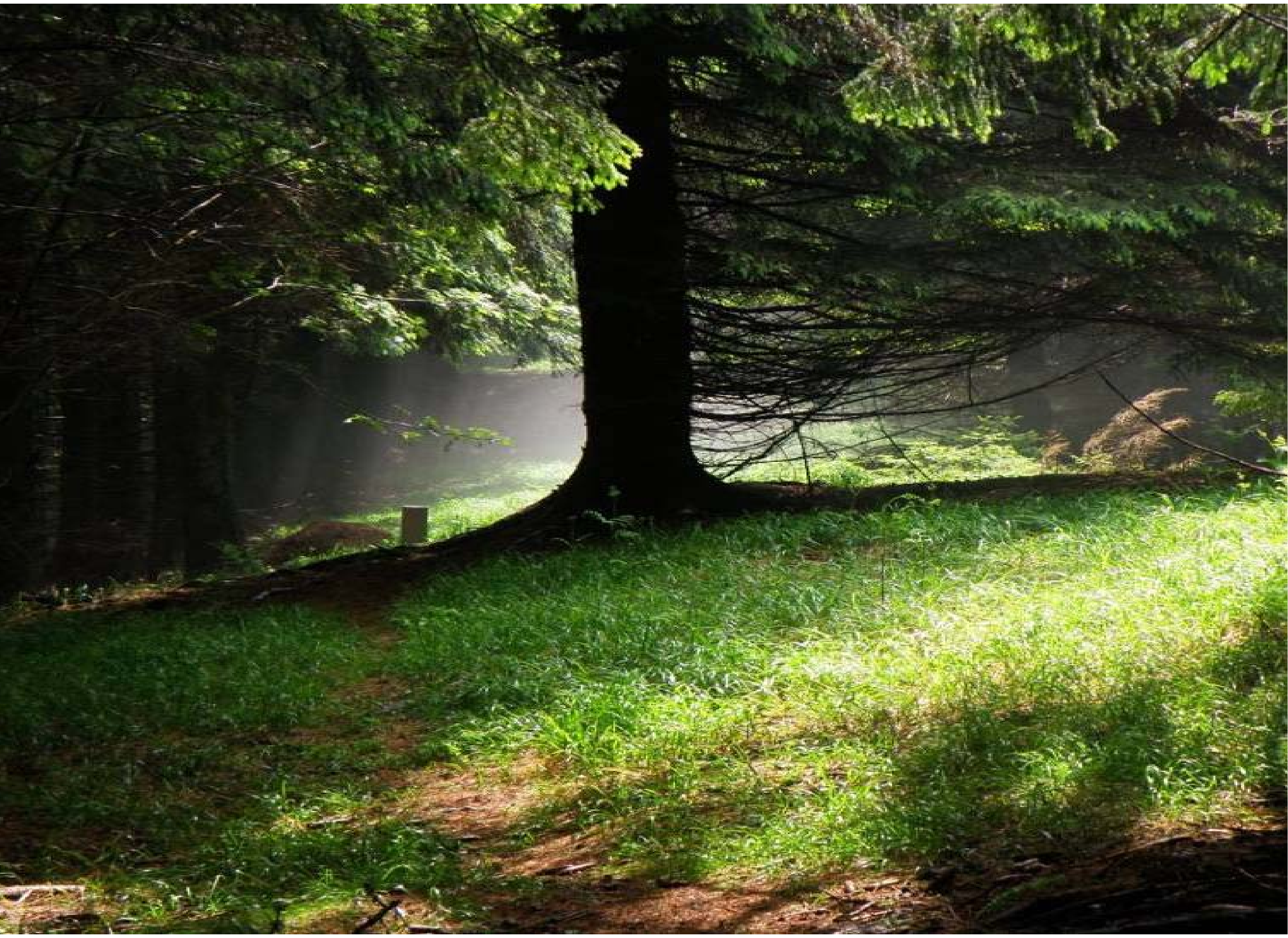
REPUBLIC OF SLOVENIA
MINISTRY OF AGRICULTURE AND THE ENVIRONMENT
**SLOVENIAN NUCLEAR SAFETY ADMINISTRATION**

# Annual Report 2011 on Radiation and Nuclear Safety in the Republic of Slovenia



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# Annual Report 2011 on Radiation and Nuclear Safety in the Republic of Slovenia

June 2012

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

Slovenian Radiation Protection Administration,
Administration of the Republic of Slovenia for Civil Protection and Disaster Relief,
Ministry of Infrastructure and Spatial Planning,
Ministry of Agriculture and the Environment,
Ministry of the Interior,
Agency for Radwaste Management,
Nuclear Pool GIZ,
Financial Fund for Decommissioning of the Nuclear Power Plant Krško,
Krško Nuclear Power Plant,
Jožef Stefan Institute and
Institute of Occupational Safety.

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# Summary

2011 has for sure been one of the most difficult years in the history of nuclear safety. Fortunately, not due to any hazards for the citizens of Slovenia or Europe, but because of the nuclear accident at the Fukushima power plant in Japan following the earthquake and tsunami. Since 11 March 2011, everyone in the field of nuclear energy around the world and in Slovenia has been intensively dealing with the consequences and especially tried to gain the experiences from the event we all must learn from. In Europe, the EU regulators conducted the so-called stress tests for NPPs. The purpose of these tests is to foresee all possible natural disasters and improve the preparedness of NPPs to deal with the worst events if they occur.

The Krško NPP operated without any major disruptions, except for the automatic shutdown which occurred due to the defects in transmission line. This was the first shutdown of the NPP after six years and it occurred just few days after the earthquake in Japan. The shutdown did not have any environmental impact.

Lessons arriving from the accident at the Fukushima power plant have given the Krško NPP an additional reason to once again thoroughly check its preparedness in cases of earthquakes, floods and other similar external events. During this time, two major projects, which began several years ago, were also finished. A third diesel generator was installed and flood embankments along the Sava River were raised. Both enhancements will significantly reduce the likelihood for the uncontrolled discharges into the environment in case of earthquakes or flooding. As a response to the lessons learned from the event in Fukushima, the Krško NPP purchased several additional portable diesel generators, compressors for compressed air, pumps and additional fire equipment. They also installed additional quick connection points, by which the mobile equipment could supply cooling water or electrical power to the power plant, if the main safety systems would not be available. The staff at the Krško NPP has also prepared a plan of extensive improvements for the upcoming years.

Because of the accident at Fukushima, this year's report is slightly longer, since a special section 2.3 was added where developments and consequences of the event are described.

There were no particularities in relation to the operation of other nuclear and radiation facilities and in organizations that carry out radiation practice. There were no excessive radiological impacts on the environment.

After a few years of preparation, the National Assembly adopted an Act amending the Ionizing Radiation Protection and Nuclear Safety Act in summer 2011. The majority of changes are the eliminations of minor inconsistencies and shortcomings that have been revealed by the application of Act. A restriction to strike was imposed on key personnel of nuclear facilities, provisions on physical protection of nuclear and radiation facilities were completed and procedures for obtaining licenses were slightly simplified.

By amending the Act, Slovenia harmonized its legislation with the EU Directive on Nuclear Safety, adopted in summer 2009. In two years, Slovenia also has to harmonize its legislation with the Directive on the Management of spent fuel and radioactive waste, adopted in Brussels in summer 2011. This should not present any major problems.

In spring 2011, Slovenia became a full member of the Nuclear Energy Agency (NEA) of the Organisation for Economic Co-operation and Development (OECD), where we have co-operated as observers for a decade.

In autumn, the Slovenian Nuclear Safety Administration hosted an international IRRS mission. For ten days, the mission reviewed our administrative infrastructure in the field of nuclear safety and compared it with international standards. IRRS mission commended our organisation and activities, but also made a series of recommendations for future improvements.

There were no complications in the field of radioactive waste management in Slovenia. Unfortunately, there was further delay with regard to the future repository for low- and intermediate-level waste. Since the end of 2009, when the site Vrbina near Krško was endorsed, the procedural matters have almost been halted. The Agency for Radwaste Management prepared an investment plan for the future repository, which has not yet been approved. In addition, pieces of lands have not been purchased and the preparatory work on the environment impact report has not started yet. There is also some delay with a preparation of a new decommissioning plan for the Krško Nuclear Power Plant (NPP) which shall be prepared jointly by both co-owners, Slovenia and Croatia. With the delay on the construction of the repository, the need in the Krško NPP has been growing because of the limited capacities of the storage there. Nevertheless, there is no immediate danger due to these facts.

In the former Žirovski Vrh uranium mine, there is also some delay with the final remediation of the mine. The remediation activities of the Boršt mill tailing were completed, but the area beneath has not been stabilised and the landslide is bigger than stipulated values in the safety analysis report allow. Due to this fact, additional remediation work or additional analyses need to be carried out. Based on latter, it will be checked whether even the worst case scenario of events would not cause any consequences outside acceptable levels taking into account safety and exposure of the local population to ionising radiation. Also in this case, there is no immediate danger to the local population.

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# 1 INTRODUCTION

This report is prepared annually in accordance with the provisions of the Ionizing Radiation Protection and Nuclear Safety Act. It has been issued since 1985 and summarizes all events in connection with ionizing radiation protection and nuclear safety for the previous year. The report is accepted by the Slovenian Government and is thereafter send to the National Assembly of Republic of Slovenia. It also represents the main way of communicating recent developments in the area of ionizing radiation protection and nuclear safety to the general public. This English version is the essential publication for the presentation of these activities in Slovenia to the international public.

In creating the report, the Slovenian Nuclear Safety Administration (SNSA) has the role of moderator, while content is provided also by other state bodies whose competences include ionizing radiation protection and nuclear safety, as well as other institutions in this area. Of these, the principal are the Slovenian Radiation Protection Administration (SRPA), the Administration of the Republic of Slovenia for Civil Protection and Disaster Relief (ACPRD), the Ministry of Infrastructure and Spatial Planning, the Ministry of the Interior, the Ministry of Agriculture and the Environment, the Agency for Radwaste Management (ARAO), the Nuclear Insurance and Reinsurance Pool, the Krško Nuclear Power Plant (Krško NPP), the Jožef Stefan Institute (JSI), the Institute of Occupational Safety (IOS), and the Fund for Financing Decommissioning of the Krško Nuclear Power Plant and Disposal of Radioactive Waste from the Krško NPP.

Together with this report, which is aimed at a wider interested public, an extended version in Slovene has been prepared. The extended report includes all details and data which might be of interest to the narrower group of professionals. It is available on the SNSA web page at http://www.ursjv.gov.si.

# 2 OPERATIONAL SAFETY

## 2.1 Operation of Nuclear and Radiation Facilities

### 2.1.1 Krško Nuclear Power Plant

#### 2.1.1.1 Operation and Performance Indicators

In 2011, the Krško Nuclear Power Plant (Krško NPP) operated without incidents, which might pose a threat to the environment. This year, there was no outage, since the previous one was in autumn 2010 and the next one is planned for spring 2012. The reactor automatically tripped for the first time in 6 years due to an error in the switchyard. The event is described in more detail in Chapter 2.1.1.3.

In 2011, the Krško NPP, as well as the rest of the world's nuclear industry, was marked by a nuclear accident in the Fukushima NPP in Japan on 11 March. The details about the post-Fukushima activities in the Krško NPP are described in the special Chapter 2.3 of this report.

In 2011, the Krško NPP produced 6,214,748.0 MWh (6.2 TWh) gross electrical energy on the output of the generator, which corresponds to 5,902,238.8 MWh net electrical energy delivered to the grid.

In 2011, the SNSA inspection performed 46 inspections of the Krško NPP. 44 of these were planed while others were unplanned. One inspection was not announced.

The inspection of state and tests of safety related equipment did not identify major deficiencies or failures. Problems related to the equipment were analysed and solved by the Krško NPP using its corrective program in a due time.

In 2011, the inspection did not identified substantial violations of laws and regulations. Altogether, the inspection issued 54 requirements related to corrective measures. The Krško NPP progressively harmonised its activities with two regulations which were put in place in 2009.

Inspections of the Krško NPP confirm that the plant is operating safely and without harmful effect for the people or the environment. The inspection assessed the activity of individual organisational units of the plant and came to the overall conclusion that the activities are good. The inspection found that the majority of experts have a high level of safety culture. This is reflected in the quality of performed activities where safety is a first priority and in identifying possible issues based on the analysis of plant operational experiences and operational experiences of other operators. The mentioned level can also be seen from the activities related to corrective actions.

In the field of radiation protection of exposed workers, the Krško NPP is also supervised by the Slovenian Radiation Protection Administration (SRPA). Since there was no outage in 2011, the SRPA did not perform any inspection in this regard. In the field of radiation protection, the SRPA approved 3 evaluations of the protection of exposed workers against radiation for external operators that are carrying out practices involving radiation.

The most important performance indicators of the Krško NPP are shown in Tables 1 and 2, while their changes through the years are described in the following parts of this report. The performance indicators confirm stable and safe operation of the power plant.

**Table 1:** The most important performance indicators in 2011

| Safety and performance indicators | Year 2011 | Average (1983-2011) |
|---|---|---|
| **Availability [ %]** | 98.18 | 86.42 |
| **Capacity factor [%]** | 97.93 | 84.1 |
| **Forced outage factor [%]** | 1.83 | 1.09 |
| **Gross realized production [GWh]** | 6,214.75 | 5,033.01 |
| **Fast shutdowns – automatic [Number of shutdowns]** | 1 | 2.52 |
| **Fast shutdowns – manual [Number of shutdowns]** | 0 | 0.14 |
| **Unplanned normal shutdowns [Number of shutdowns]** | 0 | 0.83 |
| **Planned normal shutdowns [Number of shutdowns]** | 0 | 0.79 |
| **Event reports [Number of reports]** | 1 | 4.38 |
| **Refuelling outage duration [Days]** | 0 | 44.0 |
| **Fuel reliability indicator (FRI) [GBq/m$^3$]** | $2.29 \cdot 10^{-4}$ | $7.03 \cdot 10^{-2}$ |

**Table 2:** Time analysis of Krško NPP operation in 2011

| Time analysis of production | Hours | Percentage [%] |
|---|---|---|
| **Number of hours in a year** | 8760 | 100 |
| **Duration of plant operation (on grid)** | 8600,45 | 98,18 |
| **Duration of shutdowns** | 159,55 | 1,82 |
| **Duration of the refuelling outage** | 0 | 0 |
| **Duration of planned shutdowns** | 0 | 0 |
| **Duration of unplanned shutdowns** | 159,55 | 1,82 |

The operation of the Krško NPP in 2011 is shown in Figure 1. It can be seen that the operation of the power plant was stable, except for one disturbance caused by the fault in the electric grid, which led to an automatic shutdown of the plant. The plant operated at reduced power in January due to repair works on heater drain valve on the secondary side and in summer months due to low Sava river flow.

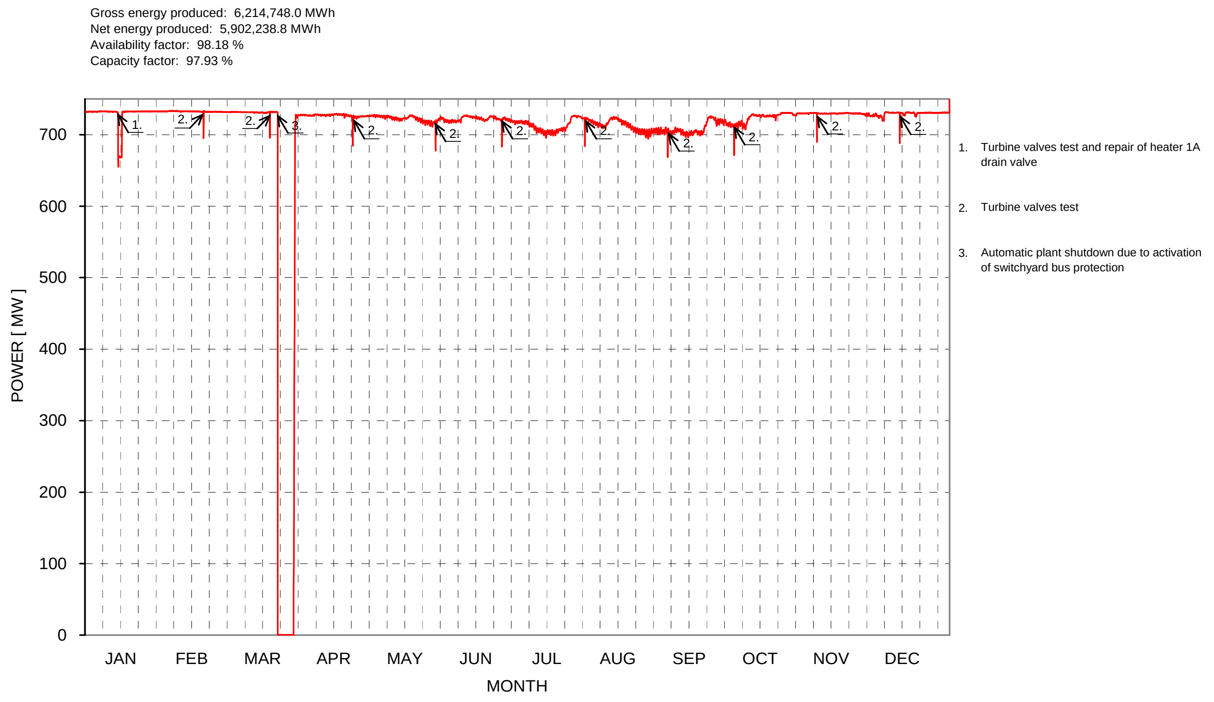


**Figure 1:** Operating power diagram for the Krško NPP in 2011

In Figure 2 and 3, the number of reactor shutdowns is shown.

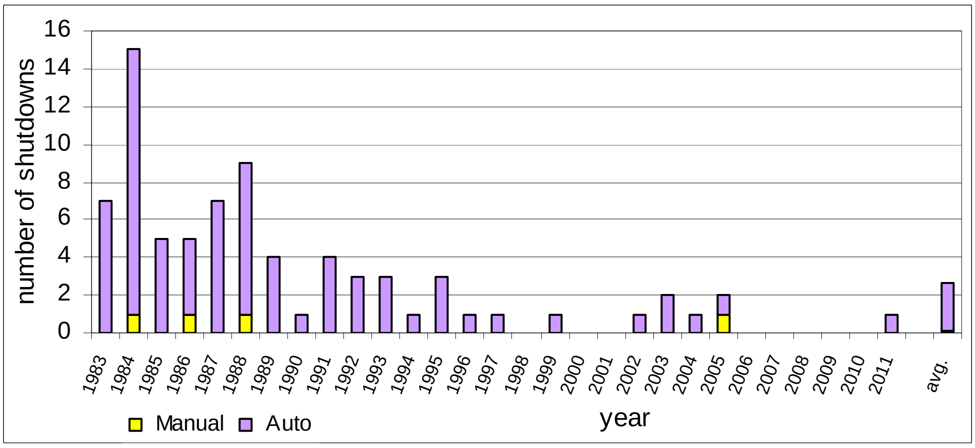


**Figure 2:** Fast reactor shutdowns – manual and automatic

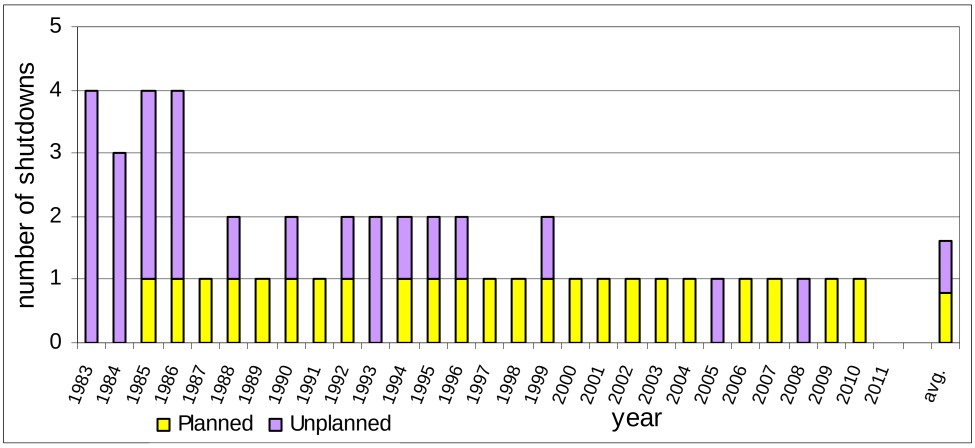


**Figure 3:** Normal reactor shutdowns – planned and unplanned

There are two types of reactor shutdowns, fast and normal. Fast reactor shutdowns are caused by the reactor protection system actuation, which can be activated manually or automatically. During normal reactor shutdowns, the reactor power reduces gradually. Normal shutdowns are divided into planned and unplanned. Outage is a special type of a normal, planned gradual shutdown of a reactor.

Figures show that the number of fast reactor shutdowns is slowly reducing through the years. In 2011, the plant had a first automatic shutdown after 6 years.

Figure 4 shows the number of unplanned actuations of high pressure injection system, which actuates automatically on the low pressure in the primary or secondary cooling system, on high pressure in the containment, or manually. In 2011, the high pressure injection system was actuated by an error in the switchyard near the plant. The event is described in the Chapter 2.1.1.3. The total number of actuations since the start of commercial operation is 11.

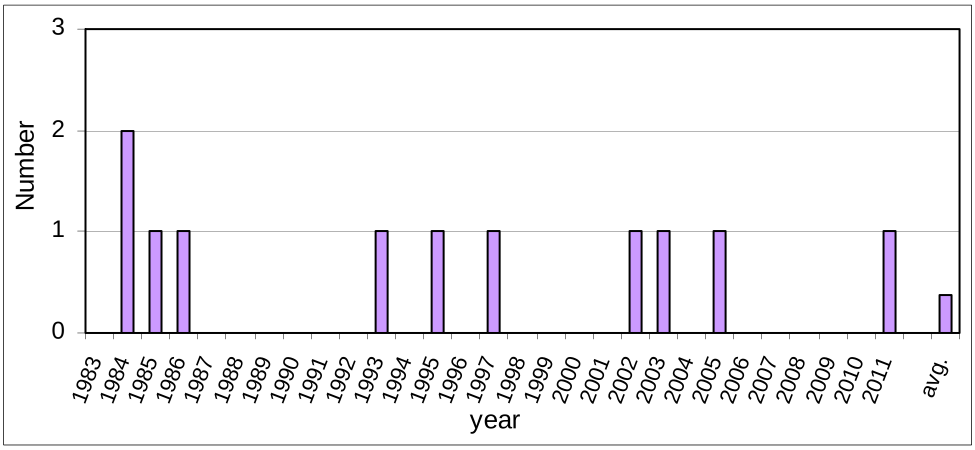


**Figure 4:** Number of unplanned safety injection system actuations

In Figure 5, the forced outage factor is shown. The factor is a ratio between the hours of duration of unplanned shutdowns and the number of hours in a year. In 2011, the plant was shutdown unplannedly for 159.55 h, thus the value of this factor is 1.82%.

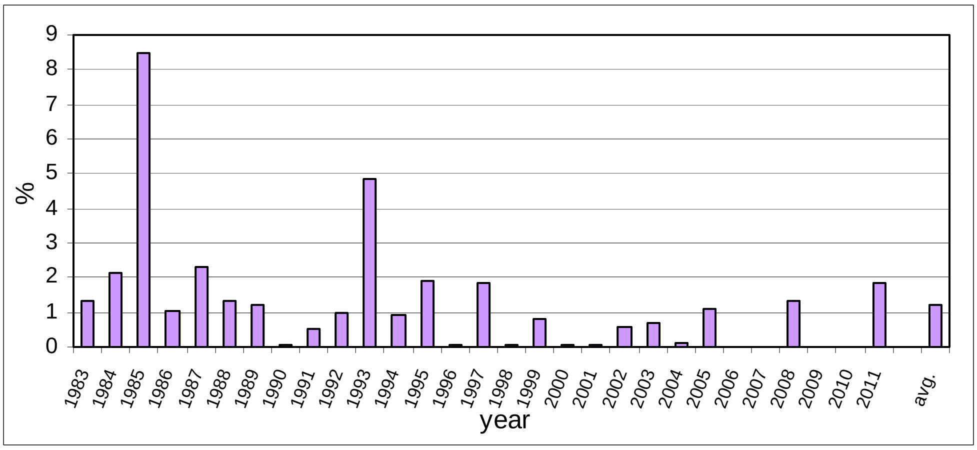


**Figure 5**: Forced outage factor

Figure 6 presents data on the different means of electrical energy production in Slovenia, specifically the production in nuclear, hydro and thermal power plants. In 2011, the production of electrical energy exceeded 14 TWh for the fourth consecutive year, mostly due to the absence of the annual outage in the Krško NPP. The Krško NPP produced 5.9 TWh of electrical energy, which is the second highest value in the history of its operation.

