use of ionising radiation in health care, which were completed in 2017. The first project, RER-6-032 and entitled "*Establishing Quality Assurance/Quality Control in X Ray Diagnostics*", was aimed at enhancing the system of quality assurance and quality control in diagnostic radiology. In the framework of the project, the SRPA hosted a regional IAEA workshop related to QA/QC in diagnostic radiology in 2016 and a workshop for training inspectors in radiation protection in health care in 2017. The second project, RER/9/135 "*Strengthening Member State Technical Capabilities in Medical Radiological Protection*", was aimed at improving the system of radiation protection in the medical use of ionising radiation. The project was divided into several topical parts. Slovenia, in accordance with its needs and current situation, joined the topical parts 1) forming the diagnostics reference levels with an emphasis on paediatric patients, and 2) interventional procedures with an emphasis on interventional radiology. Due to participation in the project, Slovenia gained access to internationally accepted guidelines for evaluating the competence of quality centres in diagnostics and interventional radiology. Participation in the project has added to the upgrading of the system for data collection as regards diagnostic reference levels. In addition, participation in this project has enabled radiological engineers, physicians, medical physicists and members of the regulatory authority to participate in professional training programmes and workshops in the organisation of IAEA.

In 2016 Slovenia actively joined the working group on the medical use of ionising radiation. In 2017 the working group developed conclusions regarding open questions in the transposition of some medical articles of the Euratom Directive 2013/59 and planned an action week related to the justification of radiological procedures.

In 2017 a representative of the Novo mesto Police Directorate, of the Police of the Republic of Slovenia, attended several international exercises and conferences on protection and threats to nuclear facilities organised by the IAEA.

It should be emphasized that a representative of the Republic of Slovenia participated in an international conference on nuclear security and delivered a paper on the usefulness of and experiences gained during force-on-force exercises. The representative also co-chaired one of the panels on crisis planning and contingency planning.

At the invitation of the IAEA, a Slovenian representative participated in a Consultancy Meeting, which prepared a training programme for simulated exercises on force-on-force security events at nuclear facilities.

## 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 2017 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 Committee for Technical and Economic Studies on Nuclear Energy Development and the Fuel Cycle and the Nuclear Science Committee 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 Experiences. In 2017 the NEA planned to establish a new standing committee on decommissioning and legacy management. The decision to establish it was postponed until 2018. The NEA Director gave an initiative to establish the Nuclear Education Skills and Technology Network (NEST), which should help educate younger people in particular. The NEA will finance a study on damaged fuel in the Fukushima NPP entitled "*Preparatory Study on Analysis of Fuel Debris (PreADES)*" in the period 2017–2020.

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 that deals with 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 organisations already mentioned, nuclear power plants, and regulatory bodies.

## 9.4 Cooperation with other Associations

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

The Western European Nuclear Regulators Association (WENRA) 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 particular, WENRA has established itself globally as one of the leading institutions in developing the best standards in the area of nuclear safety. In 2017 the core of WENRA's work continued to be carried out by its working groups for the harmonisation of safety requirements for reactors and for the management of radioactive waste and the decommissioning of nuclear installations. Work on emergency preparedness in relation to nuclear security and radiation protection was also intensified.

The growth in WENRA's reputation can also be seen globally in the fact that Japan and Canada joined it as observers, and Korea and Brazil are also interested in obtaining observer status.

**The European Nuclear Security Regulators Association (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 2017, the United Kingdom 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 approaches of the members, cooperation with the IAEA and others, as well as the future activities of ENSRA's working groups. In 2018, ENSRA will be led by Sweden and the next plenary meeting will be hosted by the Swedish Radiation Safety Authority.

### The Nuclear Security Contact Group (NSCG)

The Nuclear Security Contact Group (NSCG) is an association established after the 4th Nuclear Security Summit, held in 2016. The NSCG has also attracted a few countries that were not invited to the previous summits. Slovenia joined the NSCG in March 2017; this was an additional step in the frame of Slovenian activities in the nuclear security area. The NSCG's members from Slovenia comprise representatives from the Ministry of Foreign Affairs and the SNSA. One of the most important topics within the NSCG is future activities in pursuing the Amendment to the Convention on the Physical Protection of Nuclear Material (A-CPPNM).

### The International Nuclear Law Association (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 600 members from more than 60 countries and international organisations.