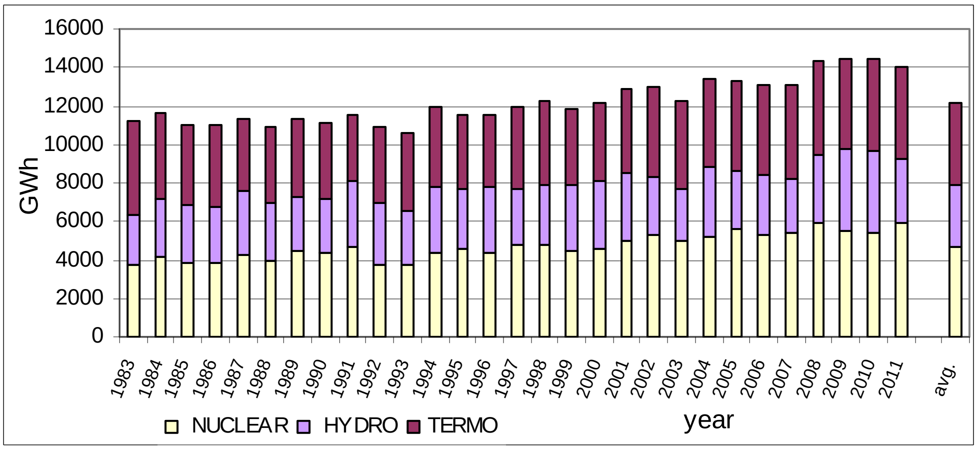


**Figure 6**: Production of electrical energy in Slovenia

The collective exposure to radiation is shown in the Figure 7. The low value of this factor indicates the high efficiency of the radiation exposure control. Its value in 2011 was record-low (68 man mSv) mostly due to the absence of outage activities, which contribute most to the value of this indicator.

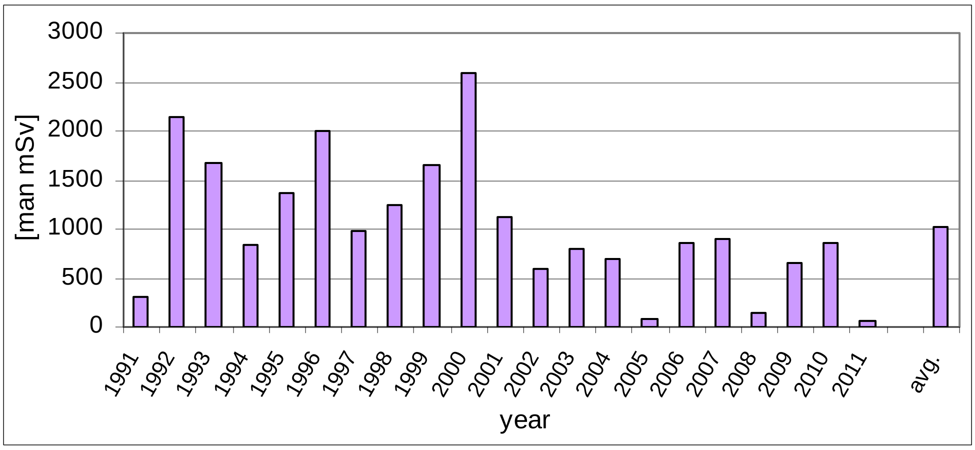


**Figure 7:** Collective exposure to radiation in the Krško NPP

The purpose of the inoperability factors given in Figures 8, 9 and 10 is to present the preparedness of important safety systems to assure their functions in the time of normal operation, as well as in the case of an accident.

In Figure 8, the inoperability factor of the safety injection system is shown. In 2011, the value of this factor was 0.0020, which is less than the Krško NPP's goal value (0.005). The inoperability of this system in 2011 was caused by the planned on-line maintenance.

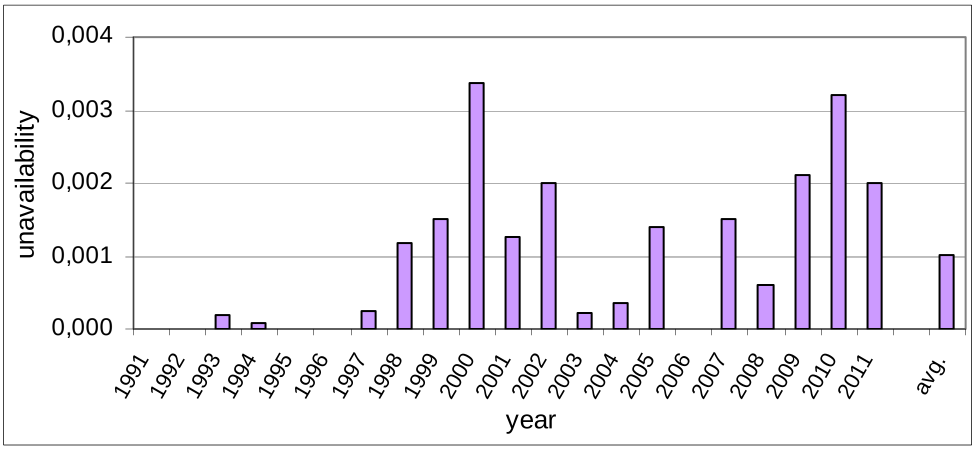


**Figure 8:** Inoperability of safety injection system

The inoperability factor of the emergency power supply (the emergency diesel generators) is shown in Figure 9. This system is important if there is a loss of normal offsite and onsite power supplies. The operability of diesel generators, which has been stable for several years, was also high in 2011. The value of this factor in 2011 is 0.00001, which is less than the Krško NPP's goal value (0.005).

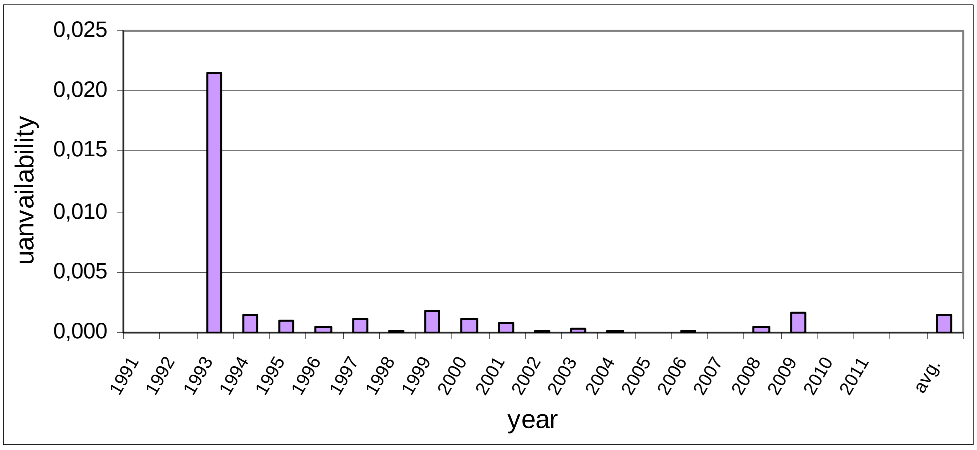


**Figure 9:** The inoperability of the emergency power supply

In Figure 10, the inoperability factor for the auxiliary feedwater system is shown. This system is used to supply water to steam generators when the main feedwater system is unavailable. In 2011, the value of this indicator was 0.0012, which is below the goal value of the Krško NPP (0.005). All unavailability of this system in 2011 was caused by the planned on-line maintenance.

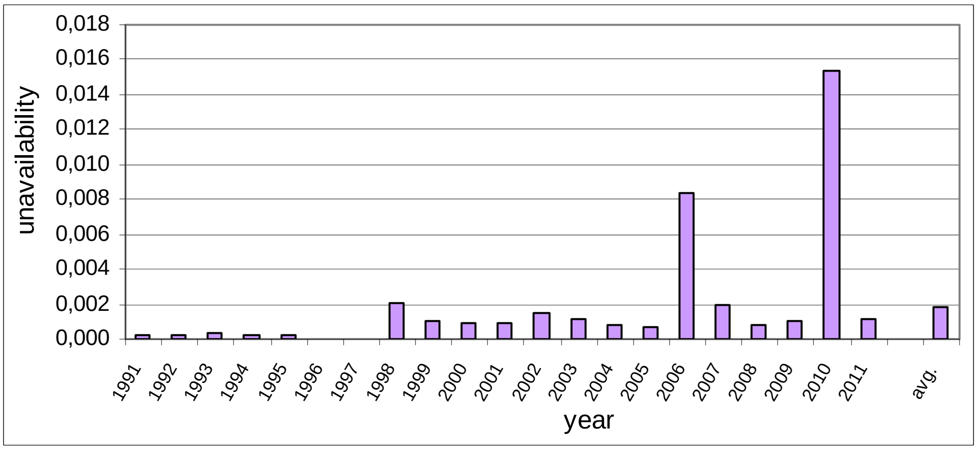


**Figure 10:** The inoperability of the auxiliary feedwater system

### 2.1.1.2 Regulatory Oversight through Safety and Performance Indicators

At the end of 2007, the SNSA introduced its own set of safety and performance indicators (hereinafter SPI) for the surveillance of Krško NPP operations. In 2011, the set of SPI numbered 38. These include the changes of the SNSA thresholds for warnings and alarms. The Krško NPP has enough time to implement corrective measures before the SNSA warning or alarm limits for the parameters are reached and consecutively increased regulatory inspection is enforced.

The SNSA sends monthly reports to the Krško NPP about indicators status and if necessary conducts thematic inspection.

### 2.1.1.3 Abnormal Events in the Krško NPP

Event reporting is defined by the Rules on Operational Safety of Radiation or Nuclear Facilities, which in Appendix Six lists events which have to be specially reported by the operator of nuclear power plants. In 2011, the Krško NPP, in accordance with the above Rules, reported one event, which did not jeopardize nuclear and radiation safety or required stopping the plant.

The event was looked at by the SNSA. The Krško NPP, ELES and the SNSA prepared detailed analyses and corrective measures.

**Reactor trip and safety injection actuation system at the loss of external power**

On 23 March 2011, at 10:30, there was an automatic shutdown of the Krško NPP due to the unexpected disconnection of high voltage 400 kV power line to Zagreb. The disconnection occurred due to a spurious activation of bus protection in the NPP's 400 kV switchyard. This was followed by the disconnection of circuit breaker in the transformer bay and the loss of generator load. To protect the turbine, the turbine over-speed protection started to rapidly close down the turbine valves, after which steam dump valves opened and the pressure in main steam line rapidly decreased. At 10:29, a safety injection signal on low steam line pressure was triggered which lead to an automatic shutdown of the reactor and turbine. With the generator load switch automatically disconnected, there was a loss of power supply to safety and non-safety buses. The diesel generators, which turn on automatically with the "safety injection" (SI) signal, connected to the safety buses and SI loading sequence was launched. At 10:55, an "abnormal event" was declared according to the criterion E/1 (Loss of power 6.3 kV bus). At that time, the power supply to safety buses has been established through the auxiliary transformer and diesel transformers were trip. At 12:15, the plant transited to a "hot standby" mode and the termination of "abnormal event" was declared.

After losing power, the non-safety equipment remained without AC power supply and as a consequence the auxiliary pump in the seal oil system of the main generator launched on DC power. Due to the deviations in the operation of this pump, a fluctuation of pressure and insufficient stable flow on seal oil occurred. Since that caused the hydrogen leak through the seals, the staff released the hydrogen from the generator. When the system was disassembled, scraps were found.

The amount of water in the lub oil increased over specified values. 2 $m^3$ of water was found in the lubricating oil system of the turbine. The extractor was replaced and the oil was dried. Since the oil specifications were adequate for the start up, the oil was not replaced.

The generator's seal oil system supplied oil from the turbine's system of the lubricating oil. Since that oil contained too much water, the generator's seal oil system became stained. At normal operating conditions, the systems are separated, although they both use the same oil.

After the shutdown, the following problems occurred:

- difficulties in the opening of the main feedwater's isolation valve,
- ground fault on the emergency diesel generator No. 2 (despite that contact, the diesel generator remained operable),
- difficulties in the movement of valves in the drainage system,
- level loss of the lub oil on the engine of the reactor pump No. 2. This engine was replaced during the last outage. 7 liters of about 200 l oil was lacking. After the review of the reactor pump, it was discovered that the leakage was on the seal of the cover sump and not at the labyrinth seal. Seal was replaced and the review conformed that the oil does not leak anymore.

The event has been examined in details by the NPP and ELES. They prepared an analysis of the event and a corrective action programme. The power operation of the NPP begun after 162 hours and was at full strength on 30 March at midnight.

#### 2.1.1.4 Periodic Safety Review (PSR)

PSR is an intense systematic review of all operational and safety aspects of the NPP and must take place once every ten years.

**First Periodic Safety Review (PSR1) actions from 2003**

The Krško PSR 1 was carried out in 2001 to 2003. Its result was an action plan which contained 122 individual tasks. By the end of 2011, 96 of them were fully completed. Most of the remaining tasks, deadlines for which were extended, will be completed during the outage and refuelling in 2012.

The remaining tasks are:

- installation of a third diesel generator,
- second level of under voltage for degraded voltage,
- pressure locking and thermal binding of safety related power-operated gate valves,
- 17 actions from the set of Environmental Qualifications (EQ).

Areas of groups of tasks or individual tasks that must be completed by the NPP by the end of 2015 are:

- Reactor operating modes,
- PSA at shutdown.

**Second Periodic Safety Review (PSR 2)**

In the first half of 2010, the SNSA approved the program of PSR2. In 2011, the NPP carried out the review of two individual safety factors under the PSR 2 program. In the middle of 2011, the NPP conducted a review of compliance with the requirements of new legislation (RCP - Regulatory conformance program), which includes changes in PSR1 campaigns and new legislation from the U.S, where the NPP was supplied, from 2002 until the end of 2010. Final report PSR 2 together with the action plan of improvements will be delivered in the first half of 2013.

#### 2.1.1.5 Long-term operation in the Krško NPP

Currently, the planned project life-cycle of the Krško NPP is 40 years, i.e. to year 2023. State of the facility and global practice encouraged owners to think about extending the service life for 20 years. The Krško NPP should change limits in their design bases to secure operation after 2023. In 2009, the Krško NPP suggested changes to allow the extension of the plant operation. Implementing the ageing management programme for systems and components is one of the prerequisites for the long-term operation of the plant. Comprehensive documentation was enclosed to the application, along with the detailed explanation of the Krško NPP's approach to ageing management and analyses.

In 2011, the SNSA has reviewed and assessed the documentation and the situation in the power plant. A positive expert opinion of the international group of experts, who reviewed the documentation in 2009 and 2010, has been of great help.

The Krško NPP manages very well aging of systems, structures and components. It has created a system that ensures long-term safe operation. In addition, it plans its investment in a way to ensure not only the current successful operation and meeting regulatory requirements, but also long-term technological suitability (e.g. the change of reactor head) and improved nuclear safety (e.g. preparations for the third diesel generator and improvements in preparedness for incident).

Before approving the changes of the safety report and supporting documentation, the Krško NPP should implement a few minor changes during an outage in 2012, which will be reviewed by the SNSA. At the end of 2011, the Krško NPP delivered to the SNSA a comprehensive set of the revised documentation to be reviewed. According to its findings, the SNSA will then consider whether to approve the programme.

#### 2.1.1.6 Nuclear Fuel Integrity, Reactor Coolant Activities and Fuel Elements Inspections

The year 2011 comprised part of fuel cycle 25 which started on 31 October 2010 and will last 18 months until the refuelling outage in April 2012.

The condition of 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 transients. Fuel damage is indicated by isotopes of xenon, krypton and iodine. The size of the fuel damage and contamination of the coolant can be determined from measuring iodine isotopes activities. From the caesium isotopes activities can be estimated the burnup of the damaged fuel. The data of the primary coolant activities in the year 2011 are shown in Table 3.

Based on the specific activities of isotope $^{133}Xe$ from 28 September 2011 on, it was estimated that there is one leaking fuel rod in the core of the fuel cycle 25 at the end of the year 2011. Relatively small values of the specific activities of the iodine and krypton isotopes in the coolant showed that this was a small tight leaking fuel rod. This was also confirmed from the $^{133}Xe$ over $^{131}I$ ratio of specific activities. Even with the leaking fuel, the specific coolant activities of the fuel cycle 25 reached less than 1 percent of the limit from the plant operational limits and conditions.

**Table 3:** Average primary coolant activities in 2011 for the fuel cycle 25

| **Isotope** | **Average specific activity [GBq/m³]** | |
|---|---|---|
| | **Cycle 25 (1 January –31 December 2011)** | |
| | **Stable conditions** | **All Measurements** |
| **$^{131}I$** | 0.00076 | $^{131}I$ |
| **$^{133}I$** | 0.010 | $^{133}I$ |
| **$^{134}I$** | 0.051 | $^{134}I$ |
| **$^{133}Xe$** | 0.10 | $^{133}Xe$ |
| **$^{135}Xe$** | 0.033 | $^{135}Xe$ |
| **$^{138}Xe$** | 0.036 | $^{138}Xe$ |
| **$^{85m}Kr$** | 0.0034 | $^{85m}Kr$ |
| **$^{87}Kr$** | 0.0085 | $^{87}Kr$ |
| **$^{88}Kr$** | 0.0086 | $^{88}Kr$ |
| **Fuel cycle length [EFPD]** | 411 (end of the year)<br>(of which 357 only in the year 2011) | |
| **Core burnup [MWD/MTU]** | 16,695 (end of the year) | |
| **Maximum burnup and mark of the fuel assembly [MWD/MTU]** | 47,449 (AC01 in the position K-03) | |

Fuel Reliability Indicator (FRI) shows fuel damage and is used for comparison with nuclear power plants around the world. FRI values are determined from the specific activities of $^{131}I$ corrected with the contribution of the $^{134}I$ from tramp uranium in the reactor coolant system and normalized to a constant value of the reactor coolant purification rate. A FRI value equal or below $2\cdot10^{-2}$ GBq/m³ represents fuel with no damage according to an internationally adopted criterion. Figure 11 shows the FRI values for individual fuel cycles. The FRI values have risen in October and November 2011, but still remained small. At the end of 2011, the FRI reached 4.4 percent of the criterion of the international society INPO for the fuel with no damage.

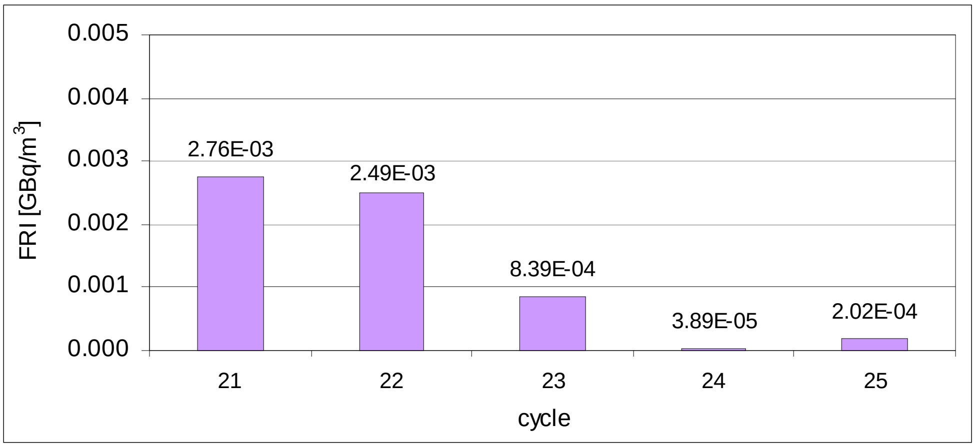


**Figure 11:** Fuel Reliability Indicator (FRI) values for last five fuel cycles

### 2.1.1.7 Modifications in the Krško NPP

According to the Ionizing Radiation Protection and Nuclear Safety Act (paragraph 83), the SNSA approved 5 modifications and agreed to 19 modifications. During the preliminary safety evaluation, the Krško NPP found out that there was no open safety issue for 7 modifications, so the NPP only informed the SNSA about the changes. By the end of 2011, there were 23 temporary modifications. Altogether, there were 34 temporary modifications in 2011 including 12 approved in 2010 or earlier.

In 2011, the Krško NPP issued the 18$^{th}$ revision of the Updated Safety Analysis Report, considering all modifications confirmed until 1 November 2011.

### 2.1.1.8 External influences on the operational safety of the Krško NPP

#### Hydro Power Plants on the river Sava

In 2011, the project for the Brežice HPP had to be adapted because of its influence on the nuclear safety and operation of the Krško NPP. The construction permits were issued and the implementation of the projects for the reconstruction of the road from Krško to Brežice on the flood protection dyke of the Krško NPP and for the upgrade of the dykes along the river Sava and creek Potočnica began. Preparation of the national spatial plan for the connecting road from Krško to Brežice and of the construction project for a bridge across the Sava river in Krško continued. Other important external influence to the Krško NPP in 2011 was the construction of the Krško HPP. The spatial plan and the basis studies were prepared for the Brežice HPP and Mokrice HPP. The HPP chain can influence the flooding hazard of the Krško NPP because of the faster transfer of the flood waves, decreased flooding areas along the Sava river waterbed upstream of the Krško NPP, dam rupture waves, operational waves which can occur due to the sudden opening of dam gates and sediments that can harm the safety relevant cooling systems of the Krško NPP. Most important will be the effect of the Brežice HPP, since a higher river level at the Krško NPP will require extensive modifications of the Krško NPP systems. Preparation of the Mokrice HPP was also in course. The SNSA followed the preparation of three HPPs on the middle Sava river which could influence the flooding hazard analyses of the Krško

NPP and the quality of the Sava water that is used for the Krško NPP operation as well as cooling of the safety systems.

#### The Project of Dykes Upgrade for the Protection against the Probable Maximum Flood

The upgrade of the dykes along the Sava river and the Potočnica creek is one of important actions that results from the first periodic safety review. After several years of preparation, the SNSA issued consents to the construction projects in June and July 2010. The expert opinion of the Institute for water of the Republic of Slovenia in 2011 confirmed the flow and level of the Probable Maximum Flood (PMF) which is the project parameter used to determine the project of the Krško NPP flood protection dykes upgrade. By using hybrid hydraulic models, the adequacy of the dykes' elevation was checked to assure the protection against the PMF with a sufficient safety margin. The influence of the planned Brežice HPP on the PMF flow and Sava river level was also checked. It was confirmed that such flood protection dykes will ensure the flood safety of the Krško NPP.

Construction permits for the projects have been issued in June and August 2011. The upgrade of dykes started in the autumn of 2011 and will continue in the year 2012.

### 2.1.2 TRIGA Mark II Research Reactor in Brinje

#### Operation

In 2011, the TRIGA research reactor of the Jožef Stefan Institute operated for 127 days and released 125 MWh of heat. The reactor operated only in stationary mode. The TRIGA reactor was mostly used as a neutron source for neutron activation analysis and for educational purposes. A total of 737 samples were irradiated in the carrousel or the channels (676) and in the pneumatic post (61).

In 2011, there were eleven forced shutdowns of the reactor, four of which occurred during practical exercises for trainees, two were caused by an error of the operator during the reactor startup, one was caused by too fast retrieval of the sample from the irradiation channel and four, which happened at reactor startup, were caused by a malfunction of the reactor period measurement instrumentation. Forced shutdowns during practical exercises were anticipated, since they are a part of educational process. The cause of all these cases was errors at switchover of the nuclear instrumentation linear channel meter. During shutdowns, the rated power reactor was not exceeded. The shutdowns due to malfunction of the reactor period meter were caused by a weak contact on the connector of the measuring module for measurement of the reactor period. This malfunction has been repaired and the cause for the forced shutdowns was eliminated.

There were no violations of the operational limits and conditions from the Safety Analysis Report in 2011. There were no events that would require reporting to the SNSA in 2011.

Operational indicators for acquired doses of the operating staff and experimenters show values far below the regulatory limits. Collective dose was 14 man μSv for operating staff and 87 man μSv for personnel connected to the works at the reactor (operating staff, Radiation protection unit, experimenters).

In 2011, the SRPA approved the modification of evaluation of the protection of exposed workers against radiation that is a part of the safety analysis report of the Reactor Infrastructure Centre.

### Nuclear Fuel

In 2011, a total of 84 fuel elements were located on the reactor site. There were no spent fuel elements. All fuel elements were of the standard type with 12 percent of uranium content and 20 percent enrichment. The radiation monitoring system in the reactor building and the reactor coolant activity measurements showed that there were no damaged fuel elements. The institute reported monthly on the fuel balance to the EURATOM and the SNSA.

### Analysis of the emergency on 17 October 2010

The annual report 2010 reported on the event on 17 October 2010, when a small fire broke out in a special dryer located in the hot cell facility with the local contamination of the rooms. In 2011, the SNSA made an analysis of the causes for the event and determined 30 corrective actions for 2011 and 2012 to improve the safety of the reactor and the hot cell. In 2011, the institute implemented the corrective actions from its root course analysis to prevent the event from reoccurring. The institute completed the refurbishment of the laboratories, equipment and ventilation damaged in the fire.

### Modifications, inspections of the systems, structures and components of the nuclear facility, fire and physical safety

In 2011, the institute prepared an application for the approval of the periodic safety review programme, which the SNSA approved on 4 November 2011. The periodic safety review comprises 14 safety factors and will be completed by the year 2014.

In 2011, there were no changes to the safety analysis report of the TRIGA reactor. There were no non-routine or first time executed checks. Two reactor core modifications were performed for the experimental purposes of the institute's nuclear physics department.

Institute personnel and authorized external organizations perform periodic inspections and control of safety relevant structures, systems and components (SSC). The inspection did not recognize any improper SSC. In the course of the periodic safety review, inspection of the reactor vessel was performed.

Based on the suggested improvements and refurbishments, the first phase of renovation and upgrade of all ventilation systems in the hot cell facility was completed in 2011 as well as the replacement of the roof. In 2012 the second phase of renovation and upgrade of all ventilation systems of the hot cell facility will be completed.

In the course of the IRRS mission to the SNSA (see Chapter 9.2) in October 2011, an inspection of the TRIGA reactor was also performed. The IAEA and the EURATOM inspectors also visited the reactor.

## 2.1.3 The Central Storage for Radioactive Waste at Brinje

Central Storage for Radioactive Waste at Brinje (CSRW) is operated by the Agency for Radwaste Management (ARAO).

In 2011, special attention was given to continuous improvements and the implementation of new project solutions, taking into consideration responsible care from the viewpoint of the environmental planning and management. In relation with the planned modernisation of the mode of storaging in CSRW in Brinje, draft documentation for the approval of modifications for storage has been prepared. This new mode of storaging on self-bearing pallet frames from corrosive-resistant material will additionally improve the stability of the stored packages, fire protection, the safety of workers the management of radioactive waste as well as working conditions in the storage facility. Project documentation has also been prepared as well as an assessment of the intended activities from the following spheres: nuclear and radiation safety, environmental aspect, safety and health at work, fire protection and management system.

The comprehensive procedure of supervision and tests of operability of built-in system, aimed at active fire protection which needs to be carried out once every five years was implemented. It was determined that the system, including detectors, optical and acoustic signalisation, regulation function and transmission of signals, works in a perfect manner. The grid of hydrants is also in line with all legislative requirements and technical norms in the area of fire extinguishing (Figure 12).

**Figure 12:** A function test of smoke detectors in CSRW

In 2011, the ARAO accepted 100 packages of radioactive waste from 68 generators into the CSRW. There were 15 packages of solid wastes, 16 packages containing sealed sources, and 63 packages containing spent ionization smoke detectors (Figure 13). The total volume of the waste was 2.6 m$^3$. At the end of 2011, there were 729 packaging units, namely:

- 414 packages of radioactive waste (solid waste, classified based on its compressibility, inflammability, form and size),
- 130 packages with sealed sources,
- 179 packages with ionization smoke detectors,
- 6 packages with mixed waste (deriving from medicine).

At the end of 2011, the total activity of the 89.6 m$^3$ waste stored is estimated at 3 TBq, with total mass of 49,7 tons.

In 2011, the activities and arrangements with regard to the conditions and costs of the common use of a hot cell facility which is run by the Jožef Stefan Institute have continued. The ARAO will use the hot cell facility for the preparation and processing of radioactive waste in accordance with the acceptance criteria for central storage facility. In 2011, regular supervisions, measurements, tests and obligations which are determined in the programme of operation of CSRW were performed.

In 2011, the Slovenian Radiation Protection Administration confirmed the evaluation of the protection of exposed workers against radiation for carrying out the economic public service of radioactive waste management of small producers.

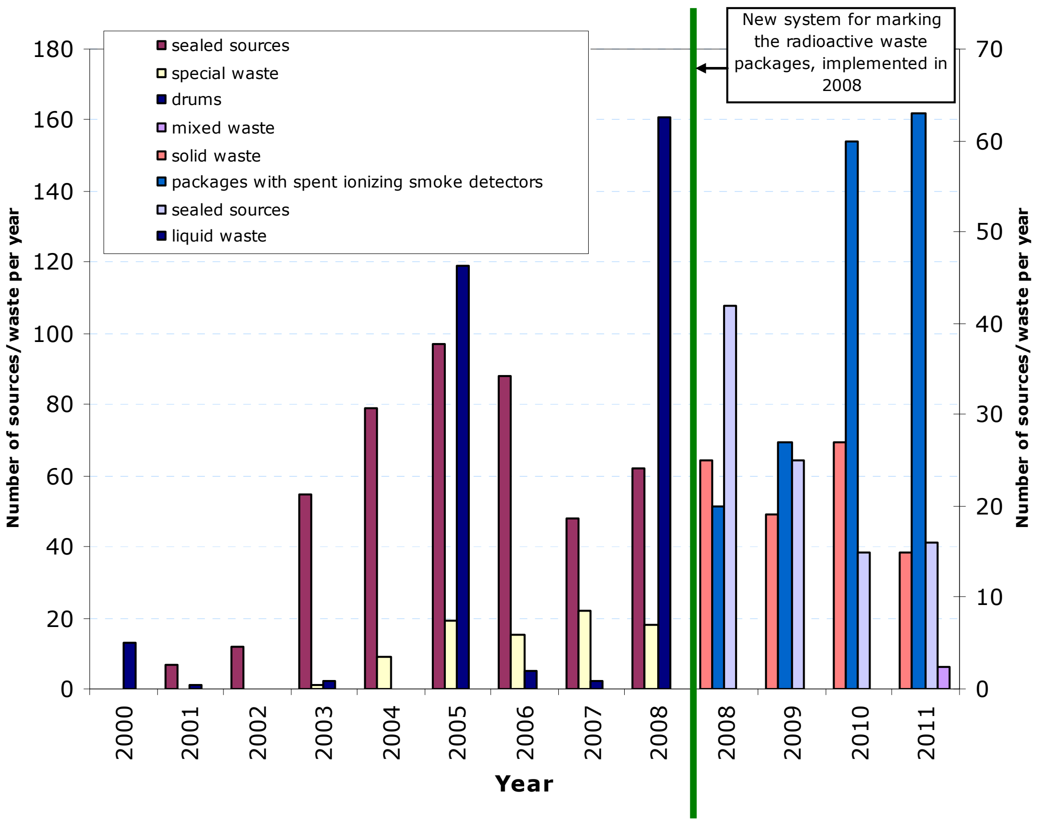


**Figure 13:** Types and quantities of radioactive waste annually accepted in the CSRW

Notes:
In 2001, 1 drum was accepted as a result of repacking of radium sources.
In 2003, 2 drums were accepted as a result of repacking of cobalt sources.
In 2005, 95 drums were accepted as a result of the Phare project "Characterization of Institutional Low and Intermediate Level Radioactive Waste in the Central Storage Facility for Waste from Small Producers in Slovenia at Brinje"; 24 drums were accepted from other users.
In 2008, 154 drums were accepted as a result of the project "Improvement of the Management of Institutional Radioactive Waste in Slovenia" and 7 drums were accepted from other users.
In 2008, the new system for marking the radioactive waste packages was implemented. For easier comparison of the distribution of the accepted waste packages, the figure presents the distribution of the waste packages accepted in 2008 as shown by both old and new marking systems.

### 2.1.4 The Former Žirovski Vrh Uranium Mine

In the area around Žirovski vrh, the excavation of uranium ore started in 1982 and uranium concentrate was processed from it. Mill tailings were disposed off on the Jazbec mine waste pile and hydrometallurgical tailings were disposed off on the Boršt site. In 1990, after the exploitation of uranium ore was temporarily stopped and subsequent decision on permanent cessation was made, the process of the remediation of mining and its consequences has started. More information on remediation activities due to former mining activities at the Žirovski vrh can be found in Chapter 5.5.

## 2.2 Radiation Practices and the Use of Sources

Ionizing Radiation Protection and Nuclear Safety Act stipulates advanced notification of intention to carry out radiation practice or intended use of a radiation source, the evaluation of radiation exposure of workers, a mandatory licence to carry out a radiation practice and a licence for the use of a radiation source. The competent authority for licensing in an area of industry and research is the SNSA, while the competent authority in the area of medicine and veterinary medicine is the Slovenian Radiation Protection Administration (SRPA).

In 2011, the above-mentioned act was amended, defining inter alia the transport of radioactive materials as a radiation practice. Thus, transport of radioactive materials is allowed only if the licence to carry out the new radiation practice has been obtained beforehand. This is very similar to the arrangement for the transport of nuclear material.

One of the licensing documents is an evaluation of the protection of exposed workers against radiation, which has to be approved by the SRPA. In the document, the nature and extent of radiation risk for exposed workers, apprentices and students are assessed in advance. In addition, based on this assessment, a programme for the optimization of radiation protection measures in all working conditions is drawn up. The document must be prepared by the applicant, who is obliged to consult an authorized radiation protection expert. The evaluation can also be prepared by the authorized expert in this field. In 2010, the SRPA approved 180 such evaluations. Authorized radiation protection experts perform examination of radiation sources according to the legislation.

Prescribed supervision of radiation sources is exercised by authorized experts, either the Institute of Occupational Safety or the Jožef Stefan Institute.

### 2.2.1 Use of Ionizing Sources in Industry and Research

In 2011, 35 licences to carry out radiation practices, 59 licences for the use of a radiation source, 3 certificates of registration of radiation sources, 5 approvals to the external operators of radiation practices, 2 decisions on the termination of validity of licences to carry out radiation practices and 1 decision on conditional clearance regarding radioactive material were issued by the SNSA.

At the end of 2011, based upon the registry of radiation sources, 109 organizations in industry, research and state administration in the Republic of Slovenia were using 216 X-ray devices; 820 sealed sources were used in 85 organizations. As many as 41 radioactive sources have been stored at 18 organizations, intended to be handed over to the ARAO in the future. The users will retain 13 empty shielding containers with depleted uranium. Among these sources, 8 containers with depleted uranium are temporarily stored at users' premises and will not be transferred to the ARAO but will be used as deemed appropriate. The distribution of application of radioactive sources according to their purpose and mode of use, excluding X-ray devices and ionization smoke detectors, is shown in Figure 14.

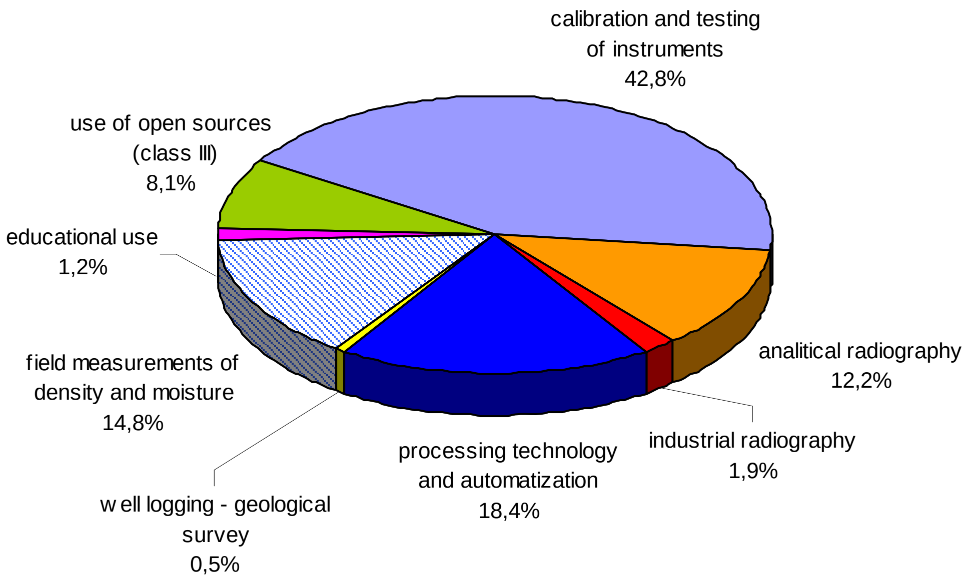


**Figure 14:** Distribution of application of radioactive sources according to their purpose and mode of use

Ionization smoke detectors, comprising isotope $^{241}$Am, form a special group of radiation sources. According to the registry of radiation sources, there were 27,929 ionization smoke detectors used at 309 organizations by the end of 2011. In addition, 327 ionization smoke detectors were stored at users' premises, most of them new detectors (208) at a company dealing with maintenance (mounting and dismounting). In 2011, one of the companies, dealing with the maintenance of ionization smoke detectors, transferred all radioactive sources which were temporarily stored at its premises (several thousands of dismantled or complete ionization smoke detectors).

The SNSA has put a lot of effort in the last few years into registering all ionization smoke detectors, and now calls on all users to notify their use. The success of this effort can be seen in the increasing number of detectors registered and of those transferred to the Central Storage facility for radioactive waste. A couple of tens of proposals for inspection control were submitted, in particular for those companies which dealt with or have been dealing with the radiation practice of maintenance (mounting, dismounting) of ionization smoke detectors. By the end of 2011, as many as 12 different companies obtained the licence to carry out such radiation practice.

### 2.2.2 Inspection Control of Radiation Sources

62 inspections were conducted altogether in 2011. Among these, 15 were focused on owners of smoke detectors that contain a radioactive source. As a rule, non-compliances with safety measures are related to the dismantling of smoke detectors or keeping them in storages. If smoke detectors are dismantled unprofessionally, radioactive conta—mination is possible. In addition, a company that was servicing of smoke detectors for decades handed over parts of smoke detectors to the Agency for Radioactive Waste in 2011. This radioactive waste was put in the storage for radioactive waste after a few years of preparation.

In 2011, the inspection also carried on 8 inspections which were related with the companies authorised to check the radioactivity of shipments of scrap metal.

In 2011, six inspections related to interventions were conducted. Altogether 19 inspection cases required an activity of SNSA inspection. The number of cases is comparable with numbers in recent years. Interventions related to safety measures are grouped into four types of interventions, namely:

- interventions related to sources in enterprises,
- interventions related to a transport of sources from abroad,
- intervention at the scrap yard Barje in Ljubljana,
- other interventions.

Four interventions were related to the first mentioned group. Such interventions are the most comprehensive because they are related to radioactive waste whose ownership before the detection is not clear. The Republic of Slovenia is obliged to assure that radioactive waste is safely stored and there is no exposure of humans or contamination of the environment. Figure 15 (photo Institute of Occupational Safety) shows collimators produced from depleted uranium found by Dinos d.o.o from Ljubljana. The collimators were found in a cargo from Croatia or Bosnia and Herzegovina. Altogether, three such collimators were identified. They were safely stored by the Agency for Radioactive Waste in the Interim Storage for Radioactive Waste as radioactive waste.

**Figure 15:** Collimators produced from depleted uranium

Radioactive waste was also found in the material of the company Štore Steel d.o.o. The waste which contained $^{226}Ra$ was stored in the Interim Storage for Radioactive Waste. Additionally, radioactive waste was found in scrap of the company Odpad Pivka d.o.o. Since the item was found in Italy, the Italian company authorised to handle such waste took over the waste later on. In last year, the material with enhanced activity of $^{60}Co$ was identified in the company Štore Steel, d.o.o. Material was later reused and melted under the supervision of the Institute of Occupational Safety.

In 2011, nine interventions were related to a transport of sources from abroad. Such transports were related to companies Acroni d.o.o and Štore Steel d.o.o, as well as to the customs at the Obrežje border crossing. Both companies as well as the customs office at the mentioned crossing are equipped with instruments for detection of radioactive sources in a cargo in a due time. In all nine cases, a source or radioactive waste, as appropriate, was transferred without any delay back to a state of its origin or to a neighbouring state from which the item came. Before the transfer, the SNSA informed the appropriate regulatory authority of involved neighbouring state.

Figure 16 (photo: Customs office) shows a device with $^{226}Ra$, so-called »radon emanator«, which was found at the Obrežje border crossings. It was found in the cargo from Croatia. Such devices were not used for decades. At a time of its use, harmful effects of ionising radiation were not known in details. The source was used for the contamination of drinking water with radon. According to the documentation available, the source was produced in Germany between both World Wars.

**Figure 16:** »Radon emanator«

In 2011, two interventions were related to the medical radioactive waste found at the Barje scrap yard.

In 2011, the inspection also conducted inspections initiated by a fire in the electrical equipment of the hall of the Reactor Infrastructure Centre at the IJS. The TRIGA reactor is also a part of the mentioned centre. In addition, from 2005 on, the IJS conducted an extensive campaign related to the decontamination of several sites and objects at the IJS. The contamination was produced in the several decades, when activities with uranium compounds took place at the IJS. As a result of decontamination campaign, altogether 19 drums with elevated level of uranium and the volume of 210 litres were produced. Among these, 12 drums were not treated as radioactive waste because of their low level activities. The inspection inspected the activities with mentioned 12 drums which were released from any further control. They were transferred to a scrap yard. Figure 17 (photo: SNSA inspection) shows a storage of drums with radioactive waste at the IJS.

**Figure 17:** Storage of drums with radioactive waste and uranium compounds

In 2011, two interventions were initiated on the suspicion that handling of sources was illegal. In both cases, the suspicion was not confirmed.

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

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

According to data from the register of the Slovenian Radiation Protection Administration (SRPA), 880 X-ray devices were used in medicine and veterinary medicine by the end of 2011. The categorization of the X-ray devices based on their purpose is given in Table 4.

**Table 4:** Number of X-ray devices in medicine and veterinary medicine, by purpose

| Purpose | Status 2010 | New | Written off | Status 2011 |
|---|---|---|---|---|
| Dental | 432 | 47 | 39 | 440 |
| Diagnostic | 257 | 13 | 6 | 264 |
| Therapeutic | 10 | 1 | 1 | 10 |
| Simulator | 1 | 2 | 0 | 3 |
| Mammography | 36 | 2 | 1 | 37 |
| Computer tomography CT | 28 | 1 | 3 | 26 |
| Densitometers | 44 | 2 | 0 | 46 |
| Veterinary | 50 | 4 | 0 | 54 |
| **Total** | **858** | **72** | **50** | **880** |

In the use of X-ray devices in medicine and veterinary medicine in 2011, the SRPA granted 124 licences to carry out a radiation practice, 219 licences to use X-ray devices, 135 confirmations of the programmes of radiological procedures, and 123 confirmations of the evaluation of protection of exposed workers against radiation.

In medicine, 416 X-ray devices were used in private dispensaries and 410 in public hospitals and institutions. The average age of the X-ray devices was 9.1 years in the public sector (up from 8.7 years in 2010) and 8.8 years in the private sector (up from 8.3 years in 2010). In veterinary medicine, 44 devices were used in private dispensaries and 10 in public institutions. The average age of the X-ray devices in veterinary medicine was 13.4 years in the public sector and 7.5 years in the private sector. A detailed classification of X-ray devices in medicine and veterinary medicine, according to their ownership, is given in Table 5.

**Table 5:** Number of X-ray devices in medicine and veterinary medicine, by ownership

| Ownership | Diagnostic | | Dental | | Therapeutic | | Veterinary | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No. (%) | Age (y) | No. (%) | Age (y) | No. (%) | Age (y) | No. (%) | Age (y) | No. (%) | Age (y) |
| **Public** | 302 (78 %) | 9,3 | 97 (22 %) | 8,8 | 11 (100 %) | 7,7 | 10 (19 %) | 13,4 | 420 (48 %) | 9,2 |
| **Private** | 73 (19 %) | 9,5 | 343 (78 %) | 8,6 | 0 | 0 | 44 (81 %) | 7,5 | 460 (52 %) | 8,6 |
| **Total** | 375 | 9,3 | 440 | 8,7 | 11 | 7,7 | 54 | 8,6 | 880 | 8,9 |

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: "perfect", "service required", "disuse proposed" and "out of order". The analysis of data for recent years is presented in Figure 18. It shows that more than 95% were classified as "perfect devices" in the last five years.

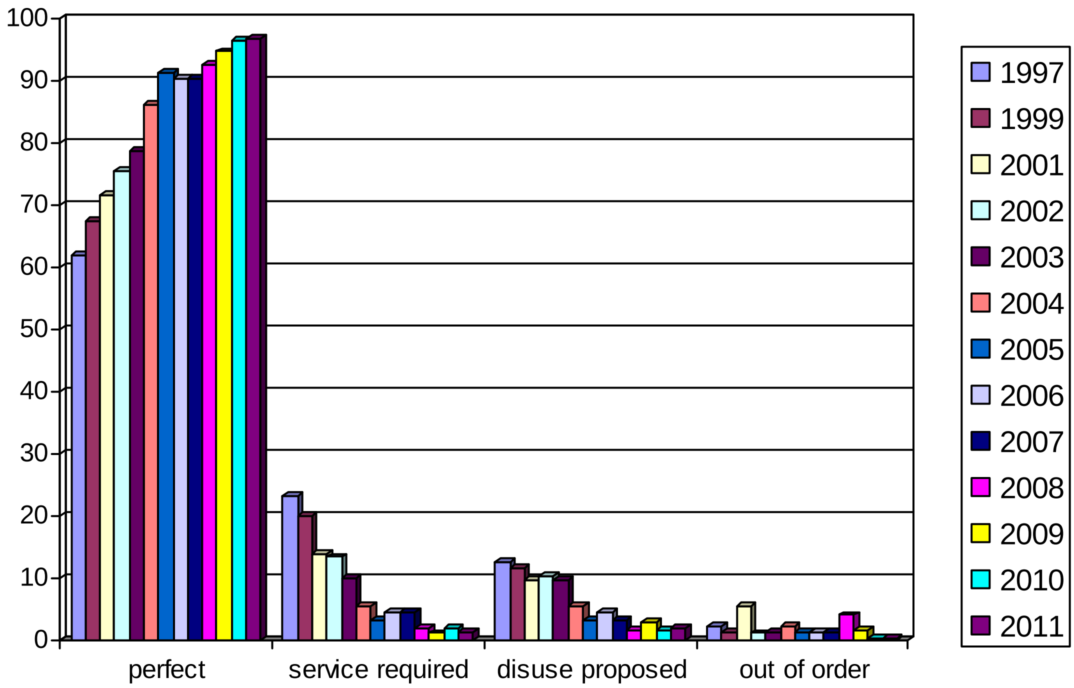


**Figure 18:** Percentage of diagnostic X-ray devices according to their quality for the period 1997–2011

In 2011, eight in-depth inspections of the use of X-ray devices in medicine and veterinary medicine were carried out, among them one inspection in the field of use of X-ray devices in veterinary medicine. On the basis of the inspection findings, a decision was issued demanding compliance with existing regulations in five cases and in one case accusation petition was given to the minor offences judge.

### Unsealed and Sealed Sources in Medicine and Veterinary Medicine

Seven hospitals or clinics in Slovenia use unsealed sources (radiopharmaceuticals) for diagnostics and therapy in nuclear medicine departments, namely the Clinic for Nuclear Medicine of the University Medical Centre Ljubljana, the Institute of Oncology, the University Medical Centre Maribor and general hospitals in Celje, Izola, Slovenj Gradec and Šempeter near Gorica. In nuclear medicine departments, altogether 6,788 GBq of isotope $^{99}Mo$, 3,167 GBq of isotope $^{18}F$, 1,026 of isotope $^{131}I$ and minor activities of isotopes $^{177}Lu$, $^{123}I$, $^{201}Tl$, $^{90}Y$ and $^{111}In$ were applied for diagnostics and therapy. Isotope $^{99}Mo$ is used as a generator for isotope technetium $^{99m}Tc$, which is extracted at nuclear medicine departments and used for diagnostics. From the initial activity of $^{99}Mo$, approximately three times higher activity of $^{99m}Tc$ can be extracted in one week.

Sealed sources for therapy are used at the Institute of Oncology and the Clinic of Ophthalmology, and for the irradiation of blood components at the Blood Transfusion Centre of Slovenia. At the Institute of Oncology, several sources of $^{192}Ir$ and $^{90}Sr$ are used. At the Clinic of Ophthalmology, 8 sources of $^{106}Ru$ with initial activities up to 37 MBq for eye tumours therapy were used, and at the Blood Transfusion Centre of Slovenia, a device with $^{137}Cs$ with the initial activity of 49.2 TBq is used for irradiation of blood components. A THERATRON device for teleradiotherapy with a cobalt $^{60}Co$ sealed source with initial activity of 290 TBq was suspended from use and the source was shipped to Germany in 2010.