In October 2014, the INLA held its Congress in Buenos Aires, Argentina; the INLA usually organises a Congress every two years. The last Congress was held in New Delhi, India, in 2016, and the next Congress will be held in Abu Dhabi, United Arab Emirates, in 2018. The contributions for that Congress were already prepared in 2017. For historical reasons, the SNSA is most closely connected with the working group that deals with the management of nuclear and radioactive waste. In 2017 the SNSA provided a contribution to this working group on the topic of public participation in the selection of the location for a waste repository.

### 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 the relevant computer programmes.

In 2017 the Jožef Stefan Institute prepared a contribution entitled "*10 % Hot Leg Break LOCA Experiment on LSTF Calculated by RELAP5 and TRACE*". In autumn 2017 the CAMP Programme Committee approved the preparation of a contribution by the Jožef Stefan Institute entitled "*Semiscale S-NC-02 and S-NC-03 Natural Circulation Tests Performed by RELAP5/MOD3.3 Patch 5*" for 2018.

### CSARP (NRC)

In 2016 Slovenia renewed cooperation in the US NRC severe accident research programme CSARP (Cooperative Severe Accident Research Program). The Slovenian members of the CSARP are the Slovenian Nuclear Safety Administration, the Krško NPP and the Jožef Stefan Institute, which is the Slovenian National Coordinator. Membership in the CSARP programme enables usage of the computer code MELCOR for the simulation of severe accidents in nuclear power plants.

Representatives of the Slovenian members of the CSARP had a business meeting in November 2017. The National Coordinator presented the status of the CSARP research in Slovenia, current activities, attendance at the EMUG meeting, attendance at the MELCOR workshop and the

CSARP/MCAP meeting, the research project "*Analysis of the influence of the Krško NPP safety upgrade to SAMG*", as well as the realisation of plans. All planned activities were realised as well as one research project.

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

A representative of the SRPA is a member of the Association of the Heads of the European Radiological Protection Competent Authorities – HERCA.

**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**

International cooperation is an important activity of the ARAO. In the Republic of Slovenia, it strives to ensure a comprehensive system for the management of radioactive waste and spent fuel that includes the most up-to-date and verified technological solutions and good practices on an international scale

In terms of gaining knowledge and experience in the field of the management of radioactive waste and spent fuel, the ARAO involvement in the programme of expert cooperation with the IAEA and in the projects of the European Community for Nuclear Energy (EURATOM) is very important. In 2017 ARAO staff were trained at several IAEA workshops in the field of ionising radiation protection, the treatment of radioactive waste, the management of radiation sources that are no longer in use, and the disposal of radioactive waste. In other workshops, they also participated with presentations of the radioactive waste management system in Slovenia. It is important that the ARAO, together with the SNSA, is involved in a new cycle of technical cooperation with the IAEA for the years 2018 and 2019. The ARAO actively participated in the JOPRAD project within EURATOM.

According to Slovenia's strategy, when planning the management of high-level waste and spent fuel, a two-sided approach will be developed (planning a geological repository for spent fuel and high-level waste from its own nuclear programme in Slovenia, while monitoring and participating in initiatives for an international geological repository in an EU country or elsewhere in the world). For some time now, the ARAO has been participating in the working group of the European Development Organization for the geological repositories (ERDO-WG) and in the activities of the European Technology Platform IGD-TP (*Implementing Geological Disposal of Radioactive Waste Technological Platform*). The ARAO also participates in the International Association for Nuclear Energy Cooperation IFNEC (*International Framework for Nuclear Energy Cooperation*).

The ARAO has also been cooperating bilaterally with several foreign professional organisations that are also engaged in the management of radioactive waste and spent fuel, such as Sogin (Italy), Covra (Netherlands), Andra (France), Surao (Czech Republic), Enresa (Spain), and the Fund for the Decommissioning of the Krško NPP (Croatia).

ARAO representatives regularly participate in major international conferences and other meetings where they can present their professional achievements and formulate international guidelines on the field of the management of radioactive waste and spent fuel. In 2017 they participated in the mission of the IAEA Emergency Preparedness Review in Slovenia, in the international expert conference NENE, in the Regional Seminar on the Management of Radioactive Waste and Spent Fuel in the Central European Countries, and in the meeting of the European Organizations for the management of radioactive waste and spent fuel.