Sealed sources of minor activities (mostly $^{57}Co$ with typical activities from a few MBq up to a few hundred MBq) are used for the operational testing of various devices and measurement equipment at some nuclear medicine departments. Most of them are used for calibration.

The SRPA register shows that there are still 2,390 ionization smoke detectors with $^{241}Am$ in 19 medical facilities. For most of them, the activity is about 30 kBq, while some have higher activity (up to 2.67 MBq).

In 2011, the following documents with reference to the use of unsealed and sealed source in medicine were granted: 4 licences to carry out radiation practice, 6 licences to use radiation sources in medicine, 3 confirmations of the evaluation of protection of exposed workers against radiation, 4 confirmations of the programmes of radiological procedures, 8 permissions for the import of radioactive materials, 1 permission for the export of radioactive materials, 46 statements about the shipments of radioactive materials from EU member states and one opinion on the unnecesariness of the license for the import of radioactive substances due to activities below the exemption limit from the regulatory control. Neither open nor sealed radioactive sources were used in veterinary medicine in 2011.

The medical departments with unsealed and sealed radiation sources were surveyed by the approved experts for radiation protection and medical physics. No major deficiencies as well as exceeded doses were found. In addition to the expert reviews, the SRPA inspectorate also carried out four inspections, two at the Clinic for Nuclear Medicine, one at the Institute of Oncology and one at the General hospital in Slovenj Gradec.

During reviews at the Clinic of Nuclear Medicine and Institute of Oncology, mainly the handling of solid radioactive waste (measurement procedures, recording, storage and disposal as a non-radioactive) was checked. On 2 February and 18 March 2011, slightly elevated levels of radiation were detected at the non-hazardous waste repository Barje like a few times in 2010. In both cases, there was a low activity, harmless to human health, but high enough to take action on the basis of the study of the authorized expert for radiation, in which an appropriate measurement procedure and the "aging" at the repository has been proposed. An expert study was conducted by the Jožef Stefan Institute in December 2010. In April 2011, the SRPA issued administrative decisions to the Institute of Oncology Ljubljana and the University Medical Centre in Ljubljana to allow the exemption of the regulatory control over radioactive materials in municipal waste resulting from the secretions of patients dismissed from the departments of nuclear medicine. These decisions referred to iodine $^{131}I$, if its activity did not exceed 2 MBq, and to technetium $^{99m}Tc$, if its activity did not exceed 20 MBq. There were no alarms from Barje repository site since then. However, they can not be completely avoided because the released patients, who secrete radioactive material, can contaminate the waste anywhere. This has resulted in the alarm on Friday, 18 March 2011. One day before three female patients, who received iodine $^{131}$I, were dismissed in accordance with the regulations from the University Medical Centre Ljubljana. Although all three signed special instructions to limit socializing with people, avoid the public areas and be careful with the spread of the contamination, one of them did not respect the rules. Waste in the Barje repository did not come from the controlled area of the Clinic of Nuclear Medicine, but from the other radiation uncontrolled areas of the University Medical Centre Ljubljana.

Storage place at the Clinic of Nuclear Medicine is not large enough for the storage of solid radioactive waste and has no containment tanks for liquid discharges to the sewage system. Situation will improve when the extension is built. The inspector reviewed the new design concept in March 2011. Project construction documentation was planned already for this year. In addition to the waste management, the inspections in the Clinic of Nuclear Medicine and in the Institute of Oncology also included incomplete records of some delivered isotopes, since foreign suppliers (IASON for $^{131}$I and Perkin Elmer for $^{177}$Lu and $^{111}$In) did not report on the deliveries. All liable subjects received warnings and since then the supplies have been reported on a more regular basis. The employee responsible for the radiation protection resigned from Clinic of Nuclear Medicine at the end of March 2011. The appointment of a new responsible person has been issued on the day of inspection 5 May 2011. That day ten workers did not have valid medical certificates and eight did not have certificates of training in radiation protection. It was agreed that the workers will carry out the necessary medical examinations and exams until 15 June 2011.

During the inspection in the General hospital in Slovenj Gradec in February 2011, the overall situation was reviewed in order to evaluate whether the conditions are fulfilled for the renewal of all licenses and certificates in connection with radiation practices, protection of workers and patients, and for deliveries and the use of radioactive sources. Two anomalies were found. The dosimeters on the hands were not used regularly and the control of the operation of the sample activity measuring unit has not been implemented. A warning on the regular use of finger dosimeters has been issued as well as a proposal to purchase a new gamma camera and equipment for quality control. In March 2011, relevant certificates and licenses were renewed.

### 2.2.4 Transport of radioactive and nuclear materials

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

In 2011, the Institute of Occupational Health carried out a transport of radioactive material, based upon a licence on special arrangement. This radioactive material was a $^{226}$Ra source (0.5 MBq) which was discovered in scrap and later returned to an Austrian consignor of scrap metal Schrottwolf.

In 2011, the amended Ionizing Radiation Protection and Nuclear Safety Act also defined "the transport of radioactive materials" as a radiation practice. Thus, the transport of radioactive materials is allowed only if the licence to carry out the new radiation practice has been obtained. This is very similar with the arrangement for the transport of nuclear material.

The European Union has endeavoured to simplify different systems of notification and licences for carriers. Therefore, the European Commission has prepared a draft regulation with which it would create a European system for registration of carriers of radioactive material. The draft text of the regulation will be discussed in a working group for nuclear questions in the second half of 2012.

In 2011, the SNSA also considered an endorsement of packaging for radioactive materials. The application was submitted by a Slovene company CONTAINER, d.o.o.

which submitted documentation about the packaging they produce, and which is intended to be used for package types IP-2, IP-3 in A. Testing of the packaging was carried out in accordance with international agreements on the area of transport of dangerous goods as well as in accordance with the recommendations of the IAEA. A designated Slovene expert from the company Q TECHNA d.o.o. has found out that the packaging is designed and manufactured in accordance with the legislative requirements. The Minister for the Environment and Spatial Planning signed the approval for 31 different models of packaging. All these packaging can be used for road transport, rail transport, maritime transport and inland waterways, while some packaging can also be used in air transport.

### 2.2.5 Import/shipment into, transit, export/shipment out of radioactive and nuclear material

The SNSA and the SRPA issue permits for the import and export of radioactive and nuclear materials and approve prescribed forms for the shipment of radioactive material from other EU Member States.

In 2011, the SRPA issued 8 permits for import and one permit for export as well as approved 46 forms of consignees of the radioactive material. The standard document of declaration is valid for multiple shipments, but only for a period of three years.

In 2011, the SNSA approved 8 forms of consignees of the radioactive material from other EU Member States and issued one permit for the import of radioactive material, two permits for multiple import and one permit for the import of nuclear material (fresh fuel for the Krško NPP).

In 2011, the SNSA also issued a licence for the transit of radioactive source with important activity. Radionuclide $^{60}Co$ with the activity of 51.3 TBq, which was once used in medicine, was returned to Germany through Slovenia from Croatia.

Shipments of radioactive waste and spent nuclear fuel among EU Member States as well as among the EU Member States and third countries are regulated in the Council Directive 2006/117/EURATOM on the supervision and control of shipments of radioactive waste and spent fuel. In 2011, there was no such shipment on the Slovenian territory. The SNSA prepared first report on the implementation of this Directive and sent it to the European Commission. The Slovene report focused mainly on the transposition of the Directive into national legislation and on the past already accomplished shipments.

## 2.3 Events in the Fukushima I NPP and stress test reports

### 2.3.1 A description of the event and the consequences of the earthquake and tsunami in the Fukushima I NPP

#### Introduction

Fukushima I or Fukushima Daiichi was the first of three nuclear power plants operated by Tepco. It is located on the northeast coast of Japan, approximately 260 km from Tokio. Fukushima I was one of the largest NPP on the world, consisting of six BWR's (Figure 19, reference IAEA), which were capable of generating 5.480 MWe total. The units are designed so that two units (1 and 2, 3 and 4, 5 and 6) share common facilities and structures (control room, turbine building). The shared spent fuel pool is located on the west side of Unit 4 and the dry cask storage facility is located between units 1 and 5 along the coast.


**Figure 19:** NPP Fukushima I (units 1 – 6) before the earthquake

## Design basis for the construction of Fukushima I NPP

In 1938, there was a Shioyazaki offshore earthquake in the vicinity of the Fukushima I NPP. That earthquake had the most significant impact on the site before the earthquake in 2011, since the seismic design basis for earthquake for Fukushima I is based on it. A review of plant indications and operator logs does not indicate any seismic damage that affected the operator response to the earthquake. Before the tsunami, all operable emergency diesel generators and the emergency core cooling turned on.

The tsunami design basis for Fukushima I was based on the Chilean tsunami in 1960, when the water level at the Onahama port north of the Fukushima I NPP raised up to 3.1 m. The tsunami design basis considered only the inundation and static water pressures, but not also the impact force of the wave or the impact of debris associated with the wave. For that reason, Japan designed a breakwater with the height from 5.5 to 10 m. In 2002, the Japan Society of Civil Engineers published a Tsunami Assessment Methods for NPPs in Japan. Tepco voluntarily reassessed its tsunami design basis, which resulted in a maximum water level of 5.7 m. According to that new evaluation, the evaluation of the Unit 6 sea water pump motor for the emergency diesel generator was raised for 0.2 m and the sea water pump motor for high pressure core spray was raised for 0.22 m. These changes ensured that all vital sea water motors were installed higher than the new inundation level of 5.7 m. According to new evaluation of maximum water level, Tepco did not change the height of the breakwater, because the study was made to minimize wave action in the harbour. In 2006, Tepco performed a study on the development of probabilistic tsunami hazard analysis, which estimated the probability that a tsunami is higher than 6.0 m. It was estimated that there is less than $1{,}0 \cdot 10^{-2}$ probability in the next 50 years.

## The Great East Japan earthquake

On 11 March 2011 at 14:46 (local time), a 9.0 magnitude earthquake occurred on the eastern coast of Japan. It was the largest earthquake in the history of Japan. The epicentre of the earthquake was 180 km from the Fukushima I NPP and the hypocenter was 24 km under the Pacific Ocean. The earthquake lasted approximately three minutes.

Earthquake and tsunami endangered nuclear power plants in Onagawa (3 units), Fukushima I (6 units), Fukushima II (4 units) and Tokai II (1 unit). At the time of the earthquake, only three of the six units in the Fukushima I NPP were operating, since other three units were shut down for the outages. Eleven operating reactors in this and other location automatically shut down after the earthquake. The worst affected site was Fukushima I NPP. The rest NPP's kept partial off-site power, so that the reactors were safely shut down.

The highest peak acceleration measured at Fukushima I was 0,561 g in the horizontal direction and 0,308 g in the vertical direction. This exceeded the design basis acceleration of 0,447 g in the horizontal direction. There were severe aftershocks and associated events:

- 5 aftershocks with the magnitude higher than 7,
- 82 aftershocks with the magnitude higher than 6,
- 506 aftershocks with the magnitude higher than 5.

41 minutes after the earthquake, the first of seven tsunamis hit the site. The first tsunami was approximately 4 m high. The maximum height of tsunami was estimated to be 11.5 to 15.5 m (for units 1-4) and 13 to 14.5 m (for units 5 and 6). This exceeded the design basis for tsunami, which was 5.7 m.

The tsunami inundated the area surroundings units 1-4, causing extensive damage to the site buildings and flooding the turbine and reactor buildings, as shown on the figure 20 (reference: INPO). The tsunami and the debris heavily damaged the pumps and other equipment, which resulted in a loss of the ultimate heat sink for all units.

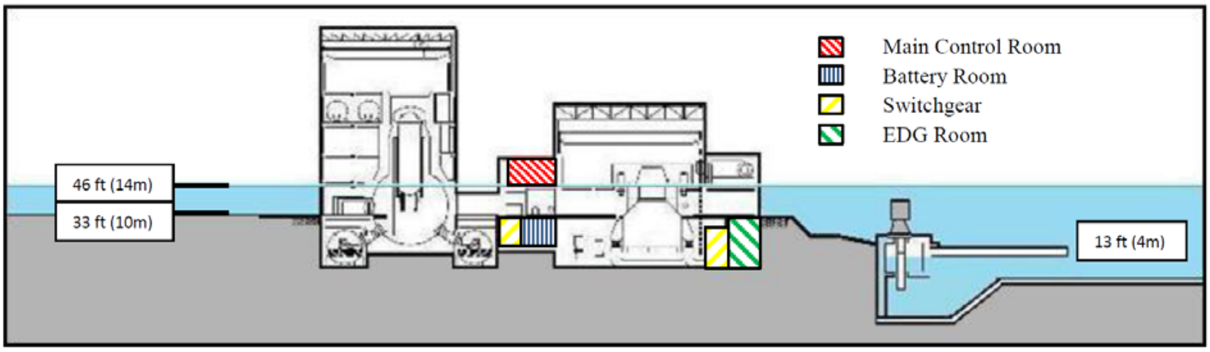


**Figure 20:** General elevations and inundation level after the earthquake and tsunami in March 2011

Because of the earthquake and tsunami, over 15.000 people died and approximately 3.000 people are still missing.

## The consequences of the earthquake and tsunami in Fukushima I NPP

Units 1, 2 and 3 were operating before the event, while units 4, 5 and 6 were shut down due to the outage. The earthquake and tsunami caused the loss of all AC and DC power in Units 1 to 4, including diesel generators; therefore the core cooling system did not work. In the Unit 3, the staff used batteries. Because there was no core cooling and removing of the residual heat in the Units 1-3, water which was used as reactor coolant started to vaporize and the pressure started to raise. The level of the cooling water in the reactors decreased, therefore the core deteriorated and started to meltdown. Meanwhile, the hydrogen began to emerge in the reactor vessel. To preserve the integrity of the primary system and the containment, the operators started to lower the pressure with a controlled discharge of radioactive steam and hydrogen in the reactor building. In the reactor building, hydrogen mixed with oxygen, which caused an explosion outside the primary system and primary containment in units 1, 3 and 4. The explosion damaged the reactor building, as shown in Figure 21 (reference: Kyodo News). Portable diesel generators were later installed in the plant to power pumps, which injected sea water in the reactor core. This stopped further deterioration.

**Figure 21:** Fukushima I NPP after the earthquake

The accident at the Fukushima I NPP was first rated by the NISA with level 5 (accident with wider consequences). Based on the newest data of the radiological releases in the environment ($^{131}$I, $^{137}$Cs), the accident was rated with level 7 (major accident), which is the highest level on the international nuclear and radiological event scale (INES).

## Radiological impacts to the environment

The consequences of the accident in Fukushima I is a huge environmental pollution, especially on the territory of Fukushima and its prefectures. Although the Fukushima accident is classified on the same level of the INES scale as the Chernobyl accident (level 7), there were, according to the newest information, radioactive releases reached about 20 to 30 percent of those from the Chernobyl accident.

The majority of the radioactive releases to the atmosphere were released in the first days after the accident, but the releases of the contaminated cooling water into the sea lasted longer. The highest concentrations of radioactivity released into the sea were 0.095 Bq/cm$^3$ $^{134}$Cs and 0.12 Bq/cm$^3$ $^{137}$Cs. An estimated total amount is around 850,000 TBq. Total amount of $^{131}$I was 160,000 TBq and $^{137}$Cs 15,000 TBq.

On the same day as the accident occurred, the government ordered an evacuation in the area surroundings the plant for people living within 2 km of the site. A few hours later, the evacuation was extended to 3 km radius. People living within 10 km were directed to shelter within their homes. The next day, the evacuation radius was extended to 20 km and four days after the accident, they extended the evacuation radius to 30 km from the Fukushima I NPP. The highest dose rates recorded at the site boundary were measured 5 days after the accident, when dose rates reached 12 mSv/hr. That day the government officials directed the public to take potassium iodide and restricted consumption of food and water. After additional measurements, the government decided to evacuate some settlements, which were outside the 20-kilometer evacuation zone, whose inhabitants, according to calculations, will in one year receive doses exceeding the intervention level.

The Japanese government ordered the monitoring of the concentrations of radionuclides in food samples. First, they prohibited drinking water and eating certain food, such as cow milk, spinach, mushrooms, vegetables, sea food and fruit. The concentrations of radionuclides in food and water soon decreased below the legal restrictions, except in the prefecture Fukushima.

Since large quantities of radioactive material were released in the sea, the concentrations of radionuclides in sea water are being measured particularly carefully. The measurements were performed in the range of 15 and 30 km from the place of discharge. The concentrations of radionuclides in the area of the NPP decreased by more than 10,000 times compared with the highest, but were still about 100 times higher than legally permitted. At 15 km, they were at the legal limit, and at 30 km area, the pollution was no longer detected.

The latest measurements of food contamination showed that more than 99 % of food samples do not contain radioactive isotopes $^{134}$Cs, $^{137}$Cs and $^{131}$I or that the contents are below the legal restrictions. The increased levels of $^{134}$Cs and $^{137}$Cs were detected in beef, pork, rabbit, lake trout, rice, mushrooms and some species of marine fish.

Workers at the nuclear power plant were the most exposed to a radiation. The legal restriction for such intervention is 250 mSv/year, and up to 500 mSv/year when saving lives (recommended by IAEA). According to the plant operator TEPCO, 167 workers received doses exceeding 100 mSv. Of these, 134 workers received doses between 100 and 150 mSv, 24 workers between 150 and 200 mSv, 3 employees a dose from 200 to 250 mSv and 6 employers a dose of more than 250 mSv.

In Fukushima prefecture, the health of almost 2 million residents is checked. The check-up focuses on radiation to which the residents were externally exposed during the period of 4 months since the accident. Around 4.000 people received radiation dose of less than 1mSv/year and 71 persons received radiation doses from 10 to 23 mSv/year. Central government and Fukushima government decided to examine breast milk for around 10.000 mothers, who lived in Fukushima, for radioactive substance. For around 360.000 youths aged 18 or younger, living in Fukushima prefecture, thyroid examinations will be carried out through their lifetime. The impact of radiation exposure on 25.000 children born to mothers in Fukushima will also be monitored. The checks will continue until the children reach the age of 13.

Plume from Japan also reached Europe. Smaller amount of $^{131}$I was measured in many European countries, the biggest in Spain (2,3 mBq/m$^3$). The SNSA ordered additional measurements of radioactive $^{131}$I due to the potential impact of a nuclear accident in Fukushima on Slovenia. The air samples showed the concentration of $^{131}$I between 0.1 - 1 mBq/m$^3$. The measured values were similar to those elsewhere in Europe and were in line with the predictions of the spread of the plume. The measured values were very low, barely measurable and did not affect human health.

#### After earthquake actions in the Fukushima I NPP

Japan prepared the plan for the decommissioning of the Fukushima I NPP in the Units 1-4. So far, they managed to keep conditions which equal a cold shutdown and significant reduced emissions, stable. Next steps will be taken in three phases:

- Phase 1 (within 2 years): period of starting the removal of fuel from the spent fuel pools,
- Phase 2 (within 10 years): period of starting the removal of the fuel debris,
- Phase 3 (after 30 - 40 years): period of the end of the decommissioning.

### 2.3.2 Response of the competent authorities in Slovenia

The SNSA first received the information about the earthquake through the media and only later through the official IAEA notification channels. At the beginning, on Friday, 11 March 2011, there was no alarming information about the safety of nuclear power plants. Therefore, the SNSA only routinely monitored the events. But the first explosion on Saturday, 12 March 2011, indicated the beginning of a nuclear accident and therefore the director of the SNSA activated the SNSA expert team.

Due to the distance of the accident, there was no direct threat to Slovenia and the main tasks of the expert team were giving public information and communicating with the media. The SNSA director also reported on the development of events to the government.

In the first weeks of the accident, the director of the SNSA and other SNSA experts had almost daily appeared in the Slovenian media to explain details of the event in plain language. They emphasized that there was no immediate danger to the people of Slovenia.

The SNSA expert team was partly activated up to the beginning of April. During this time, the team issued 13 press releases and responded to numerous questions from the media, from newspapers and on-line media to radio and television. Press releases as well as all of the responses to media inquiries were regularly published on the SNSA's website www.ursjv.gov.si. There were daily website updates until the end of April and later on less frequent, depending on the news. The SNSA actively followed the events in Japan until the end of August, and later on as part of the daily work.

During the Fukushima accident, the public was also interested in the emergency preparedness in Slovenia, especially in the use of potassium iodide tablets. This was the subject of a special press release and in addition, the SNSA webpage was dedicated to this topic. Other competent authorities, namely the Ministry of Health and the Administration for Civil Protection and Disaster Relief, which were also involved in publicity, received questions on this topic.

The SRPA was actively involved in the response of Slovenia to the nuclear accident in Fukushima as well. The director of the SRPA participated in TV and radio interviews. The SRPA issued a guide for the employees at the Slovenian Embassy in Japan. In addition, the SRPA experts were answering questions from foreign regulatory bodies and the European Commission regarding the control of goods imported from Japan and passengers returning from there. They also participated in telephone conferences on the Health Security Committee, which coordinates security measures taken by Member States of the European Union.

### 2.3.3 Extraordinary reviews of European NPPs – the Stress Tests

Immediately after the accident in the Fukushima NPP, the European Council ordered the preparation of specifications for the extraordinary review of European NPPs with which the preparedness of nuclear facilities for extreme external events would be reviewed. This campaign became known as the Stress Tests. The Western European Nuclear Regulators Association (WENRA) has prepared a first draft, which was refined and adopted by the European Nuclear Safety Regulator Group (ENSREG). Extensive negotiations between the European Commissioner and the ENSREG followed, mainly on how to deal with terrorist attacks (e.g. intentional airplane crash). The negotiations ended with a consensus that the stress tests would include the analysis of the effects of all types of external events, including those caused by man, but that the counter-terrorism measures would be addressed by a specific task group in a separate process. The president of the ENSREG and the director of the SNSA, Dr. Andrej Stritar, played a major role in the negotiations with Commissioner Günther Oettinger.

Immediately after the ENSREG and the European Commission adopted the specifications for the stress tests at the end of May, the SNSA issued a decision for the Krško NPP to carry out the stress tests analysis in line with the agreed specifications.

#### 2.3.3.1 The preparation of the report on stress tests

The Krško NPP has fulfilled its obligations on time and sent a draft report on stress tests to the SNSA before 15 August 2011. Then, the SNSA reviewed the draft report in detail and presented its findings and comments to the Krško NPP, which would consider them in the final report. The Krško NPP prepared the final report on time and submitted it to the SNSA on 27 October. The report was supported by additional analyses conducted by the NPP with the subcontractors, as well as expert opinions of technical support organizations regarding the review of individual analyses. These included an overview of important areas, such as:

- evaluation of the seismic and flooding margins,
- additional station black-out analysis and analysis of the containment failure,
- water heat-up and evaporation rate in the spent fuel pool,
- criticality in the spent fuel pool,
- drain cycle of the safety batteries.

The SNSA has reviewed the Krško NPP's final report on stress tests as well as all analyses and expert opinions. Based on the Krško NPP's final report, the SNSA prepared the final national report and sent it to the European Commission on 23 December 2011.

The final report on the stress tests shows that the Krško NPP is well designed against all credible and even some very unlikely external threats at the site. With the additional planned and ongoing modifications, the plant will further enhance its robustness and thus also the nuclear and radiation safety of its employees and the public in general.

#### 2.3.3.2 Stress tests' peer review

After the national reports on the implementation of stress tests are prepared, they are subdued to peer reviews of Member States. The peer reviews are divided into two parts, the so-called horizontal and vertical review.

In the framework of the horizontal review, the European experts will review the individual chapters of the report (external events, the loss of all power supplies and the ultimate heat sink, and preparedness for severe accidents management) and pose questions to individual countries. Each state than prepares answers and presents them on a joint meeting in Luxembourg, at which the member states present individual chapters of the report and their responses to high priority questions.

The second part of the reviews, the so-called vertical review, is held in each country. In March 2012, a group of experts will come to Slovenia to answer any still open issues, visit the Krško NPP and produce a final report for the country.

### 2.3.4 The SNSA activities regarding the Krško NPP

#### 2.3.4.1 The extraordinary safety review

Following the adoption of the stress tests specifications by the ENSREG and European Commission, the SNSA issued a decision to the Krško NPP on 30 May to perform a special safety review. The programme of this review was fully in line with the ENSREG specifications for the European stress tests. The implementation of stress tests is described in Chapters 2.3.3.1 and 2.3.3.2.

#### 2.3.4.2 Other SNSA's safety requirements based on the Fukushima event

On 1 September 2011, the SNSA issued a second (ex officio) decision, which required from the plant to reassess the severe accident management strategy and existing design measures and procedures as well as to implement necessary safety improvements for the prevention of severe accidents and the mitigation of its consequences. These improvements should further complement the requirements arising from special safety review and stress tests. The Krško NPP must reexamine the plant's response to severe accidents, verify the capacity of the facility for severe accident management, and prepare an action plan of measures to further prevent or reduce the consequences of the most severe accidents taking into account the most modern world practice.

The required analysis shall be delivered in early 2012, together with an action plan for the safety upgrades of the Krško NPP. The action plan should include proposals for changes and the construction of new systems, structures and components. These will provide greater reliability of AC power supply, improve the cooling of the reactor core, maintain the integrity of the containment, reduce potential controlled releases of radioactivity in the environment during a severe accident, enable the control and management of severe accidents from the backup (emergency) control room and provide alternative means for the spent fuel pool cooling. All the planned improvements are to be implemented by the end of 2016.

The SNSA prepared a third decision, which will require from the Krško NPP to implement the analysis and prepare the proposal for improvements of the basis and assumptions of the national Radiological Emergency Response Plan (RERP). The national RERP in case of a nuclear or radiological accident represents the last barrier, which protects people against the consequences of a severe accident. In such case, the emergency response actions would include also the protection and rescue forces at the municipal, regional and state level. Their foreseen actions were prepared on the basis of assumptions derived from the time, when the plant started to operate.

From the accident in Japan quite a few lessons were learned in the area of emergency response, thus the Krško NPP, in accordance with the decision, shall have to reassess its hazards, paying special attention to the actions required in the vicinity of the plant during and after a severe accident. Based on the hazard re-assessment, the Krško NPP shall further verify and update the basic assumptions of the national RERP and the concept of protection and rescue as well as suggest possible proposals for changes that could be useful to implement. This should take account of best international practices and experiences resulting from the Fukushima event. Proposals for changes will be the basis for the preparation of amendments to the national RERP, which must be approved by the Government of the Republic of Slovenia.

#### 2.3.4.3 Foreseen improvements in the Krško NPP based on the post-Fukushima analysis

On the proposal of industrial associations, the Krško NPP started to prepare the program of improvements immediately after the Japan accident. The first phase of the program, the so-called "STORE modifications" was carried out by 30 June 2011. The phase included purchasing additional portable diesel generators of various capacities, portable pumps and air compressors as well as installing quick connection points, by which this new mobile equipment can be quickly and easily connected to the main safety systems of the plant. The second phase of "STORE modifications" will be implemented during the annual outage in April and May 2012, when additional quick connection points will be installed.

The second part of improvements has its basis in the second SNSA decision issued in September 2011, by which the Krško NPP is required to perform an analysis of the severe accident management strategy, existing design measures and procedures and to implement necessary safety improvements for the prevention of severe accidents and mitigation of its consequences. The Krško NPP will prepare this analysis and a proposal of an action plan in early 2012. The following improvements are foreseen:

- Additional flood protection of previously (pre-Fukushima) planned third emergency diesel generator.

- Additional mobile diesel generator (2 MW) which could be connected to the new third emergency diesel generator's safety bus.
- Additional high pressure pump for RCS injection in the separated bunkered building with the associated source of borated water for 8 hours with provisions to refill by mobile equipment from different water sources.
- Installation of high temperature reactor coolant pump' seals if needed
- Additional high pressure pump for feeding steam generators in the separated bunkered building with the associated source of water for 8 hours with provisions to refill by mobile equipment from different water sources.
- Alternative air cooled ultimate heat sink.
- Additional low pressure pump for spraying (pressure control) and flooding of the containment for preventing core concrete interaction in case of failed reactor pressure vessel. This pump would also be located in the separated bunkered building with associated source of water for 8 hours with provisions to refill by mobile equipment from different water sources.
- Filtered venting system capable of depressurizing containment, which would filter over 99.9% of volatile fission products and particulates (not including noble gasses).
- Replacement of electric design basis accident (DBA) recombiners with passive beyond DBA auto-catalytic recombiners in the containment.
- Merging of existing shutdown panels and their functional expansion (the installation of emergency control room in the separate bunkered building) with enough capabilities to ensure safe shutdown of the plant and maintaining the safe shutdown conditions.
- Installation of separate dedicated instrumentation and controls for severe accidents with completely independent power supply which is capable of monitoring and controlling all newly installed equipment both from the existing as well as the new emergency control room.
- The abovementioned emergency control room will enable long term habitability of control room staff even during severe accidents (air filtering and radiation protection). Likewise, a capability for long term habitability and operation of the emergency support staff will be established for the same conditions.
- Installation of permanent sprays around the spent fuel pool with provisions for quick connection of mobile equipment and different sources of water.
- Mobile heat exchanger located outside the nuclear island with provisions to quickly connect to the spent fuel pool or reactor and capability to be cooled by mobile equipment or air.
- Acquiring the technology and material for the quick filling of possible ruptures in the spent fuel pool.

It should be noted that the newly installed equipment and buildings shall be designed for increased seismic loading (maximum or Peak Ground Acceleration - PGA of 0.6 g) in relation to the existing Krško NPP design basis (0.3 g PGA). Also, the new equipment as well as the nuclear island will be additionally flood protected against the failure of flood protection dikes or higher river flows exceeding flood protection dikes by 0.4 m. The newly installed equipment and buildings will also be more resistant to extreme outside temperatures.

In addition, the plant will also conduct an analysis of alternative options for spent fuel management. In accordance with the conclusions of the analysis, the solutions to reduce the risk of spent nuclear fuel management will be implemented.

# 3 RADIOACTIVITY IN THE ENVIRONMENT

Protection against ionizing radiation is implemented for three categories: radiation workers, patients in medical diagnostics that use radiation and the general population. Protection of the population is managed by the competent authorities through measurements of radioactivity throughout Slovenia, with special attention to the protection of populations living in the vicinity of nuclear and radiation facilities.

The main purposes of radioactivity monitoring in the environment are monitoring the levels of radioactive contamination, following trends in concentrations of radionuclides in the environment and providing timely warning in case of sudden increases in radiation levels in Slovenia.

Radiation protection of the population is ensured through the on-line monitoring of the levels of external radiation and radioactivity in the environment, and continuous control of radioactivity in drinking water, food, feed and products in general use on the basis of the laboratory measurements.

Controlling nuclear and radiation facilities is carried out through operational monitoring; its programme is determined by the competent authority, whereas the operator is liable for the implementation of this programme. The control of emissions from all facilities and the extent of radioactivity in the surrounding areas are covered by this programme. Sampling and measurement of samples is carried out by accredited technical support organizations, which are in turn authorized by competent administrative authorities.

Radioactivity released into the environment by the nuclear power plant in Krško, the former uranium mine at Žirovski Vrh, the TRIGA research reactor and the temporary central storage of radioactive waste both in Brinje near Ljubljana, is controlled. Doses to the population living in the vicinity of nuclear and radiation facilities, which emit radioactive substances into the environment, are estimated on the basis of measured or modelled data. Received doses for the population should be lower than the dose constraints set by the competent administrative authority.

The monitoring of radioactivity in the environment which is a result of global contamination from the Chernobyl nuclear accident and past nuclear testing has been carried out for over five decades and consists mainly of tracking the long-lived fission track radionuclides $^{137}$Cs and $^{90}$Sr by different transmission paths.

This chapter contains a summary of reports on the state of radioactivity in the environment in Slovenia in 2011.

## 3.1 Early Warning System for Radiation in the Environment

An automatic on-line warning system for environmental radioactivity is established in Slovenia. It is designed to immediately detect elevated levels of radiation in the environment and is one of the key elements of the warning and emergency response. In case of elevated levels of external radiation and concentrations of radioactive particles in the air, drinking water, food and feed would be contaminated due to subsequent deposition and rinsing of radioactive particles on the ground. Automatic probes for real-time measurements of external radiation are positioned around Slovenia. They are managed by the Slovenian Nuclear Safety Administration (SNSA), the Krško Nuclear Power Plant and Slovenian thermal power plants. Data are collected at the Environmental Agency of Slovenia (EARS) and the SNSA, where they are constantly analysed, archived and displayed on the internet for the public. In the event of elevated values, an automatic alarm is sent to the officer on duty.

In 2011, there were no events that would trigger an alarm due to increased radiation in the environment.

Since 1997 the SNSA has been sending data from the Slovenian early warning system to the European system EURDEP, with its centre at the Joint Research Centre in Ispra, Italy, where data from a majority of European national early warning networks are collected. Through this arrangement, Slovenia also gained access to the real-time data on external radiation from other participating countries. Additionally, Slovenian data are daily exchanged with the centres in Vienna (Austria), Zagreb (Croatia) and Budapest (Hungary).

## 3.2 Monitoring of Environmental Radioactivity

Monitoring of the 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 followed in the atmosphere, water, soil and drinking water as well as in foodstuffs and feedstuffs. Part of the monitoring programme related to the radioactivity of surface waters is the contamination of river water with $^{131}$I due to the medical use of this radionuclide. Other natural gamma emitters are also measured in all samples, and additionally tritium $^{3}$H in drinking water and in precipitation.

The results for 2011 showed that concentrations of both long-lived fission products in samples of air, precipitation, soil, milk, foodstuffs of vegetal and animal origin, and feedstuffs continued to decrease slowly and were in most cases already lower than before the Chernobyl accident. The only exception is the specific surface activity of $^{137}$Cs in the upper layer of uncultivated soil, which is still much enhanced. At the time of the Chernobyl accident, approximately five-times higher contamination (20–25 kBq/m$^{2}$) was measured on average in Slovenia, compared to the total contribution of all nuclear bomb tests in the past. The highest contamination of the ground was measured in the Alpine and forest regions. This indirectly contributes to the enhanced contents of this radionuclide in forest produce (forest fruits, mushrooms and game) and produce from Alpine pastures (milk and cheese). The concentrations of tritium in liquid samples (surface waters, precipitation and drinking water) decrease very slowly, by only few percents per year.

In May and June 2011, two additional samples of milk were analysed. Measurements confirmed that the milk does not contain the isotope $^{131}$I, which would have been released from the damaged nuclear power plant in Fukushima, Japan.

In Slovenia, consequences of the releases due to the nuclear accident in Fukushima on 11 March 2011 were negligible. Only values of the isotopes $^{131}$I and $^{134}$Cs in atmosphere and in precipitations were measurable. Releases from Fukushima contributed only to the inhalation dose, which was nevertheless lower than the $^{137}$Cs contribution of the Chernobyl contamination and nuclear bomb tests by approximately two orders of magnitude.

The biggest contribution to the radiation exposure of the public comes from external radiation and from food ingestion, while the inhalation dose due to aerosols with fission radionuclides is negligible. In 2011, the effective dose from external radiation of $^{137}$Cs (mainly from the Chernobyl accident) was estimated at about 7.0 μSv, which is 0.28% of the dose received by an average adult in Slovenia from natural background radiation. This value is similar but lower as the one that was measured and calculated for the previous year (7.7 μSv).

The annual dose from the ingestion pathway (consumption of food and drinking water) was 2.0 μSv, which is comparable with doses in previous years. The dose for 2008 was higher due to the higher average values of the radionuclide $^{90}$Sr in the selected samples of vegetables sampled in regions with higher Chernobyl contamination (Figure 22). The contribution to the annual dose of the $^{90}$Sr due to ingestion is 71% and 28 % to the annual dose of the$^{137}$Cs. The annual contribution due to the inhalation of both radionuclides is only about 0.001 μSv, which is negligible when compared with the radiation exposure from other transfer pathways. The effective dose for drinking water, taking into account artificial radionuclides, was also estimated. It turned out that on average this dose was around 0.034 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 2011, the total effective dose of an adult individual in Slovenia arising from the global contamination of the environment with fission products was estimated at 8.9 μSv, as shown in Table 6. This is approximately 0.4% of the dose compared to the annual exposure of adult in Slovenia received from natural radiation in the environment (2,500–2,800 μSv). In the regions with lower radioactive contamination of the ground, such as Prekmurje and the Coastal-Karst region, the corresponding dose is lower, while it is much higher in the Slovenian Alpine region.

Considering all the 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 using mathematical models and are based on measurable quantities. The measurement uncertainties are therefore considerable and they differ considerably from year to year in some cases. Most importantly, these values are far below the limit values.

**Table 6:** Radiation exposure of the adult population in Slovenia due to global contamination of the environment in 2011

| Transfer pathway | Effective dose [μSv per year] |
|---|---|
| Inhalation | 0.001 |
| Ingestion:<br>drinking water<br>food | <br>0.034<br>2.0 |
| External radiation | 7.0* |
| **Total (rounded)** | **8.9**** |

* Applies to central Slovenia; the value is lower for the urban population and a bit higher for the rural population.
** Radiation exposure from natural radiation is 2,500–2,800 μSv per year.

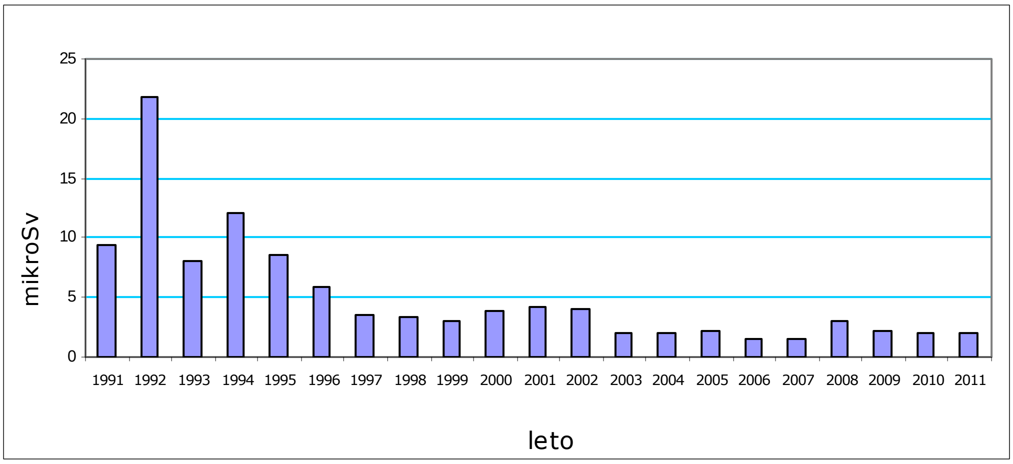


**Figure 22:** Annual effective doses to members of the public received by ingestion due to global radioactive contamination of the environment with the radionuclides $^{137}Cs$ and $^{90}Sr$ in Slovenia

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

## 3.3 Operational Monitoring in Nuclear and Radiation Facilities

Each installation or facility that discharges radioactive substances into the environment is required to be subjected to the control. Radioactivity measurements in the surroundings of the installations must be performed in the pre-operational period, during operation and for a certain period after the installation cease to operate. The goal of operational monitoring is to find out whether the discharged activities are within the authorized limits, whether environmental specific activities are inside the prescribed limits and whether population exposure is lower than the prescribed dose constraints or 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 measuring of gaseous and liquid radioactive discharges and by carrying out radioactivity measurements of environmental samples. The measured values of analysed radionuclides in environmental samples (i.e. in air, soil, surface and underground water, precipitation, drinking water, agriculture products, and feedstuffs) during the normal operation of the plant are low, usually considerably lower than the detection limits of analytic procedures. The impacts of the nuclear power plant are therefore evaluated only on the basis of data on gaseous and liquid discharges. Discharge data are used as an input for the modelling of the dispersion of radionuclides to the environment. Low results of environmental measurements during normal operation are seen as a confirmation that radioactive discharges into the atmosphere and in aquifers were low. In the event of an emergency, the established monitoring network enables immediate sampling and analysis of contaminated samples.

In 2011, independent monitoring confirmed that the measurements of discharges performed by the Krško NPP were in full accordance with the results of measurements carried out by the authorized performers of radioactivity monitoring, the Jožef Stefan Institute and the Institute of Occupational Health.

#### Radioactive discharges

In 2011, the total released activity of noble gases to the atmosphere was 0.948 TBq, which resulted in the public exposure of 0.06 μSv, or 0.12% of the limit (set at 50 μSv per year). Calculated doses depend on dilution coefficients and composition of discharged noble gases. The released activities of iodine isotopes were below the detection limit, because there was no refuelling outage in 2011. The activity of the dust particles was 0.0005% of the limit. The activity of alpha emitters was below the detection limit. Discharges of tritium into the atmosphere caused slight increases of the $^{3}H$ activity in gaseous releases due to the improvements of sampling method and laboratory analysis. The release level of the $^{3}H$ is expected to stabilize in upcoming years. The activity of $^{14}C$ corresponds to the values that are characteristic for the years without refuelling outages.

In liquid discharges from the plant to the Sava River, the tritium ($^{3}H$), bound to the water molecules, prevails. There was no refuelling outage in 2011,so the total released activity of $^{3}H$ was a little bit lower, only 3.7 TBq, which is 8.2% of the annual regulatory limit (45 TBq). This value is in accordance with the values from years without the refuelling outage. The increasing released activity of $^{3}H$ in last years is a consequence of the increased $^{3}H$ formation in the reactor coolant due to technological modifications, needed for the prolonged fuel cycle to 18 months. Total released activity in 2010 was 21.2 TBq, which represents 47.2% of the annual limit. This value is almost three times higher then in 2009, when it was 7.3 TBq. Due to its low radiotoxicity, tritium is not as important radioactive contaminant as other radionuclides. The total discharged activity of fission and activation products was lower than last year and amounted to 26.1 MBq, which represents less than 0.03% of the annual operational limit value (100 GBq).

## Environmental radioactivity

The monitoring programme of environmental radioactivity due to the mentioned discharges comprises the following measurements of concentrations or contents of radionuclides in environmental samples:

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

Concerning the impact of the Krško NPP, it should be noted that the presence of the radionuclides $^{137}Cs$ and $^{90}Sr$ is a consequence of a global contamination and not a result of plant operations. The measurable contribution of the plant operations results in the higher concentrations of tritium in the Sava river downstream of the plant. The measurements of the Sava river water showed an increase of the $^{3}H$ concentration, as in previous years, due to liquid effluents of the Krško NPP. An annual average concentration of tritium of 1.4 ± 0.2 kBq/m$^3$, measured at Brežice, was twice as high as the average measured concentration at the reference site in Krško (0.75 ± 0,04 kBq/m$^3$). An average concentration at Brežice in 2011 was lower than in 2010, when the measured concentration (5.9 ± 2.0) kBq/m$^3$ was eight times higher as at the reference site in Krško. Direct correlation between $^{3}H$ discharges and $^{3}H$ concentration in underground water can be seen from the data from the VOP-4 and Medsave boreholes where maximum measured values correspond to higher discharges from Krško NPP. Measured average annual $^{3}H$ concentrations in the water from other boreholes, pipelines and water catchment are comparable with those measured in 2010, when the discharge was five times higher, or previous years respectively, which means that the Krško NPP has negligible small or no influence. The concentrations of other artificial radionuclides discharged to the Sava river ($^{60}Co$ and others) were below the detection limits in all samples. The measured concentrations of radioisotope $^{131}I$ in the Sava river could be caused by discharges from the clinics of nuclear medicine in Ljubljana and Celje, not by the operations of the nuclear power plant.

## Exposure of the public

The dose assessment of the public was based on model calculations. The calculated dispersion factors for atmospheric discharges, based on realistic meteorological data, showed that the most important pathways for public exposure were the ingestion of food with $^{14}C$, external radiation from clouds and deposition, and the inhalation of air particles with tritium and $^{14}C$. The highest annual dose was received by adult individuals due to $^{14}C$ intake from vegetable food ingestion (0.03 µSv only from ingestion of local apples), while a ten-fold lower dose was received due to inhalation of tritium. The dose assessment due to liquid discharges in 2011 showed that their additional contribution to the population exposure was very low, at less than 0.01 µSv per year. The levels of external radiation in the immediate vicinity of some structures on-site were higher than in the natural surroundings, but the plant's contribution is hardly measurable at the perimeter fence. It was estimated that the plant-related external exposure was less than 0.2 µSv per year. This estimation is similar to those in recent years and it is now based on more realistic data than in the first period of plant operation, when the estimated values of external dose were higher at least by one order of magnitude.

Table 7 clearly shows that the total effective dose for an individual who lives in the surroundings of the Krško NPP is less than 0.2 µSv per year. The contribution of $^{14}C$

ingestion is lower than in 2010 due to the fact that the annual outage, when most of the releases occur, was performed after the vegetative period. This value represents less than 0.4% of the authorized limit value (dose constraint of 50 µSv per year) or less than a ten thousandth of the effective dose received by an average Slovenian from natural background radiation (2,500–2,800 µSv per year).

**Table 7:** Assessment of partial exposures of adult member of the public due to atmospheric and liquid radioactive discharges from the Krško NPP in 2011

| Type of exposure | Transfer pathway | Most important radionuclides | Effective dose [µSv per year] |
|---|---|---|---|
| External radiation | Cloud immersion<br>Deposition | Noble gases: ($^{41}$Ar, $^{133}$Xe, $^{131m}$Xe)<br>Particulates: ($^{58}$Co, $^{60}$Co, $^{137}$Cs, …) | 0,0036<br><4E-10 |
| Inhalation | Cloud | $^{3}$H, $^{14}$C | 0,0035 |
| Ingestion (atmospheric discharges) | Vegetable food | $^{14}$C | <0,2* |
| Ingestion (liquid discharges) | Drinking water (the Sava river) | $^{3}$H, $^{137}$Cs, $^{89}$Sr, $^{90}$Sr, $^{131}$I | 0,04** |
| **Total Krško NPP** | | | **< 0,2*** ** |

*Estimated dose of the samples taken in the first half of 2011 does not show the difference between the Krško NPP surroundings and the reference location Dobova. The estimated value is therefore taken as a measurement uncertainty of the measurement at the reference location Dobova (Report IRB from 6 Feb. 2011).
** Less likely transfer path (not taken into account in the estimation of the annual effective dose).
*** Single dose contributions from particular exposures are not added, since different groups of the public were taken into consideration.

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

The TRIGA research reactor and the Central Storage of Radioactive Waste are both located at Brinje near Ljubljana. The samples irradiated in the reactor are analysed in the laboratories of the Department of Environmental Science of the Jožef Stefan Institute, which are located by the reactor. Therefore, potential radioactive discharges at this location come from the operation of the reactor, from the Central storage of radioactive waste and from the work in the laboratories. The operation of the facilities was stable and there were no incidents that would cause releases of the radioactive material to the environment; thus the results of the operational monitoring for 2011 are essentially the same as for the previous year.

Environmental monitoring of the TRIGA research reactor comprises measurements of atmospheric and liquid discharges and the measurements of radioactivity levels in the environment. The latter are performed to determine the environmental impact of the installation and comprise measurements of radioactivity in air and underground water, external radiation and radioactive contamination of the soil as well as of radioactivity of the Sava river sediments.

Measurements of radioactive aerosol discharges into the atmosphere showed results below the detection limit. Discharges of $^{41}$Ar to the atmosphere, calculated on the basis of the reactor operation time, were in 2011 estimated close to 0.9 TBq, which is comparable with previous years. The measurements of specific activities in the environment showed no radioactive contamination due to the operation of the reactor. The external dose due to the radiation from the cloud on an individual because of the $^{41}$Ar discharges was estimated 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 and ploughing snow and that he stays in the cloud only 10% of his time. An inhabitant of Pšata village who lives at a distance of 500 m from the reactor receives 0.46 µSv per year. For the dose assessment for individuals for liquid discharges, a conservative assumption was used. If the river water is ingested directly from the recipient river (Sava), the annual exposure is 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 authorized dose limit of 50 μSv per year. The total annual dose for an individual from the public in 2011, irrespective of the model used, is still more than thousand times lower than effective dose from the natural background in Slovenia (about 2,500–2,800 μSv per year).

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

After the reconstruction of the storage in 2004, radon releases to the environment gradually decreased from the annual average value of 75 Bq/s in 2004 to 52 Bq/s in 2005, 35 Bq/s in 2006, 31 Bq/s in 2007, and 24 Bq/s in 2008. The radon release essentially dropped to only 4 Bq/s on average in 2009, due to the packing of the radium waste into the new package and its good sealing. The estimated average radon emission in 2011 was 6 Bq/s, which is, taking into account the measuring uncertainty, similar to the emissions in 2009 and in 2010 (Figure 23). Enhancement of 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 0.2 Bq/m$^3$ at the fence of the reactor site. In the waste water from the new drainage collector, the only artificial radionuclide measured was $^{137}$Cs, which is a consequence of global contamination and not of storage operation. $^{241}$Am, which was last measured in 2008, appeared again in the tank (0.5 Bq/m$^3$). Concentrations of radionuclides were far lower than clearance levels and also lower than the derived concentrations for drinking water.