## 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 (Official Gazette of RS No. 5/03 - International Treaties; hereinafter referred to as: the Bilateral Agreement), an Intergovernmental Commission was established in accordance with Article 18 of the Bilateral Agreement.

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

In 2017 the Government of the Republic of Slovenia reappointed the members of the Slovenian delegation. On 21 July 2017, the $11^{th}$ session of the Intergovernmental Commission was held, convened by the President of the Slovenian delegation. A report by the members of the Krško Nuclear Power Plant Management Board was adopted. It was established that the provisions of the Bilateral Agreement in the period since the last meeting of the Commission were implemented in a responsible and successful manner and that good operational, safety and economic results were achieved. The Croatian side informed the Intergovernmental Commission of an open issue regarding the tax burden imposed on the employees of the Krško Nuclear Power Plant.

The Intergovernmental Commission ascertained that at the technical level the expert organisations together with the Krško Nuclear Power Plant had prepared and harmonised new project proposals for the Programme for the Decommissioning of the Krško Nuclear Power Plant and the Programme for the Disposal of Low- and Intermediate-Level Radioactive Waste and Spent Fuel at the technical level. Both projects were accepted by the Commission.

The Intergovernmental Commission assigned the ARAO and the Croatian Fund the task of developing, together with the Krško Nuclear Power Plant, the third revision of the Programme for the Disposal of Radioactive Waste and Spent Nuclear Fuel by the end of November 2018. At the same time, the Intergovernmental Commission ordered the Krško Nuclear Power Plant to develop, in cooperation with the ARAO and the Croatian Fund, a Programme for the Decommissioning the Krško Nuclear Power Plant.

The Intergovernmental Commission established a coordination committee for monitoring the implementation of the preparation of the third revision of the Programme for the Disposal of

Radioactive Waste and Spent Nuclear Fuel and the Programme for the Decommissioning of the Krško Nuclear Power Plant.

Croatia presented its position regarding the offer of Slovenia to include Croatia in the joint project on low- and intermediate-level radioactive waste disposal at the Vrbina location in the Municipality of Krško. The offer as presented in the Investment Programme for the Vrbina Disposal Project Rev. C is not acceptable to the Croatian side.

The Intergovernmental Commission supports further activities for joint consideration of the possibility regarding the construction of the LILW repository. Therefore, the Commission instructed the Coordination Committee to prepare a joint proposal for the construction of the repository as soon as possible or by May 2018 at the latest.

Reports on the status of financial funds already collected in both funds for financing the decommissioning of the Krško Nuclear Power Plant and the disposal of radioactive waste from the Nuclear Power Plant were presented to the Intergovernmental Commission.

The next session of the Intergovernmental Commission will be convened by the Croatian side.

## 9.6 Cooperation within the Framework of International Agreements

In June the regular annual meeting of the nuclear regulatory bodies of the Czech Republic, Hungary, Slovakia, and Slovenia, which all have bilateral agreements with each other, i.e. the so-called Quadrilateral Meeting, was held in Bratislava. The main objective of such meetings is to inform each other of important developments in the field of nuclear safety. In all countries, legislation is being intensely updated because it needs to be aligned with the revised Nuclear Safety Directive and the new Radiation Protection Directive (the so-called BSS Directive). The main goal of all regulatory bodies is to ensure nuclear safety, which is linked to the lifetime extension of the existing nuclear power plants, which is related to the aging management of the components and the implementation of periodic safety reviews. All countries have been implementing safety upgrade programmes since the 2011 stress tests and are preparing for a topical peer review required by the amended Nuclear Safety Directive. Important event reports were presented. Most of them were failures of individual parts of the equipment on the secondary side due to instrumentation and control systems, aging, inappropriate materials that cause equipment failure, minor leakages, and, rarely, planned shutdowns (trips). International topics related to the participation of the mentioned governing bodies in the WENRA, ENSREG, MAAE, and NEA were also discussed and the interfaces between nuclear safety and security were emphasised.

In October, representatives of Austria and Slovenia convened at their annual meeting in Moravske Toplice. 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. The topics discussed were advances in the field of legislation, radiological monitoring, preparedness for emergencies, radioactive waste management and modifications and important events in the field of nuclear programmes. Slovenia reported on the process of adopting the new nuclear safety law. It also reported on preparations for the construction of a dry spent fuel storage. Slovenia had an extensive presentation on the operation of the Krško NPP. The Austrian counterparts explained that they had not met the deadlines for the transposition of the directives on nuclear safety and the management of radioactive waste into their legal system. They also reported on the operation of their LILW storage in Seibersdorf and on the modifications of the TRIGA research reactor in Vienna.