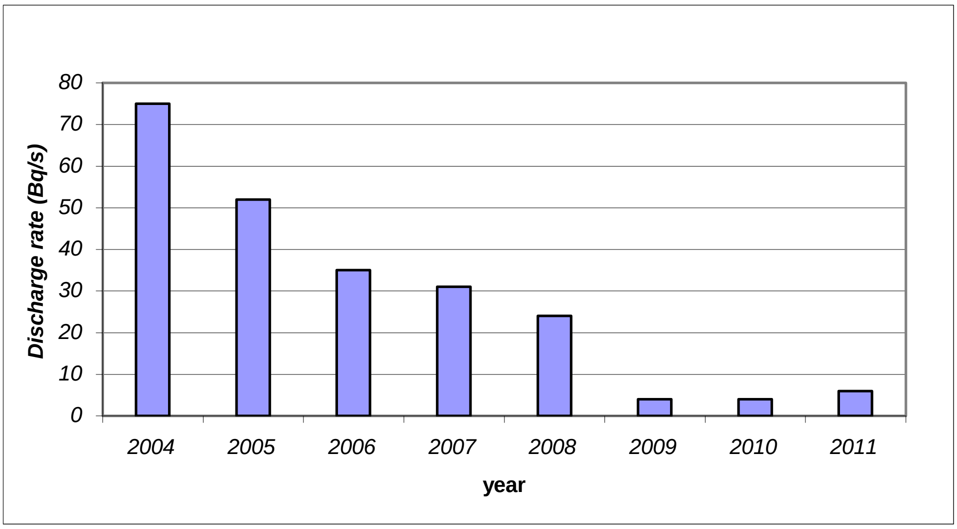


**Figure 23:** Emission rate of $^{222}$Rn from the Central Storage of Radioactive Waste at Brinje

For the dose assessment of the most exposed members of the public, the inhalation of radon decay products and direct external radiation were taken into account. The most exposed members of the reference group are the employees of the reactor centre, who could potentially be affected by radon releases from the storage. In 2011, according to the model calculation, they received an estimated effective dose of 0.85 μSv. The security officer received about 0.4 μSv per year due to his regular rounds, while the annual dose to the farmer adjacent to the controlled reactor area was estimated to be only about 0.02 μSv. These values are comparable with those for 2010 and much lower than in 2008, mostly due to lower radon releases, and are much lower than the authorized dose limit for individuals from the reference group of the population (100 μSv per year). The annual dose collected by an individual from natural background is 2,500–2,800 μSv.

### 3.3.3 The Former Žirovski Vrh Uranium Mine

The monitoring of environmental radioactivity of the former uranium mine at Žirovski Vrh, which is currently in the post-operational phase, consists of the measurements of radon releases, liquid radioactive discharges and concentrations of the radionuclides in the environment. An integrated programme of measurements is implemented, including the radionuclide-specific activities of the uranium–radium decay chain in the environmental samples, the concentrations of radon and its decay products in the air, and 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 the village of Gorenja vas to Todraž. For the evaluation of the impact of uranium mining and milling, the relevant measurements of radionuclides of natural origin have to be carried out at reference points outside the influence of mine and repository discharges (as an approximation for natural radiation background). The net contribution of radioactive contamination is assessed by correcting the measured values with regard to the natural background of the measured examined radionuclides.

In 2011, measurements of the external gamma radiation in the vicinity of mine repositories and hydrometallurgical tailings repositories were performed in smaller extent as in years from 1992 to 2010. In 2011, the Uranium Mine Žirovski vrh did not perform additional measurements, as in 2009 and 2010, to the regular programme of the radioactivity control with the intention to find possible radon sources or natural radionuclides in waters which are not a consequence of the uranium mine operation. In 2011, only the measurements of $^{238}U$, $^{226}Ra$ and $^{210}Pb$ in milk were performed apart from the regular programme. The samples were taken in the vicinity of the uranium mine and at the reference location to determine the dose due to milk intake, specially by the children.

In recent years, the radioactivity of surface waters has been slowly but steadily decreasing, especially $^{226}Ra$ concentrations in the Brebovščica, the main recipient stream, where the concentrations are already close to the natural background level (4.3 Bq/m$^3$ in 2011). Only the concentrations of uranium $^{238}U$ in the Brebovščica stream (average monthly concentration in 2011 was 206 Bq/m$^3$) are still increased, since all liquid discharges from the mine and from disposal sites flow into it. In 2011, the mine's contribution of radon $^{222}Rn$ from the repository sites and the mine to the natural concentrations in the environment is estimated at around 6 Bq/m$^3$.

In 2011, the Uranium mine Žirovski Vrh conducted measurements of radioactivity in milk samples from the mine surroundings. An increase of natural radionuclides relative to the reference location can be observed. The biggest difference between the reference location and the surrounding area of the uranium mine is in $^{226}Ra$, since its concentration of in milk from Dolenja Dobrava is almost ten times higher than concentrations in milk from a reference location.

The calculation of the effective dose for the population took into account the following exposure pathways: the inhalation of long-lived radionuclides from the decay series of uranium, radon and its short-lived progeny, ingestion and external gamma radiation. Radiation exposure of an adult member of the public living in the vicinity of the mine for 2011 was estimated at 0.097 mSv, which is a little lower as last year. The exposure is low because the restoration at the mine repositories at the Jazbec and Boršt sites was finished and represents approximately one third of the effective dose which was estimated in the last decade of the 20$^{th}$ century. However, the most important radioactive contaminant in the mine environment still remains radon $^{222}Rn$ with its short-lived progeny, which contribute to two-thirds of the additional exposure in this environment, 0.064 mSv (Table 8).

**Table 8:** Effective dose for an average individual living in the surroundings of the former uranium mine at Žirovski Vrh in 2011

| Transfer pathway | Important radionuclides | Effective dose [mSv] |
|---|---|---|
| Inhalation | – aerosols with long-lived radionuclides (U, $^{226}Ra$, $^{210}Pb$)<br>– only $^{222}Rn$<br>– Rn – short-lived progeny | 0.00<br>0.0016<br>0.064 |
| Ingestion | – drinking water (U, $^{226}Ra$, $^{210}Pb$, $^{230}Th$)<br>– fish ($^{226}Ra$, $^{210}Pb$)<br>– agricultural products ($^{226}Ra$ in $^{210}Pb$) | (0.0099)*<br><0.0006<br><0.03 |
| External radiation | – immersion and deposition (radiation from cloud and deposition)<br>– deposition of long-lived radionuclides (deposition)<br>– direct gamma radiation from disposal sites | 0.001<br>/<br>/ |
| **Total effective dose (rounded):** | | **0.097 mSv** |

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

The total effective dose for an adult individual in 2011 due to the contribution of the former uranium mine is 50% lower than in 2007 and amounted to one-tenth of the general limit value for the population (1 mSv per year). Estimated dose for a 10-year-old child was 0.144 mSv and for a 1-year-old 0.130 mSv. These values represent about 2% of the natural background dose in the Žirovski Vrh environment (5.5 mSv). Annual changes of effective doses due to the mine are shown in Figure 24.

Measurements and dose estimations for the last several years show that because of the cessation of uranium mining and the restoration works already carried out, the environmental impacts and exposure of the population have decreased. The estimated dose exposure in the present restoration phase is already only about one-third of the authorized dose limit of 300 µSv per year which will be in force after the restoration works are completed.

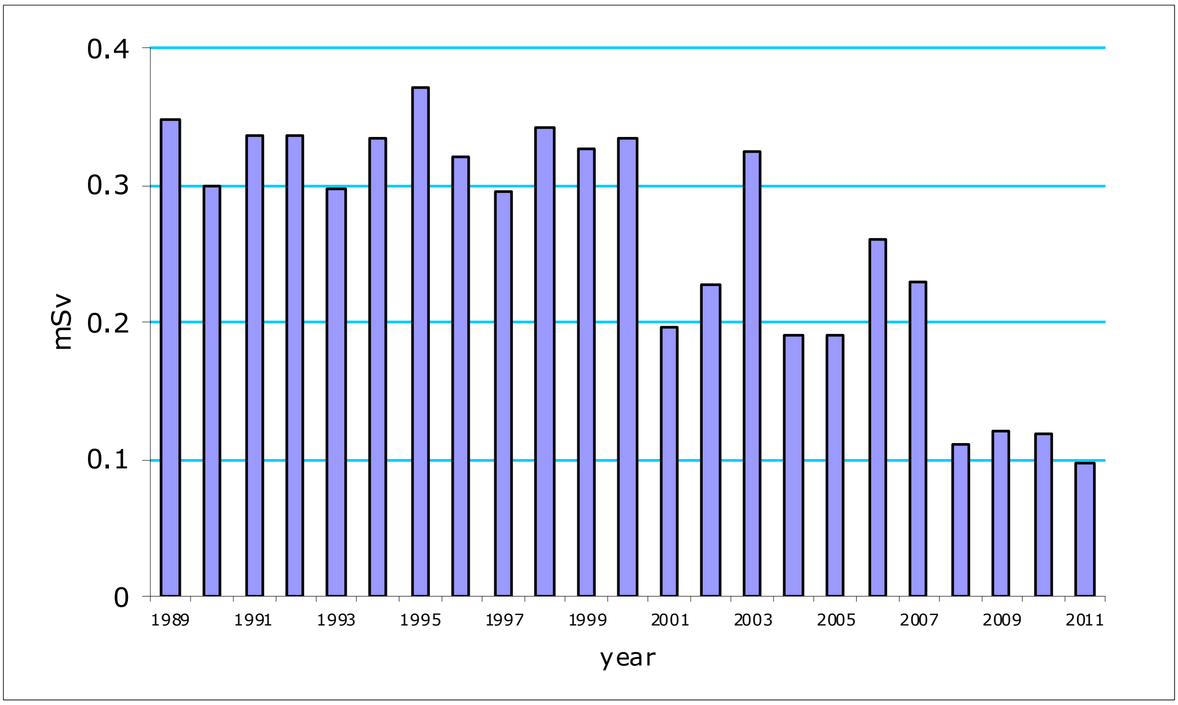


**Figure 24:** Annual contributions to the effective dose for an average adult member of the public due to the former Žirovski Vrh uranium mine in the period 1989–2011

In 2011, the Slovenian Radiation Protection Administration (SRPA) confirmed the modification of the evaluation of the protection of exposed workers against radiation at the Jazbec mine tailings.

## 3.4 Radiation Exposures of the Population in Slovenia

Every inhabitant of the 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. External radiation means that the source is located outside the body. Internal radiation occurs if radiation material enters the body by inhalation, ingestion of food and drinking, or through the skin. The data on population exposure are presented below, while the occupational exposures to both artificial and natural sources as well as medical exposures are presented in Chapter 4.

### Exposure to natural radiation

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

### Radon measurements in working and living environment

In 2011, the SRPA continued with the implementation of the governmental programme of systematic examination of workplaces and dwellings. This programme comprises of monitoring of radon concentrations and informing the public about the measures for decreasing the exposure due to the presence of natural radioactive sources and was approved in 2006. The highest priority was repeatedly given to radon exposure, since this radioactive noble gas is the main source of natural radiation in dwellings and at workplaces. On average, radon contributes to more than a half of the effective dose received from all natural sources of ionising radiation. It penetrates into rooms from the ground, mainly through various openings, for example shafts, outlets, gaps and cracks.

In the scope of the programme, the measurements of radon concentrations and its decay products were performed in 67 premises of 45 objects. Also, effective doses were assessed for employees as well as for children in schools and kindergartens. The effective doses for employees and children were assessed on the basis of results of the measurements and the occupancy time in these buildings. In 15 premises, the doses were lower than 1 mSv per year, in 8 between they were between 1 and 2 mSv per year, in 23 between 2 and 6 mSv per year and in 13 higher than 6 mSv per year.

In 2011, the SRPA in 2011 conducted eight in-depth inspections in the facilities with increased levels of radon. In four cases, the decision ordering measures to reduce radiation exposure was issued.

## Radiation exposure of population due to human activities

Additional radiation exposures due to the regular operation of nuclear and radiation facilities are usually attributed only to local populations. The exposures of particular groups of the population which are a consequence of radioactive discharges from these facilities are described in the Chapter 3.3. In Table 9, the annual individual doses are given for the maximum exposed adults from the reference groups for all objects in consideration. For comparison, an average annual dose for individuals related to 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 at Žirovski Vrh. These were estimated at a maximum of 5% of the exposure due to natural sources in Slovenia. In no case does the exposure of members of the public exceed the dose levels defined by the regulatory limits.

The population is exposed to radiation also because of other human activities. These exposures come from deposited materials with enhanced natural radioactivity and originate from past industrial or mine activities, related mostly to mining and processing of raw materials containing uranium or thorium.

**Table 9:** Exposures of adult individuals from the general population due to the operation of nuclear and radiation facilities and to general contamination in 2011

| **Source** | **Annual dose [mSv]** | **Regulatory limit [mSv]** |
|---|---|---|
| Žirovski Vrh uranium mine | 0.097 | 0.300* |
| Chernobyl and nuclear weapon tests | 0.0089 | / |
| Krško NPP | < 0.0002 | 0.050** |
| TRIGA reactor | 0.00002 | 0.050 |
| Central Storage of Radioactive Waste | 0.00002 | 0.100 |

* Limitation after the final restoration of disposal sites
** Due to radioactive discharges

# 4 RADIATION PROTECTION OF WORKERS AND MEDICAL EXPOSURES

Due to occupational exposure, individuals can receive a substantial dose of radiation. Therefore organizations that carry out radiation practices should optimize working activities to decrease the dose of ionizing radiation to a level as low as reasonably achievable (ALARA). Exposed workers are subject to a regular medical surveillance programme and have to receive adequate training. The employer has to assure that the dose of ionizing 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 regularly report to the CRPD for all exposed workers on their external exposure on a monthly basis and annually or semi-annually for internal exposures due to radon.

The approved dosimetry services in 2011 were the Institute of Occupational Safety (IOS), the Jožef Stefan Institute (JSI) and the Krško Nuclear Power Plant (Krško NPP). Additionally, approval was granted to the IOS to perform internal dosimetry for radon exposure in mines and Karst caves. Currently 11,195 persons have their records in the central register, including those who have ceased working with sources of ionizing radiation. In 2011, the dosimetric service at the IOS performed measurements of individual exposures for 3,811 workers, while the JSI monitored 875 radiation workers. The Krško NPP performed individual dosimetry for 396 plant personnel and 218 outside workers, who received an average[1] dose of 0.18 mSv of ionizing radiation. In other working sectors, the average annual effective dose due to external radiation was the highest for workers in industrial radiography, at 0.62 mSv, while the employees in medicine received on average 0.30 mSv. The highest average value among these, 0.75 mSv, was recorded for nuclear medicine workers.

In 2011, the highest collective dose due to external radiation was received by radiation workers in the medical sector (372 man mSv), followed by workers in the Krško NPP (60 man mSv). Total exposure in industry was 42 man mSv.

Since 2010, the data on doses received by radiation workers who took part in NPP outages abroad and data on doses of Adria Airways flight personnel who are exposed to cosmic radiation have been included in the CRPD. In 2011, the collective dose for 44 workers in foreign NPPs was 38.7 man mSv (average dose 1.11 mSv). During Adria flights, 141 workers were exposed, receiving an average dose of 1.06 mSv and a collective dose of 149 man mSv.

The highest doses are received by workers exposed to radon and its progeny.

In 2011, 38 out of 166 tourist workers in Karst caves received an effective dose between 5 and 10 mSv, 10 workers received an effective dose between 10 and 15 mSv, while none of the workers received a dose exceeding 15 mSv. The highest individual dose was 13.6 mSv. The collective dose was 589 man mSv, with an average dose of 4.24 mSv. Tourism workers in Karst caves are the category of workers most exposed to ionising radiation.

The findings of a study on the exposure of individuals in Karst caves show that the doses assessed according to ICRP[2] 65 and received due to radon exposure are underestimated

[1] All average doses in this section are calculated per number of workers who received a radiation dose above the minimum detection level.

[2] ICRP stands for the International Commission on Radiological Protection, which, among other tasks, periodically recommends methods for dose assessments.

for tourism workers in Karst caves. Due to the high unattached fraction of radon progeny, an approximately two times higher dose factor should be taken into account as described in the ICRP 32 model. Therefore, doses due to radon and its progeny are assessed according to the ICRP 32 model in this report. Doses calculated in such a manner are thus twice as high as those calculated according to ICRP 65, which was used in the past.

At the Žirovski Vrh Uranium Mine, the highest annual individual dose was 1.46 mSv and the average for a group of 6 workers was 0.61 mSv. The collective dose was 3.63 man mSv.

The distribution of workers by dose intervals in different work sectors is shown in Table 10.

**Table 10:** Number of workers in different work sectors distributed according to dose intervals (mSv)

| | **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 | 277 | 331 | 6 | 0 | 0 | 0 | 0 | 0 | 614 |
| Industry | 361 | 103 | 11 | 0 | 0 | 0 | 0 | 0 | 475 |
| Medicine and veterinary | 2,266 | 1,142 | 82 | 1 | 0 | 0 | 0 | 0 | 3,491 |
| Air flights | 0 | 34 | 107 | 0 | 0 | 0 | 0 | 0 | 141 |
| Radon | 27 | 29 | 68 | 38 | 10 | 0 | 0 | 0 | 172 |
| Other | 522 | 222 | 19 | 1 | 0 | 0 | 0 | 0 | 764 |
| **Total** | **3,453** | **1,861** | **293** | **40** | **10** | **0** | **0** | **0** | **5,657** |

MDL – minimum detection level
E – Effective dose in mSv received by an exposed worker

Education level of workers using sources of radiation is in accordance with regulations. Minor deficiencies were found regarding timely refreshment of knowledge and skills. Training, refreshment courses and tests were carried out by the approved technical support organizations, namely the IOS and the JSI. In 2011, a total of 1,369 participants attended courses on ionizing radiation protection.

In 2011, the medical surveillance of radiation workers was performed by five approved occupational health institutions:

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

Altogether, 2,170 medical examinations were carried out. Among examined candidates, 1,941 fulfilled requirements for work with sources of ionising radiation, 193 fulfilled requirements with limitations, 9 did not fulfil requirements temporarily and one did not fulfil requirements at all. In 26 cases, the evaluation was not possible.

## Exposure of patients during radiological procedures

Since 2010, Slovenia has taken part in the project Dose DataMed2 as a test country and receives expert assistance. The project is running under the guidance of the European Commission.

In the project framework, the first systematic assessment of public exposure due to medical use of ionising radiation was carried out.

The results of the study show that the average exposure (effective dose) due to diagnostic medical procedures in Slovenia is about 0.7 mSv per capita. Approximately 60 % of that is due to computer tomography and about 10 % due to investigations in nuclear medicine.

This extensive project consisted of evaluation of the frequency of the selected radiological procedures and the evaluation of the average patient exposure from those procedures. Due to very limited resources the SRPA selected the simplest approach. It was based on exposure assessment for 20 radiological procedures that present the largest contribution to collective exposure of the public as well as assessment of exposure due to diagnostic procedures in nuclear medicine. The frequency of procedures was assessed by a questionnaire distributed among institutions in Slovenia, performing those procedures. Patient exposure for different types of procedures was assessed based on data from programmes of radiological procedures.

# 5 MANAGEMENT OF RADIOACTIVE WASTE AND IRRADIATED FUEL

In Slovenia, high-level radioactive waste (HLW) is the spent nuclear fuel (SNF) from the Krško NPP and the Research reactor TRIGA. 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. A special category of waste are spent sealed radioactive sources, produced by small holders, which are stored in the Central Storage for Radioactive Waste at Brinje.

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

In recent years, the volume of LILW radioactive waste was reduced in few ways, e.g. by compression, super-compaction, drying, incineration and melting. The total volume of waste accumulated by the end of 2011 amounted to 2,234 $m^3$. The total gamma and alpha activity of the stored waste were $2.05 \cdot 10^{13}$ Bq and $2.64 \cdot 10^{10}$ Bq respectively. In 2011, the equivalent of 135 standard drums containing solid waste were stored with total gamma and alpha activity of $1.56 \cdot 10^{12}$ Bq and $1.32 \cdot 10^{9}$ Bq respectively on 31 December.

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

Figure 25 shows the accumulation of low- and intermediate-level radioactive waste in the Krško NPP storage. Periodical volume reductions, which are a consequence of compression, super-compaction, incineration and melting, are marked. After 1995, the accumulation of waste volume has reduced as a result of a new in-drum drying system (IDDS) for evaporator concentrate and spent ion exchange resins.

In 2006, the super-compactor was installed in the storage facility at the Krško NPP, thus it started with the continuous super-compaction of its radioactive waste. In 2011, 57 standard drums with compressible and other waste were super-compacted.

In 2011, 17 packages with compressible waste and one package with other waste were transferred to the Decontamination Building. As a result, 247 packages of compressible waste and three packages with other waste are currently stored in the Decontamination Building. This waste is stored temporarily and will be transported to Sweden for incineration.

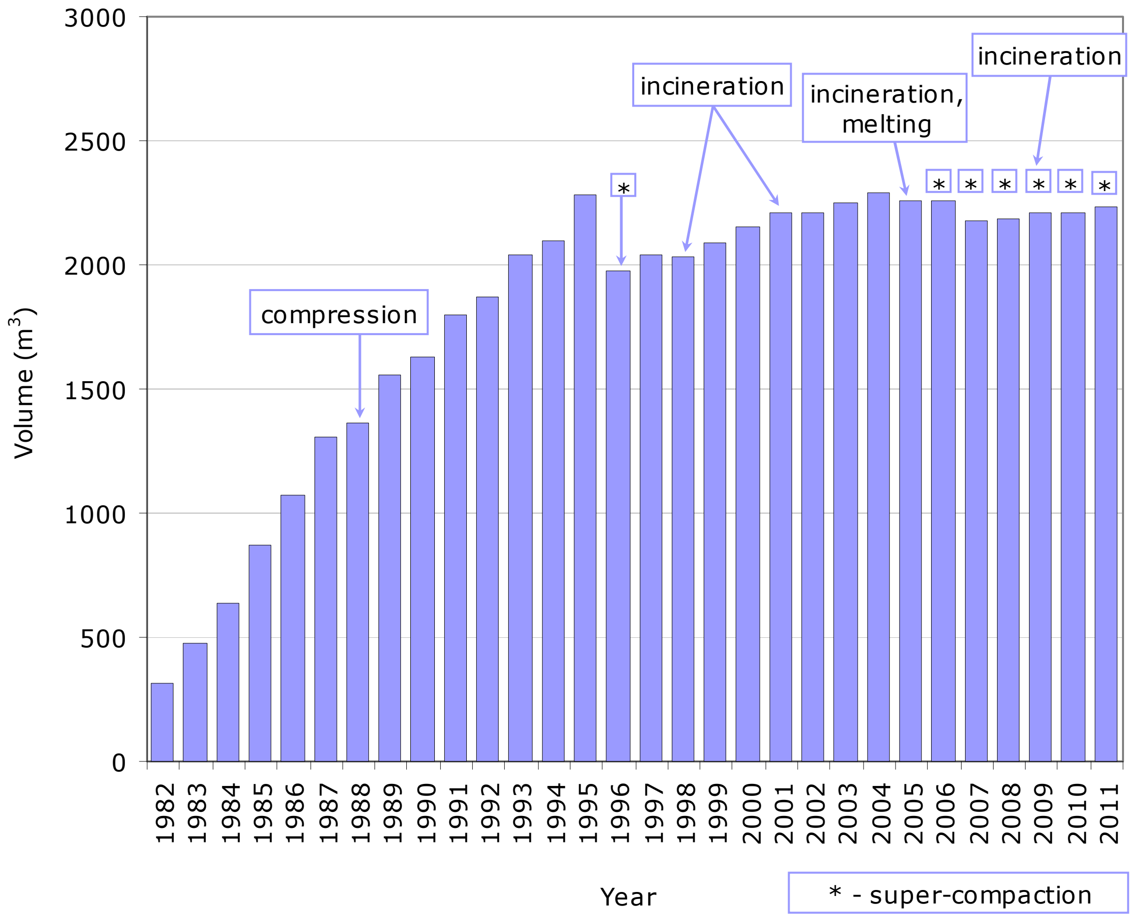


**Figure 25:** Accumulation of low- and intermediate-level radioactive waste at the storage in the Krško NPP

### 5.1.2 Management of Spent Nuclear Fuel

In 2004, the Krško NPP introduced a longer fuel cycle, according to which outages take place every 18 months. In 2011, there was no regular outage in the Krško NPP. At the end of 2011, there were 984 irradiated or spent fuel elements stored in the spent fuel pool, plus one container ("FRSB") with fuel rods, removed from fuel elements due to the investigation of fuel leakage.