On October 4, the 7th meeting under the agreement between the Republic of Slovenia and the Republic of Croatia on the early exchange of information in the event of a radiological emergency was organised in Ljubljana. After reporting on the news in the respective regulatory bodies since last November's meeting in Zagreb, which mainly concerned the drafting of new legislation and alignment with the EU acquis, the Slovenian side also reported on the software modernisation of the early warning network. The main item of the meeting was the coordination of planned protective actions in the case of an emergency in the Krško NPP.

### 9.6.1 Convention on Nuclear Safety

From 27 March to 7 April 2017, the 7th Review Meeting of the Parties to the Convention on Nuclear Safety took place in Vienna. On the first day of the review meeting, the Slovenian National Report was presented by Dr. Andrej Stritar, the SNSA Director. The most important developments during the reporting period were the implementation of the Post-Fukushima National Action Plan, which consists of the Krško NPP Safety Upgrade Programme (SUP) as the most important part, and an additional 11 measures, which include issuing decisions, topical peer reviews, additional studies, inviting international missions for the assessment of nuclear safety, the re-assessment of the strategy for severe accidents management and the existing design criteria and procedures. He also reported on major outage modifications. He pointed out the importance of knowledge management in the nuclear field. The SNSA improved the training programme, which is designed as a systematic approach to training.

The rapporteur's report prepared for Slovenia contains three challenges, namely:

- completion of the Krško NPP Safety Upgrade Programme by 2021;
- completion of the dry spent fuel storage facility and low- and intermediate-level radioactive waste repository before operational safety problems arise;
- coordination of protective actions with neighbouring countries in case of an emergency.

In addition to the challenges, the report commended the root cause technical analysis and the successful solution for eliminating fuel leakage in the Krško NPP, the proactive action of the administrative body in the event of falsification in the Creusot forge in France, and the conclusion of a multi-party agreement to promptly notify any aircraft flying outside the given flight corridor, and particularly praised the efficient work of the SNSA along with its high level of competence, as well as the extensive international cooperation in managing a small nuclear programme.

The second week of the review meeting was dedicated to plenary work. The rapporteurs of all seven groups presented their main summaries of the reports, examples of good practice and performance, as well as measures for the short and long-term improvement of nuclear safety for each participating country.

### 9.6.2 Preparation and Elaboration of the Report under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management

In 2017 the sixth Slovenian National Report on the fulfilment of the obligations under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management was prepared. In October, the report, approved by the Slovenian Government, was sent to the IAEA, which provides for the services of the secretariat for the meeting of the Contracting Parties. Besides the SNSA, the following organisations cooperated in the preparation of this report: the Slovenian Radiation Protection Administration, the Agency for Radwaste Management, the Krško NPP; the Jožef Stefan Institute, the Žirovski Vrh Mine, the Department of Nuclear Medicine of the University Medical Centre Ljubljana and the Institute of Oncology.

The report will be presented at the sixth review meeting of the Contracting Parties, which is to be held in Vienna at the end of May 2018. The National Report for the three-year cycle from 2014 to 2016 presents information on the safety of radioactive waste and spent fuel management, information on the inventory of radioactive waste and spent fuel in the Republic of Slovenia at the end of 2016, legislation regulating this working area and the scope and manner of fulfilling the obligations from the Joint Convention. The National Report is written in English. The report concludes that the Slovenian legislation and practice in the area of the management of radioactive waste and spent fuel are harmonised with the requirements from the Joint Convention.

## 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 2017**

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 membership in organisations such as the 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 institutions 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 2017**

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 and 36 of the Euratom Treaty, and followed the work of the group established by Article 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; in 2017 the SNSA began providing support to the Iranian Nuclear Regulatory Authority.

**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 2017**

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 2017**

The Slovenian representatives are actively involved in the work of the committees and working groups of the NEA, in particular in the committees and working groups dealing with regulatory activities, 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 2017, there were 448 nuclear reactors for electricity production operating in 31 countries. There are 54 nuclear reactors under construction, of which construction began in 2017 in India, Bangladesh, and Republic of Korea. There were four new grid connections, three in China and one in Pakistan. Five reactors were permanently shut down, one each in Korea, Spain, Germany, Sweden, and Japan.

In Europe, there are nuclear power plants under construction in Finland, Slovakia, France, Russia, Ukraine, and Belarus.

Detailed data on the number of reactors by country and their installed power is presented in Table 10 (data source: PRIS database, IAEA).

**Table 10: 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 | 5,927 | | |
| Bulgaria | 2 | 1,926 | | |
| Czech Republic | 6 | 3,904 | | |
| 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 | 25,443 | 5 | 3,398 |
| Slovakia | 4 | 1,814 | 2 | 880 |
| Slovenia | 1 | 688 | | |
| Spain | 7 | 7,121 | | |
| Sweden | 10 | 8,629 | | |
| Switzerland | 5 | 3,333 | | |
| Ukraine | 15 | 13,107 | 2 | 2,070 |
| United Kingdom | 15 | 8,883 | | |
| **Europe total** | **182** | **161,139** | **13** | **11,796** |
| Argentina | 3 | 1,627 | 1 | 25 |
| Brazil | 2 | 1,884 | 1 | 1,245 |
| Canada | 19 | 13,500 | | |
| Mexico | 2 | 1,330 | | |
| USA | 99 | 98,639 | 2 | 4,468 |
| **Americas total** | **125** | **116,980** | **4** | **3,504** |

| Country | Operational | | Under construction | |
|---|---|---|---|---|
| | No. | Power [MW] | No. | Power [MW] |
| Armenia | 1 | 375 | | |
| Bangladesh | | | 1 | |
| India | 22 | 6,240 | 5 | 2,990 |
| Iran | 1 | 915 | | |
| Japan | 42 | 39,752 | 2 | 2,653 |
| China | 38 | 29,462 | 16 | 16,416 |
| Korea, Republic of | 24 | 21,667 | 4 | 5,360 |
| Pakistan | 5 | 1,318 | 2 | 2,028 |
| Taiwan | 6 | 5,052 | 2 | 2,600 |
| United Arab Emirates | | | 4 | 5,380 |
| **Asia and Middle East total:** | **139** | **104,781** | **37** | **39,424** |
| South Africa | 2 | 1,860 | | |
| **World total** | **448** | **384,760** | **54** | **54,724** |

# 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 2017**

In 2017 23 event reports were published via the NEWS system. The reports were divided into the following groups: five events in NPPs, one event concerning the release of radioactive water from the Fukushima Daiichi NPP, one event at a research reactor, five events in nuclear facilities, one event at an accelerator facility, one event during the transport of radioactive material, six events involving the theft of radioactive sources, two events involving the exposure of personnel in medicine and two events involving the exposure of workers during the performance of radiography. In 2017 there was one event rated level 3, seventeen events rated level 2 and five events rated level 1.

An event in a research reactor in Australia was rated as level 3 on the INES scale. During a routine procedure for handling isotope $^{99}$Mo the liquid spilled onto the workers hands and contaminated them. The estimated dose to the hands was 850 mSv, which exceeds the authorised limit. Subsequently, the hands showed skin erythema and blistering, which are deterministic effects of the exposure.

Four findings in NPPs in France were reported and were rated as level 2. Investigations of the seismic robustness of the NPPs showed that in case of the design basis earthquake or stronger earthquakes there could be failures in the safety systems of several NPPs. In the first case there could be a failure of diesel generators; in the second case a failure of an embankment for flood protection against a river channel with the consequential possibility of flooding the plant's buildings; in the third case the systems for ensuring the heat sink would be lost; and in the fourth case the diesel generators' support systems could fail. In all of these cases there were no real events and equipment failures, and the INES ratings are based on the methodology for rating a degradation of defence in depth.

In a NPP of an Asian country an event occurred involving the exposure of workers due to the release of contaminated heavy water during a refuelling outage of the NPP. Several workers participated in isolating the leaking valve of the heavy water drainage vessel and in recovering the spilled heavy water. While performing these activities, some workers's protective clothes were soaked with heavy water. This resulted in the exposure of four workers above the annual dose limit, which is the INES criterion for a level 2 event.

Five events occurred in the nuclear facilities of different countries and all of these were rated as level 2. In all of these events there was a spread of contamination to areas not envisaged by design or through barriers. In three of these events the workers were contaminated as well and the doses exceeded the annual dose limits. The other two events were rated as level 2 based on a degradation of defence in depth. The details on these events are as follows:

- In the first event, the workers were contaminated with Plutonium and Uranium Oxide dust while they were checking nuclear fuel material storage conditions.