## 5.2 Radioactive Waste at the Jožef Stefan Institute

In 2011, approximately 200 litres of radioactive waste was produced during the operation of the reactor and from the work in the hot cell and controlled areas of the Department of Environmental Sciences. This waste was still stored in the hot cell facility at the end of 2011. The Radiation Protection Unit of the Institute intends to hand the waste over to the Central Storage for Radioactive Waste at Brinje (managed by ARAO).

During the decontamination and decommissioning of buildings used for the processing of uranium ore, which took place from 2005 until 2007, as many as 31 drums of waste contaminated with NORM were produced. A part of this material, i.e. 12 drums which contained low levels of radionuclides, but which were still a bit higher than in the remaining material in the other drums, were transferred to the Central Storage Facility in February 2010. Since waste in these remaining 19 drums comprised very low levels of concentration of NORM, the Institute asked for a conditional clearance on this waste material in 2010. After thoroughly checking matter, the SNSA issued its decision endorsing such a conditional clearance.

In accordance with the SNSA's decision, on 20 June 2011, the Institute sent part of the material (12 drums of contaminated construction material and soil) to be conditionally cleared to a municipal landfill and the waste was covered with other waste material. Because it is not allowed to dispose metal pieces and wood on any municipal landfill, the remaining 7 drums are still temporarily stored at the location.

## 5.3 Radioactive Waste in Medicine

The Institute of Oncology in Ljubljana, as the largest user of radioactive iodine $^{131}I$, has appropriate hold-up tanks to decrease the activity of waste liquids through decay. The tanks are emptied every four months or more after authorized radiation protection experts carry out preliminary measurements of specific activities. Appropriate temporary storage for radioactive waste is arranged also at new building of the Oncological Institute. Sealed radioactive sources which are no longer in use were returned to the producer or handed over to the Central Interim Storage in Brinje. Short-lived solid radioactive waste is temporarily stored in a special place for decay until it is disposed as non-radioactive waste. On the other hand, the Clinic for Nuclear Medicine at the University Medical Centre in Ljubljana has not yet built a system for holding up liquid waste. In the course of renovation of the University Medical Center, the Clinic intends to build new premises with an appropriate system for holding up liquid waste. Since only ambulant treatment is carried out in other Slovenian hospitals, patients leave the hospital immediately after the application of a therapeutic dose, which means that the hold-up tanks are not necessary.

In the spring of 2011, similar to the events from the past years, contaminated waste from the Clinic for Nuclear Medicine and the Institute of Oncology was detected at the facility for the disposal of non-dangerous waste at Barje. In all cases, the contamination levels were low and there was no health threat to people, yet the levels were sufficiently elevated to warrant further action. Actions were based on a study made by an authorized expert for radiation, which has proposed an appropriate measurement procedure and the "aging" at the landfill. The study and the methodology were developed by the JSI in December 2010.

In April 2011, the SRPA has issued an administrative decision to allow the Institute of Oncology Ljubljana and the University Medical Centre Ljubljana to suspend the control over radioactive materials in municipal waste resulting from the secretions of patients dismissed from the departments of nuclear medicine. The control is waived for $^{131}I$ iodine, if its activity does not exceed 2 MBq, and for technetium $^{99m}Tc$ up to the activity of 20 MBq. Since then, no elevated activity resulting from health care waste was detected at Barje. Such events can not be completely avoided though, because patients, once they are dismissed from the hospital, can release radioactive materials and contaminate waste anywhere.

## 5.4 Public Service for Radioactive Waste Management

### 5.4.1 Public Service for Radioactive Waste Management from Small Producers

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

- take-over of the radioactive waste from small producers in cases of accidents and in cases where the holder of the waste can not be identified;

- transport, radioactive waste treatment for storage and disposal, storage and disposal;
- management of the accepted radioactive waste in a prescribed manner;
- management of the Central Storage Facility in Brinje.

Within the public service for radioactive waste management from small producers, the ARAO ensured regular and smooth take-over of the radioactive waste at its place of origin, its transport, treatment and preparation for storage and disposal and management of the Central Storage Facility in 2011, as described in Chapter 2.1.3.

### 5.4.2 Disposal of Radioactive Waste

A success for the ARAO and indeed for the country was the adoption of the Decree on Detailed Plan of National Importance for the LILW repository in Vrbina in Krško municipality at the end of 2009. With its publication in the Official Gazette RS, No. 114/09 on 31 December 2009, the procedure for the siting of the repository was finished.

In 2011, the preparatory work for obtaining building permit continued. The ARAO prepared the investment programme. The investment includes purchasing pieces of land, on-site filed research, the preparation of the project documentation for building permit, elaborating Environmental Impact Assessment, elaborating safety analyses and acceptance criteria, and other adjacent activities. Since the investment programme has not yet been approved, the activities have not been performed. In September 2011, the steering committee of ARAO considered Revision A of the investment programme. A decision was made to request a revision of the investment programme so as to find an optimised and credible solution of the disposal of LILW.

In 2011, an improved analysis of the owners' structure which included the whole area from the Detailed Plan of National Importance (DPN) for LILW disposal was carried out. The comprehensive list of lands within the DPN was prepared. The list includes relevant data on the owners, their attainability, share of ownership and the area of all pieces of land inside DPN. This analysis complements previous work in this field and represents a good basis to begin purchasing pieces of land or making servitude.

In 2011, a programme for the field investigation of geosphere and hydrosphere was prepared as well as four mining projects for carrying out the investigation of wells. These documents will be a part of the tender documentation for the field investigation on the site of the disposal of LILW. The study »The Review and Preparing of the Parameters for Modelling Biosphere« was carried out. The model will be used to calculate dose rates of a critical group of the public. In the same extent as in 2010, the monitoring of the underground water continued throughout 2011. Within the scope of the project, a database was extended with data on hydrogeological monitoring of facilities which are not owned by the ARAO. The gained data and the database were used as a basis for the study »Hydrogeological Interpretation of the data received by the monitoring of a broader area of the location for LILW repository« which was finished at the end of 2011.

For critical solutions in the conceptual design, such as disposal silos and disposal technology, an analysis of variant solutions or their optimization was made in 2011. Regarding the scope of technological capacities needed to prepare waste for its disposal as well as other technological capacities, the conceptual design of the LILW disposal resumes generic requirements, determined in the Resolution on National Programme of Radioactive Waste and Spent Fuel Management for the period of 2006 – 2015. Expert assessment and international screening have shown that both the preparation of waste for disposal and disposal itself are complex and demanding and that technological procedures for disposal should be optimised in further phases of the project.

Last year, several year lasting research project »Development of Technologies for Durability of the Engineering Barriers«, which was financially sponsored by the ARAO, the Krško NPP and the Ministry of Higher Education, Science and Technology, was concluded. Possible degradation processes of metallic and concrete materials which are used in engineering barrier of LILW disposal were presented; the most important parameters which can influence the development and speed of degradation were also shown. Based on the findings of this research, guidelines were given for the composition of different concretes and for the selection of material for the reinforcements as well as a proposal of methodology for monitoring corrosion processes of such reinforcements in concrete.

In 2011, the preparatory work for a new iteration of safety analyses and acceptance criteria based upon some known data (location Vrbina, conceptual design, field investigation, characterisation of waste) started. The results have confirmed that the selected site and the concept of disposing are suitable, since the influences of such disposal are lower than required in the legislation. New acceptance criteria for the disposal of radioactive waste were also prepared and for the first time, they were suitably tailored for the selected site and selected technology of disposal.

In the framework of the preparation of the Environmental Impact Assessment, the Slovenian Environment Agency has provided information on the content of this assessment as well as on the content of the safety analysis report. Based on this, both documents will be prepared and they will serve as a basis for obtaining the Environmental protection consent.

Due to the dynamics of the repository siting, the repository for the Slovene part of the waste coming from the Krško NPP will probably not be in operation until 2013. For the continuous and undisturbed operation of the Krško NPP, the ARAO will prepare credible time line plan.

## 5.5 Remediation of the Žirovski Vrh Uranium Mine

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

The majority of technical work on both disposal sites was successfully concluded, but a non-stable landslide on the Boršt site has prevented its final remediation. The rock beneath the hydrometallurgical tailings at the site has been sliding despite the remediation work at the site; the sliding is larger than accepted and determined in the safety analysis report.

In 2011, on both the Jazbec mine waste pile and the Boršt hydrometallurgical tailings site, the monitoring activities were carried out together with the activities in the scope of the five years transitional period plan, such as mowing the grass, strengthening of grassy vegetation, removing of bushes on both sides of the fence, maintenance and cleaning of channels and drainage trenches, and control of the overall state of the sites.

At the beginning of 2011, some final work took place at the Boršt site; this included drainage wells and the remediation of the damage on concrete lining in the drainage tunnel under the Boršt site. No emergency events, including those due to weather conditions, occurred during the work.

In August, the Žirovski vrh mine was moved from the former administration building of the Žirovski vrh uranium mine and a laboratory on the plateau of the former processing facility to the Centre for the long-term management and public relations (Figure 26), located on the former plateau of the exterior facilities of the mine pit (P-10). For this new centre, the former building 106, where the storage of the cores from wells used to be, was adapted. In the centre are rooms, intended for the long-term management of the Jazbec and Boršt mine disposal sites. Former closed mine pits were transformed into offices, a laboratory for water studies, dressing rooms and toilet facilities. There are also a multi-purpose room and a mine museum with a smaller collection. The center also has its own small technological park.

The above-mentioned building is a part of the radiation facility »Jazbec mine waste pile«, for which the Žirovski vrh mine has not yet obtained consent from the SNSA, as determined in Article 85 of the Ionizing Radiation Protection and Nuclear Safety Act. Based upon the stipulation of this act, the Žirovski vrh mine should notify the SNSA about the changes and prepare a proposal for the changes of safety analysis report. The SNSA warned the Žirovski vrh mine that they were violating legislation and demanded that changes of the safety analysis report for the Jazbec disposal site had to be made.

In relation with the issue, mentioned in the previous paragraph, the SNSA inspection carried out an inspection control of the Žirovski vrh mine (Public company for the closure of the mine) and found out that the reconstruction of the former building, intended for storing of the cores was carried out. The Žirovski vrh mine had not obtained the prescribed consent from the SNSA before the building permit was issued. The mine had not even asked for such consent, therefore it violated Article 139 (item 22) of the same act. The Žirovski vrh mine and responsible person (Director of the company) have received a written warning by the SNSA inspection.

**Figure 26:** The Centre for the long-term management and public relations

Monitoring the stability of the Jazbec site and the Boršt site is an important task within this five years transitional period as well on a long-term basis. After the final settlement of the both sites and when working activities on the area of located geodetic grids of control points for monitoring stability were finished, the conditions for qualitative periodical geodetic monitoring as well as for continuous (on-line) monitoring using GPS system via satellites (Figure 27) came to an existence.


**Figure 27:** The scope of the landslide on the area of the Boršt site, the direction of movement of the landslide (informative), the locations of monitoring points through GPS system (points GRS1, GMX1 and GMX2) and of geodetic grid (point 115)

The financial resources needed for the planned activities and safe working conditions for the staff and external workers and for limiting the effects of the mine on the environment were assured until July 2011, but not afterwards. For this reason, it was not possible to build planned intervention drainage wells from the drainage tunnel into the grounding or hinterland of the Boršt disposal site in the second half of 2011. In order to carry out regular activities, the mine used its own financial resources which should be transferred from Žirovski vrh mine to the community of Gorenja vas – Poljane as a contribution for the limited use of the land.

The Žirovski vrh mine began an administrative procedure for getting the licence for the closure of Jazbec disposal site. Oral proceedings took place and a change and an amendment of the safety analysis report were requested. By the end of 2011, the application has not been complemented yet. In the process of issuing of the licence for closure, based upon official duty, the SNSA will issue a decision on the cessation of the status of radiation facility and (based upon the Government decision) also a decision on the transfer of the site into national infrastructure. By issuing above-mentioned administrative acts, the conditions for long-term supervision will be established, which will be carried out by the Agency for Radioactive Waste Management.

On 18 May 2011, a technical review of the concluded work regarding the final remediation of the Boršt disposal site took place. Due to the fact that the slides of the landslide have increased more than it is acceptable according to the stipulated values in the safety analysis report, and have not been in accordance with the safety analysis report for Boršt, its technical acceptance has not been concluded. It was found out that the remediation work was accomplished in a correct manner, but the desirable, stable conditions have not been met due to unforeseen circumstances. By tackling further activities, the efforts will be made to reduce the present speed of the sliding of the landslide. It will also have to be analysed, if there are any dangers regarding health and life of people, animal and pollution of the environment despite the present instability, including the worst case scenario of events. The commission for the technical review has ordered the preparation of technical documentation (mine project), where intervention measures as well as permanent measures proposed by the Expert Project Council will be duly considered. After the conclusion of activities, the Žirovski vrh mine will have to obtain an opinion of an expert institution about the suitability of remediation of disposal which would have to ensure that the measures being carried out provide the long-term stability of the tailings and landslide there. The safety analysis report will also have to be amended.

## 5.6 The Fund for Decommissioning of the Krško NPP and for the Deposition of Radioactive Waste from the Krško NPP

Slovenian Fund for the decommissioning of the Krško NPP and for the management of radioactive waste from the Krško NPP collects financial resources for the decommissioning of the Krško NPP and for the safe disposal of LILW and spent nuclear fuel. In 2011, the Krško NPP delivered one half of electric power to the Slovenian and the other half to the Croatian utility. The company GEN Energija, d.o.o., was liable for the payment of the regular levy to the Fund in the amount of 0.003 EUR for every kWh of electric power received by Slovenia from the NPP. In 2011, a total of 8.9 million EUR was paid into the Slovenian fund.

The safety of investments is assured by the structure of investments, as 86% of the total portfolio is invested in debit securities, deposits and CDs which have low credit risk and assure long-term stable incomes.

As of 31 December 2011, the fund managed 147,995,808 EUR of financial investments. 30% of the sum was invested in banks in the form of deposits and CDs, 37% in state securities, 19% in other bonds, 2% in mutual funds, 4% in bond mutual funds or shares of closed-end fund, and 8% in equity mutual funds or shares of closed-end fund.

The market yield of the entire portfolio of the fund for 2011 amounted to ~~2.2%~~ -2.2 %. This is calculated by taking into consideration insider rate of return. The yield to maturity amounted to 0.4%. The income from financing in 2011 amounted to 14.5 million EUR which is 0.23% more than planned. The expenses in 2010 were 22.36% lower than planned and amounted to 7.2 million EUR. The expenses of portfolio managing in relation to the entire portfolio amounted to 0.26%.

In all whole period of the existence of the Slovenian fund, a total of 136.7 million EUR was paid by the Krško NPP and GEN Energija d.o.o. From 1998 until the end of 2011, a total of 22.17 million EUR was paid out by the fund to the ARAO for the purchase of studies and projects in the area of management of radioactive waste and spent fuel. Since 2004, the municipalities have received 18 million EUR as compensation for the limited use of land.

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

At the end of 2011, the Joint Convention has been mandatory for 63 states, the Contracting Parties to the convention, including the Republic of Slovenia.

In 2011, the fourth Slovenian national report on 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 Slovene 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 organisation co-operated in the preparation of this report: the Slovenian Radiation Protection Administration, the Agency for Radioactive Waste Management, the Krško

NPP; Jožef Stefan Institute, 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 fourth review meeting of the Contracting Parties, which is to be held in Vienna in May 2012. The national report for the 3-year cycle from 2008 to 2010 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 2010, legislation regulating this working area and the scope and the manner of fulfilling the obligations from the Joint Convention. The national report which is 134 pages long is written in English. The report concludes that the Slovene legislation and practice in the area of management of radioactive waste and spent fuel are harmonised with the requirements from the Joint Convention.

# 6 EMERGENCY PREPAREDNESS

Emergency preparedness is important part of the comprehensive system for ensuring high level of nuclear and radiation safety. During an emergency, competent organizations must be ready to take appropriate action according to emergency plans.

Nuclear and radiological accidents are incidents that directly threat people and environment and require prompt protective actions. In general, not all incidents are accidents. They could also be, for example, reductions in nuclear or radiation safety, but this also requires an appropriate response from the relevant authorities.

The response to a radiation emergency in Slovenia is defined in the national radiation emergency response plan. The Administration for Civil Protection and Disaster Relief (ACPDR) has a leading role when dealing with an emergency, while the Slovenian Nuclear Safety Administration (SNSA) gives advice and recommendations.

## 6.1 Slovenian Nuclear Safety Administration

At the SNSA, the responsibility for emergency preparedness falls to the Emergency Preparedness Division. The division's primary functions are:

- providing training, staffing and appropriate response of the SNSA emergency team,
- maintaining the team's documentation and procedures,
- maintaining the team's equipment and emergency center.

The SNSA's capabilities to act are ensured by regular training of the emergency team members, the response verification and exercises, regular checks of computers and other equipment and participation in international activities as well as through regular reviews of all associated organizational regulations and guidelines.

In 2011, the SNSA carried out 27 training sessions running to a total of 203 hours, with 273 participants or 1,700 man-hours of training. The exercises are considered as part of training. The SNSA was the main organiser of the INEX 4 exercise, which was prepared by the OECD/NEA (see Chapter 6.3). The SNSA also participated in the 2011 annual Krško NPP exercise and in several international ConvEx and ECURIE exercises.

In the framework of international cooperation in the field of preparedness for emergencies, the SNSA chaired the EENCA (Eastern European National Competent Authorities) group, whose members represent the 31 East European countries.

During the Fukushima accident, the SNSA emergency team was activated for an extended period of time (see Chapter 2.3.2).

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

In 2011, the Administration for Civil Protection and Disaster Relief (ACPDR) maintained, developed and ensured preparedness for effective response to nuclear or radiological accident, all in accordance with statutory powers.

The ACPDR continued to harmonize radiation emergency plans on different levels.

The ACPDR and the SNSA organized a three-day seminar on emergency preparedness and response in co-operation with the Belgian Nuclear Research Centre SCK CEN. The seminar was held from 11 to 13 October 2011 at the Training Centre for Civil Protection and Disaster Relief in Ig. The seminar was fully booked, with 106 participants from all important Slovenian organizations.

## 6.3 The INEX 4 National Exercise

The INEX 4 national exercise was carried on 16 November 2011. The exercise, which was based on the OECD/NEA documentation, addressed malicious act involving the release of radioactive materials in an urban setting (dirty bomb). It was conducted as a single day table-top exercise, but it covered time span of multiple days and in addition the mobile monitoring teams were deployed in the field. The accident of the exercise was set in the town of Slovenske Konjice. 25 organizations with 149 participants took part in the exercise, out which there were 139 players, 10 inject providers and controllers, 7 evaluators and 2 observers.

## 6.4 The Krško NPP

In 2011, the activities of the Krško NPP in the area of preparedness for emergencies included:

- training, drills and exercises (annual NEK exercise),
- maintenance of support centres, equipment and communications,
- updating the NEK protection and rescue plan, procedures and other documentation,
- stuffing and replacement in the emergency organization.

Moreover, NEK staff actively co-operated with the planners and providers of protection and rescue tasks at the local and national levels and with the administrative authorities (the SNSA and the ACPDR).

In 2011, the NEK mobile unit performed two tours with the mobile unit of the Institute of Occupational Safety and one tour with the IJS mobile radiological laboratory.

# 7 CONTROL OVER RADIATION AND NUCLEAR SAFETY

## 7.1 Legislation

The most important piece of legislation in the field of nuclear and radiation safety in the Republic of Slovenia is the Ionizing Radiation Protection and Nuclear Safety Act (ZVISJV, Official Gazette RS, No. 102/04 – official consolidated text), amended for the first time in 2003 (Official Gazette RS, No. 24/03 – ZVISJV-A) and amended for the second time in 2004 (Official Gazette RS, No. 46/04 – ZVISJV-B).

In 2011, the act was amended for the third time (Official Gazette RS, No. 60/11 – ZVISJV-C).

The majority of changes are non-conceptual and editorial corrections and eliminations of minor inconsistencies and deficiencies that have been revealed through the application of Act. Up until now, the act has not regulated restriction regarding the right to strike due to the protection of public interest. This amendment introduced such restriction for certain categories of workers in nuclear and radiation facilities, who perform the most important tasks and work for the point of nuclear and radiation safety, as well as for workers carrying out transport of nuclear material and physical protection. The provisions related to the measures of physical protection had to be amended substantially due to international recommendations which foresee the use of physical protection measures not only for nuclear material, but to a certain degree also for radioactive material.

Regarding the procedure for issuing licences for carrying out radiation practice and licence for the use of radioactive sources, certain requirements were unnecessarily duplicated and therefore eliminated. In parts in which the act links to other acts, the act had to be adjusted to the amendments of these acts. The amendment also determines rules related to the operation of nuclear or radiation facility, implementation of periodic safety reviews in nuclear or radiation facility, approval of modifications on nuclear or radiation facility, qualifications of workers in nuclear or radiation facility as well as safety and quality management in nuclear or radiation facility.

Based on the ZVISJV, 27 implementing regulations were adopted by the end of 2010; six governmental decrees, ten rules issued by the minister of the environment, nine issued by the minister of health and two issued by the minister of the interior.

In 2011, the following regulations were adopted and issued:

- Rules on providing qualification for workers in radiation and nuclear facilities (Official Gazette RS, No. 32/11); on the day, when this Rules enter into force, Regulation on conditions to be fulfilled by workers performing safety-significant tasks at nuclear or radiation facilities (Official Gazette RS, No. 74/05) shall cease to apply. With this Rules, the WENRA Reference Levels were fully transposed to our national legal system and thus our legislation is harmonised with the best European practice.
- Rules amending the Rules on operational safety of radiation and nuclear facilities (Official Gazette RS, No. 87/11).

Detailed information regarding executive acts and acts under preparation could be found at the web site http://www.ursjv.gov.si/si/zakonodaja_in_dokumenti/.

## 7.2 The Expert Council for Radiation and Nuclear Safety

The Expert Council for Radiation and Nuclear Safety provides expert advice to the Ministry of the Environment and Spatial Planning and to the Slovenian Nuclear Safety Administration in the field of radiation and nuclear safety, 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 use of radiation sources other than those used in health and veterinary care.

In 2011, the Expert Council convened two regular and two correspondence sessions in 2011. In addition to the regular reporting of the SNSA Director to the Council on the news and developments in the field of radiation and nuclear safety between the meetings, the Council considered the following subject areas: monitoring of operation of nuclear facilities, causes and consequences of the Fukushima-Daiichi nuclear accident, modernization of safety systems in the Krško NPP after the Fukushima nuclear accident, life extension of the Krško NPP, stress tests, status of the project on LILW repository at Vrbina near Krško, authorization process of nuclear safety experts, perspectives, priorities and collaboration of the Republic of Slovenia in the OECD and staffing and development of human resources in the nuclear field.

In 2011, the Expert Council also adopted:

- the Annual Report on Radiation and Nuclear Safety in Slovenia for 2010,
- the Slovenian 4$^{th}$ National Report on the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management,
- corrections of Rules on Operational Safety of Radiation or Nuclear Facilities.

In 2011, two members were reappointed for another term by the minister of the environment and spatial planning.

## 7.3 Slovenian Nuclear Safety Administration

The Slovenian Nuclear Safety Administration (SNSA) performs specialized technical and developmental administrative tasks and tasks of inspection in the following areas: radiation and nuclear safety; carrying out of practices involving radiation and the use of radiation sources, except in medicine and veterinary medicine; protection of the environment against ionizing radiation; physical protection of nuclear materials and facilities; non-proliferation of nuclear materials and safeguards; radiation monitoring; and liability for nuclear damage.

Legal bases for its administrative and expert tasks in the area of nuclear safety, radiation protection and inspection are provided by the legal framework presented in detail at the SNSA website http://www.ursjv.gov.si.

In the beginning of 2011, the SNSA had 41 employees. At the end of 2011, the number of employees came close to the uniform staff plan of the Ministry of Environment and Spatial Planning. According to the plan, the SNSA as an administrative body within the Ministry of Environment and Spatial Planning could have 44 employees in the period 2010 - 2012.

The SNSA first acquired the ISO 9001:2000 certificate for the management system in 2007. In January 2012, the SNSA successfully passed regular annual external control audit of the management system. Since no non-conformances were identified. During the control audit, the external auditor concluded that the SNSA management system complied with the standard ISO 9001:2008.

From the end of September to the beginning of October, the Slovenian Nuclear Safety Administration hosted an international IRRS mission, which reviewed all aspects of the SNSA's working area and compared it with international standards. Detailed information can be found in Chapter 9.2.