- In the second event a worker was contaminated while collecting samples of radioactive material in a nuclear fuel reprocessing facility.
- The third event occurred during the removal of radioactive material from a glovebox sump when the worker punctured his protective gloves on a sharp edge, was cut, and contaminated his hand.
- The fourth event was the release of contaminated air from hot cells where spent nuclear fuel is inspected. Due to the incidental triggering of a fire alarm, an automatic injection of inert gas into the hot cells was performed and this consequentially pushed contaminated air into the laboratory's controlled area, where there was no staff present at the time.
- The fifth event was the finding of unexpected deposits of highly enriched uranium in containers for air drying at a fuel fabrication facility. Due to the unfavourable geometry of the containers, there was a possibility that spontaneous criticality could occur in the presence of water.

The above-mentioned event at an accelerator occurred during the cleaning and assembly of parts of the cyclotron. During work with a manipulator and a pneumatic screwdriver in a hot cell, some difficulties occurred and the worker removed ten screws by hand. The worker was exposed and received a dose above the annual dose limit. This was a level 2 event according to the INES criteria.

An event that drew international attention was one that occurred during the transport of a package containing a disused source of $^{192}$Ir. The package was shipped by air from an African country to a European country. The source was not appropriately placed into the radiological shield of the container. The consequence was that the passengers of two flights were exposed to $^{192}$Ir source radiation. Based on the estimated doses to the air passengers and other persons in contact with the package, the event was rated as level 2 as it exceeded the dose limits for members of the population.

In 2017 six events involving the theft of radioactive sources were reported. In four cases the sources were later recovered and it was confirmed that there was no exposure to persons because the source shielding was intact. In two cases the sources were not recovered. The INES rating depends on the source category, which reflects the potential hazard of the sources to the population in case the shielding were to be removed or the source dispersed. According to source categories and considering that there were no direct consequences to the population, one of these events was rated as level 2 and five events as level 1.

Two events occurred in medicine and both were rated as level 2 according to the doses received by the workers, which exceeded the annual dose limits. In first event, a radiologist's hands were exposed when he reached into the X-ray beam while performing an intervention. In the second event, a pharmaceutical technician was exposed while handling radioactive isotopes $^{99}$Mo/$^{99m}$Tc, $^{99m}$Tc and $^{68}$Ga.

Two level 2 events were reported where workers were overexposed during the performance of radiography. In both cases the source was not appropriately withdrawn into the radiographic camera. The workers performing the radiography received doses that exceeded the annual dose limit for workers, while no deterministic effects of the irradiation were observed.

**Other Internationally Interesting Events in 2017**

The IAEA website reported on ten events in 2017 that were not included in reporting through the NEWS system for INES event reporting. Among these events, four were events in NPPs, three events involved the theft or loss of a radiation source, one was an earthquake, one an atmospheric release of isotope $^{106}$Ru, and there was a building collapse in a location with a radioactive waste facility.

The event with widespread interest was the atmospheric release of isotope $^{106}Ru$, which was detected in several European countries. The event causing the release and the location of the release have not been identified yet, but it is known that the release spread from the area of Eastern Europe. The effect of the measured activities of isotope $^{106}Ru$ to the population is negligible.

Another interesting event occurred in a storage site for old radioactive material. There was a collapse of a tunnel and thus a possible release of material contaminated with Plutonium. The area was evacuated and secured and the measurements showed that there was no release of radioactive material into the environment.

Three emergencies in NPPs did not cause any danger to the population. The first emergency was caused by a fire on the roof of a plant's auxiliary building. The fire was extinguished soon enough and there was no need to shut down the reactor since nuclear safety was not endangered. The second event was a fire causing the loss of normal electric power supply during an outage. Following the startup of the emergency diesel generators, the emergency power supply was enabled and subsequently the normal power supply. The third event occurred following the automatic shutdown of a reactor due to an electrical failure in the plant switchyard. This resulted in an unexpected steam release in the plant machine hall and one of workers present there was injured with severe burns. There were no radiological consequences.

Another event in a NPP was reported where there was an explosion and fire in the machine hall. The fire was quickly extinguished. The event did not require the declaration of an emergency or the shutdown of the reactor and there were no effects on the environment or population.

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