As well as in 2011 and previous years, in spite of tight financial situation and with very limited financial resources, the SNSA paid special attention to qualification, education and training, with the purpose to follow the career of the employees and to establish the conditions for improving their qualifications. Special attention was devoted to the education in the area of nuclear safety and radiation protection. A number of its employees, particularly inspectors, passed a special training course and exam within the educational programme of the US NRC, and also exams on corresponding simulator.

Training and education are also carried out abroad, since this is the only way for the SNSA to professionally cover the area, which is developing continuously. Among others, SNSA employees regularly participate at the seminars and workshops organized by the International Atomic Energy Agency, OECD/NEA and the European Commission.

The SNSA is aware of the importance of its openness to the public. This is ensured by the publication of information in newspapers, on radio and television and on the internet.

The SNSA website offers general information about the SNSA, information for the public, legislation, agreements and standards in this field, annual and other reports, information on meetings, information on workshops, projects and invitations for tenders co-financed by the International Atomic Energy Agency, data on radiation monitoring, INES events, and links to the websites of other regulatory authorities, organizations and research centres. On the site's pages, all relevant information as required by the Act on the Access to Information of a Public Nature is also available. The SNSA constantly updates the website and thus tries to ensure that the level of information is interesting for the general public as well as for experts.

In 2011, the Expert Commission for the Verification of Professional Competence and Fulfilment of other Requirements in Respect of Workers Performing Duties and Tasks in Nuclear and Radiation Facilities (in short the Commission) carried out exams for Senior Reactor Operators, Reactor Operators and Shift Engineers of the Krško NPP. The Commission also organised exams for licensing of Shifts Engineers and Reactor Operators of the TRIGA reactor.

Eight candidates acquired their Reactor Operator licence of the Krško NPP for the first time. Extensions of licenses were granted to four senior reactor operators, eight reactor operators and three shift engineers. Altogether six candidates acquired the licensee for Senior Research Operator for the first time.

In 2011, one candidate received the license for Reactor Operator of the TRIGA reactor for the first time and three candidates acquired the license for the Shift Engineer of the research reactor.

## 7.4 Slovenian Radiation Protection Administration

The Slovenian Radiation Protection Administration (SRPA), an agency within the Ministry of Health, performs specialized technical, administrative and developmental tasks and tasks of inspection related to carrying out practices involving radiation and the use of radiation sources in medicine and veterinary medicine, protection of public health against the harmful effects of ionizing radiation, systematic survey of exposure at workplaces and in the living environment due to the exposure of humans to natural ionizing radiation sources, monitoring of radioactive contamination of foodstuffs and drinking water, restriction, reduction and prevention of health problems resulting from non-ionizing radiation, and auditing and approval of radiation protection experts.

As a special operational unit within the SRPA, the Inspectorate for Radiation Protection is competent for the surveillance of sources of ionizing radiation used in medicine and veterinary medicine and for the implementation of legislation in the field of protection of people against ionizing radiation. In 2011, the SRPA had five employees.

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

In 2011, the SRPA provided financial means for the technical operation check of gamma cameras at the nuclear medicine departments. Furthermore, the SRPA assured the implementation of the national programme for the systematic examination of the working and living environment and raising public awareness about the ways for reducing exposure to natural radiation sources. The means were also assured for the monitoring of radioactivity in foodstuffs and drinking water in Slovenia.

The SRPA supervised radiation practices in medicine and veterinary medicine and the use of radiation sources in these activities, protection of exposed workers in nuclear and radiation facilities and radon exposure. Altogether 128 permits to carry out a radiation practice, 225 permits to use radiation sources and 8 permits to import radioactive sources, 1 permit to export radioactive source, 139 confirmations of programmes of radiological procedures, 46 statements of consignees of radioactive materials and 180 evaluations of protection of exposed workers were granted. Of these, 123 were for the use of X-ray devices in medicine, 3 for the use of open and sealed sources in medicine, 6 for performing radiation practice in nuclear and radiation facilities and 48 for industrial, research and other activities. In 2011, the SRPA issued four approvals for radiation protection experts (natural persons), four approvals for medical physics experts and provided its opinion on fulfilment of conditions to perform medical checks for two medical practitioners.

Altogether, 203 inspections were carried out. Of these, there were 12 in-depth inspections in medicine and veterinary medicine, with 5 decisions requiring correction of established deficiencies issued, 2 decisions requiring sealing of X-ray devices and 2 decisions regarding the clearance of radioactive material. In one case, the accusation petition was given to the minor offence judge.

From the viewpoint of the radiation protection of exposed workers, the SRPA surveyed the Krško NPP, JSI and ARAO in 2011. Altogether, 7 inspections were performed in these institutions. The SRPA also supervised the Žirovski Vrh mine, the Postojna Cave, the Škocjan Caves and primary schools, kindergartens, hospitals and other public buildings with increased radon concentrations. Eight in-depth inspections were carried out. Four decisions for the reduction of ionising radiation were issued. The SRPA also participated in the technical review of Boršt disposal site at the Žirovski vrh mine.

In the field of other natural sources of ionizing radiation, the SRPA supervised flight operator Adria Airways and carried out an inspection.

## 7.5 Authorized experts

The Ionizing Radiation Protection and Nuclear Safety Act defines the operation of several types of authorised experts. The SNSA authorizes experts for radiation and nuclear safety, whereas the radiation protection experts, dosimetric services and medical physics experts are authorised by SRPA. The approvals for medical practitioners are issued by the Ministry of Health.

### Authorized experts for radiation and nuclear safety

The Ionizing Radiation Protection and Nuclear Safety Act lays down the requirement that the operators of radiation or nuclear facilities consult authorized experts or acquire their expert opinion on specific interventions in the facilities. From the reports of authorized experts, it can be concluded that in 2011 there were no major changes in their operations in comparison to previous years. Their staffs have maintained their level of competence and the equipment used was well kept and updated. The organizations established the Quality Management Programs certificated in compliance with the standard ISO 9001:2000. The authorized experts provided professional support to the Krško NPP by preparing independent expertise. An important part of their work focused on an independent review and assessment of plant modifications.

Research and development activities are an important part of their work. Certain organizations successfully participated in international research projects.

In 2011, the Commission for the Verification of Compliance with Requirements of Authorized Experts considered five new applications for the authorization of legal persons. All five legal persons have obtained the authorization of the SNSA. One authorized expert fulfilled the criteria for extension of authorization and the SNSA issued an extended authorisation on the basis of the commission favourable opinion. The authorization of one natural person terminated on her request.

In 2011, 17 legal entities and 2 natural persons have been authorized by the SNSA to become Authorized Experts for Radiation and Nuclear Safety.

The SNSA website http://www.ursjv.gov.si/si/info/za_stranke/, under the title »Pooblaščeni izvedenci za sevalno in jedrsko varnost«, presents information on authorized experts in various fields of radiation and nuclear safety.

### Authorized radiation protection experts

Approved radiation protection experts co-operate with employers in drawing up evaluations of the protection of exposed workers against radiation; give advice on working conditions of exposed workers, on the extent of 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 the control of usefulness of protective equipment; and perform training of exposed workers in radiation protection. Approved radiation protection experts regularly monitor the levels of ionizing radiation, contamination of the working environment and working conditions in supervised and controlled areas. The approval can be granted to individuals (for giving expert opinions and for presentation of topics relating to training on radiation protection) and to legal entities (for giving expert opinions, performing control measurements and technical checks of radiation sources and protective equipment and for performing training in radiation protection for occupationally exposed workers). Individuals can acquire approval if they have appropriate formal education, working experience and expert skills, and legal entities if they employ appropriate experts and have at their disposal appropriate measuring methods accredited according to the standard SIST EN ISO/IEC 17025. Authorizations are limited to specific expert areas.

In 2011, the SRPA issued four approvals to radiation protection experts. Approvals were obtained by four natural persons, whereas there were no approvals issued to any legal entities. Approvals were granted based on the opinion of a special commission which assesses whether candidates fulfilled requirements.

### Authorized dosimetric services

Authorised dosimetric services perform tasks related to the monitoring of individual exposure to ionizing radiation. An approval can be granted only to legal entities which employ appropriate experts and have at their disposal appropriate measuring methods accredited to the standard SIST EN ISO/IEC 17025.

In 2011, the SRPA did not issue any approval for dosimetric services.

### Authorized medical physics experts

Approved medical physics experts give advice on the optimization, measurement and evaluation of 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.

Based on the opinion of a special commission, the SRPA issued such approvals for four natural persons in 2011, whereas four applications were refused.

### Authorized medical practitioners

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

In 2011, the SRPA recommended two medical practitioners.

## 7.6 The Nuclear Pool GIZ

The Pool for the Insurance and Reinsurance of Nuclear Risks GIZ (Nuclear Pool GIZ) is an insurance company of a special kind, which deals with the insurance and reinsurance of nuclear risks.

The Nuclear Pool GIZ has been operating since 1994 and at the moment includes eight members. The insurance company Triglav, Ltd., the reinsurance company Sava, Ltd., Adriatic Slovenica, Ltd., and the reinsurance company Triglav have the biggest shares in the pool.

The third-party liability of nuclear operator with headquarters in the Republic of Slovenia is insured in accordance with the Act on Liability for Nuclear Damage that entered into force on 4 April 2011. Under this policy, the Nuclear Pool GIZ covers up to the amount of insurance specified in the insurance policy as well as costs, interest and expenses that the policy holder must reimburse to the victim of a nuclear incident. The insurance covers the legal liability arising from the policyholder's operation and its possession of property when accident in nuclear installation caused damage during the period of insurance.

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

# 8 NUCLEAR NON-PROLIFERATION AND SECURITY OF RADIOACTIVE MATERIALS

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

Over the last few years, the international community has focused more attention to nuclear non-proliferation. A few countries which are not contracting parties to the Treaty on Non-Proliferation of Nuclear Weapons (India, Pakistan, North Korea and Israel) continue to implement their nuclear weapons programmes. The situation in Iran shows that their civil nuclear programme is not always transparently presented. The United Nations Security Council has not adopted any additional resolution regarding Iran; the IAEA General Director reported several times to the Board of Governors on the implementation of Safeguards Agreement in Iran and Syria. In November 2011, the Board of Governors adopted a resolution which expressed deepening and increasing concern about the Iranian nuclear programme including the one related to the potential involvement of Iranian military forces.

On the eighth Review Conference on the Treaty on Non-Proliferation of Nuclear Weapons, which took place in 2010, the parties unanimously adopted the final document that includes Action Plan in the sphere of nuclear disarmament, nuclear non-proliferation and peaceful use of nuclear energy. At the end of 2011, the European External Action Service (EU) in the framework of the Working Party on Non-Proliferation (CONOP) prepared and distributed a matrix on the implementation of final document and Action plan from the Review Conference. Next preparatory meeting (»NPT PrepCom«) is to be held in May 2012.

Slovenia completely fulfils its obligations under the adopted international agreements and treaties. Together with other countries, it endeavours to prevent the further expansion of nuclear weapons.

## 8.2 Nuclear safeguards in Slovenia

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

In Slovenia, all nuclear material (fresh and spent fuel) at the Krško NPP, the Jožef Stefan Institute, the Central Storage for Radioactive Waste in Brinje and the other eleven holders of small quantities of nuclear material is under the supervision of international inspection.

All holders of nuclear material report directly to the European Commission about their quantities and status of nuclear material, in accordance with Commission Regulation (EURATOM) No. 302/2005 on the application of EURATOM safeguards. The reports are sent in parallel to the SNSA, which maintains its registry on nuclear material, in accordance with Slovene legislation.

There were ten IAEA/EURATOM inspections in 2011 (EURATOM carried out six inspections by itself); no anomalies were found. The Slovenian holders of nuclear material reported to the EURATOM in accordance with legislation.

## 8.3 The Comprehensive Nuclear Test-Ban Treaty

The Comprehensive Nuclear Test-Ban Treaty (CTBT) is one of international instruments, aimed at combating proliferation of nuclear weapons. Slovenia signed the treaty on 24 September 1996 and ratified it on 31 August 1999. The CTBT provides for the establishment of the Comprehensive Nuclear Test-Ban Treaty Organization (CTBTO). At the moment, the tasks of the CTBTO are performed by the Preparatory Commission (PrepCom), which is setting up the monitoring system meant to detect any nuclear explosion. As the signatory, Slovenia follows the activities of the CTBTO.

In 2011, several meetings of the working groups (WGA, WGB, Advisory Group and PrepCom) took place in the framework of the CTBTO. The SNSA and the Ministry of Foreign Affairs participate at the meetings.

## 8.4 Export control of dual-use goods

In the scope of international activities in this area, the SNSA and the Ministry of Foreign Affairs participate in the work of the Nuclear Suppliers Group (NSG) and the Zangger Committee. Slovene representatives regularly participate in the sessions of both organizations.

21st Plenary Week was held in Noordwijk (The Netherlands) in June 2011. NSG Member States, among other things, agreed to strengthen the guidelines on the transfer of sensitive enrichment and reprocessing technologies, in particular the guidelines regarding enrichment and reprocessing. They exchanged information on positive and negative developments in the nuclear non-proliferation regime, focusing on specific regions and countries of concern. They also emphasized the importance of export control and addressed the issues of brokering and transit; discussed the on-going fundamental review of the trigger and dual use lists and their up-dates as well as civil nuclear co-operation with India and further relationship with this (non-NSG/NPT) country. Last but not least, the group discussed a report on the NSG's outreach programme towards non-NSG countries as well as other international organisations.

On the basis of the Act on Export Controls of Dual-Use Goods, a special Commission for Export Controls of Dual-Use Goods was established at the Ministry of Economy. 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). The commission is made up of representatives of the Ministry of Economy, the Ministry of Foreign Affairs, the Ministry of Defence, the Ministry of the Interior, the Customs Administration, the SNSA, the Slovenian Intelligence and Security Agency and the National Chemicals Bureau. An exporter of dual-use goods must obtain a permit from the Ministry of Economy, which is issued on the basis of the commission's opinion. In 2011, the commission had 8 regular and 17 correspondence sessions. The role of the SNSA in this commission is primarily related to the export of goods which might be used in the production of nuclear weapons.

In November 2011, the SNSA actively co-operated with the Ministry of Foreign Affairs and other members of the commission at an outreach seminar, organised on the US initiative for the relevant representatives from the Bosnia and Herzegovina in Ljubljana.

## 8.5 Physical protection of nuclear material and facilities

The operators of nuclear facilities carried out physical protection in accordance with their plans on physical protection, which were approved by the Ministry of the Interior. The operators also checked if their plans were in line with the threat assessments (DBT) for 2011, issued by the Slovenian Police. Annual training sessions for guards of nuclear facilities and materials during transport were held. The systems of physical protection are supervised by the Inspectorate for Interior Affairs at the Ministry of Interior and the SNSA. The Inspectorate for Interior Affairs also carries out independent inspection control in the areas of private security (based upon the Private Security Act), security, purchase, possession and storage of firearms (base upon the Firearms Act) and classified information (based upon the Classified Information Act).

In 2011, the Inspectorate for Interior Affairs carried out the inspection of physical protection of nuclear fuel transport. Beside this, the management of classified information related with this transport was inspected at four subjects. In two inspections, decisions on conditions were issued; in one case the subject – based upon the minutes – settled some minor non-compliances; and in one case, administrative violations procedure was initiated.

The Commission for Performing Expert Tasks in the Field of Physical Protection of Nuclear Facilities and Materials worked in compliance with its mission. Most important task was the co-ordination of work of all stakeholders in this field.

In mid-2011, the amendments of the Ionizing Radiation Protection and Nuclear Safety Act were adopted. These amendments have brought several changes in the area of physical protection and its inspection control. Some recommendation from the IPPAS mission (International Physical Protection Appraisal Service) which should be considered in the legislation has been already included in the above-mentioned amendments, while other will be considered during drafting of two-tier regulations. The Ministry of the Interior called upon the operators of nuclear facilities to harmonise their physical protection plans with the amended act and sent them to the ministry for their approval.

At the beginning of December, the physical protection of the shipment of fresh nuclear fuel for the Krško NPP was routinely carried out. There was no transit of nuclear material through Slovenia in 2011.

Slovene representatives took part in an annual meeting of the ENSRA (European Nuclear Security Regulators Association), which was held in Bonn in Germany. In addition, Slovene experts have participated in the Ad-Hoc Group on Nuclear Security (working group under the EU Council) which has studied measures of physical protection in nuclear power plants EU-wide after the accident in Fukushima in Japan.

## 8.6 Illicit trafficking of nuclear and radioactive materials

By the end of 2011, the SNSA issued 22 authorisations for the measurements of radioactivity in scrap metal shipments. All authorised organisations sent their annual reports to the SNSA. According to the reports, 27,274 measurements of shipments were carried out in 2011. In four cases, the dose rates were elevated due to radium, $^{60}$Co and NORM.

To provide assistance and consultation, the SNSA gave other state offices and private organizations, such as scrap recyclers and melting facilities, the phone number of a 24-hour on-duty officer. Twelve calls were registered in 2011.

At the end of September 2011, the SNSA reported to the IAEA Illicit Trafficking Database about a discovery (unauthorised disposal) of three pieces of depleted uranium (detected in Ljubljana on the premises of a scrap recycler). The pieces found were probably collimators, used in industrial radiography at an unknown location. Depleted uranium, with a weight of app. 11.4 kg, was transferred to the CSRW in Brinje.

Also in 2011, a number of detected semi-finished items and final products, contaminated by $^{60}$Co, as well as radioactive sources were reported worldwide. In March, the SNSA informed the Customs Administration about these discoveries and recommended that more attention should be paid in particular to the goods imported from China and India.

# 9 INTERNATIONAL COOPERATION

## 9.1 Cooperation with the European Union

### Working Party on Atomic Questions (ATO)

In the first half of 2011, Belgium handed the EU presidency over to Hungary. The main activity during Hungary's presidency in the Working Party on Atomic Questions (ATO) was a discussion about the proposal of the Directive on the management of spent fuel, which was successfully completed. There was also a discussion about the accident in Fukushima and the review of the European Commission Report on the events in the energy market. At the end of the Hungarian presidency, the working party raised the subject of programming and monitoring of measures and financial assistance under the Bohunice, Ignalina and Kozloduy programmes for the period 2007 to 2013.

In the second part of 2011, Poland took over the presidency and set a comprehensive plan which included the conclusion of certain matters already discussed, such as the reliable supply of medical radioisotopes for medical use in the EU, the revision of the proposal for a Council Directive laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation (BSS) and international negotiations on EURATOM agreements with Russia, Canada and South Africa, as well as an introduction of new topics, such as the promotion of bilateral agreements between the Community and the third countries in the area of peaceful uses of nuclear energy, the review of the EU power plants safety standards (stress tests) and the discussion of the Council Directive laying down the requirements for the protection of the health of general public with regard to radioactive substances in water intended for human consumption. Russian Federation submitted a proposal to amend the Convention on Nuclear Safety. Monitoring of the developments related to the Fukushima power plant accident has continued.

In 2011, the SRPA actively participated at the meetings of the Working Party on Atomic Questions regarding the Council Directive laying down the requirements for the protection of the health of general public with regard to radioactive substances in water intended for human consumption and the Council Directive laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation.

### High-Level Group on Nuclear Safety and Waste Management (ENSREG)

In 2011, the High-Level Group on Nuclear Safety and Waste Management (ENSREG) had three meetings. The group is chaired by Dr. Andrej Stritar, the SNSA Director. In addition, European Conference on Nuclear Safety was organized in the end of June.

The first meeting in 2011 was held in Brussels in February, before the Fukushima accident. Participants adopted a joint declaration on EU proposal for a Council Directive on the management of spent fuel and radioactive waste, which is to be presented as a common European nuclear safety regulators' view at one of the next meeting of the Working Party of Atomic Questions (ATO). Also, ENSREG adopted the Memorandum of Understanding between the ENSREG and the IAEA, whose purpose is to help carry out so-called IRRS missions in the Member States smoothly and successfully. The format of the second report that ENSREG had to prepare and present for the European Commission, Council and Parliament was confirmed.

The next ENSREG meeting took place on 12 and 13 May and was devoted to the adoption of the so-called stress tests. The European Commissioner for Energy, Günther Oettinger, attended this meeting and delivered the opening speech. The most important question of the meeting, whether to include so-called human-induced threats (airplane crash, terrorism) or just a natural phenomena (floods, tsunamis), which were the cause of the Fukushima accident, in stress tests came to a conclusion. It was agreed that the stress tests will include both natural events (natural triggering events) as well as human-induced threats (security threats). Since individual national legislations delegate competence for the second component (security threats) to other authorities and not only to regulators, represented in the ENSREG, this component will be managed by another authority, set by the relevant Council bodies. Both components of stress tests will be conducted in parallel.

At the October meeting, ENSREG adopted methodology for the review of the national reports on nuclear power plants stress tests. All European nuclear countries were given instructions to send national reports on the results of stress tests of their nuclear power plants by the end of a year. At this meeting, ENSREG decided that the review of all national reports will be carried out in two phases. First, all national reports will be reviewed by three working groups (earthquakes and floods, provision of electrical power at emergencies and measures in case of serious accidents). This »horizontal« review will be followed by a »vertical« review when individual country reports will be examined in detail. At this meeting, ENSREG members unanimously extended the mandate of Dr. Andrej Stritar for another 6 months, when a campaign of stress tests is expected to end.

European Conference on Nuclear Safety was held on 28 and 29 June 2011. Over 200 representatives from European regulatory bodies responsible for nuclear safety, other participants in the field of peaceful uses of nuclear energy and high-level representatives of major inter-governmental, international and professional associations attended. Participants mostly discussed the 2009/71/EURATOM Council Directive on nuclear safety, the proposal of Directive on the management of spent fuel and radioactive waste, the preparation of stress tests after the Fukushima accident and the preparation of audit process, so-called peer review of the final report after stress tests.

### Consultative Committees under EURATOM

Within the framework of the European Atomic Energy Community Treaty (EURATOM), there are at present several technical and consultative committees dealing with different areas of the nuclear energy field. Representatives of the SNSA are active in the committees under Articles 31, 35/36 and 37.

The committee under Article 31, chaired by the SNSA employee, Dr. Helena Janžekovič, prepares recommendations for the European Commission regarding legal acts in the field of radiation protection and public health. The June meeting of this committee focused on the nuclear accident in nuclear power plant Fukushima I in Japan. At the meeting, two opinions, which will help both Member States and the European Commission, regarding the risk in EU due to this disaster in Europe were prepared. A draft of the Council Directive laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation (BSS) was supplemented by the recommended lower dose limit for the eye lenses in accordance with the recommendation of the ICRP. A special working group on dose constraints was set up.

EURATOMuratom requires Member States to establish a system of radiation monitoring in the environment and consequently to report to the European Commission within the committee under Article 35. The European Commission can verify the existence and compliance of such systems with the community requirements (Article 36). Such verification took place in Slovenia in 2006.

The main task of the committee under Article 37 is to prepare opinions for the European Commission regarding the impact of a certain nuclear object on adjacent Member States. In 2011, the Slovenian representative did not attend any meeting of the working group under this Article.

### Consultative Committees of the European Commission

The Consultative Committee Instrument for Nuclear Safety Co-operation (INSC) advises the European Commission on issues with regard to assistance to third countries in the area of nuclear and radiation safety. In 2011, there was one meeting in May, which was attended by a representative of the SNSA. The INSC consultative committee discussed their annual programme INSC 2011 - Part 1, the status of promised contributions for Chernobyl, the presentation of the TACIS programme (Technical Assistance to the CIS - Commonwealth of Independent States), the role of ENSREG and dissolution of a group to assist regulators (RAMG).

The Consultative Committee Euratom-Fission (a body in the seventh Framework Programme) represents a group of experts advising the European Commission regarding nuclear research projects financed by the EU. In 2011, there were two meetings of the committee. In 2011, Dr. Leon Cizelj of the Jožef Stefan Institute became the Slovenian representative in this committee. At the meetings, the representatives discussed the report of an independent observer on evaluating projects, reporting of the European Commission on the implementation of the Euratom-Fission programme (overall results and statistics of the 7th framework programme), the second revision of the work programme for 2011, the status of adoption of the Euratom programme for 2012-2013 (FP7 +2) and draft work programme for 2012.

### Co-operation in EU projects

Since 2010, Slovenia has participated in the project Dose DataMed2. The project is running under the guidance of the European Commission and is coordinated by the Finnish regulatory authority. In the project framework, the contribution of patient doses during radiological procedures to the collective dose was assessed.

## 9.2 International Atomic Energy Agency

During 2011, Slovenia successfully cooperated with the International Atomic Energy Agency (IAEA). The Slovenian delegation in 2011 also attended the regular annual session of the General Conference. The most important Slovenian activities are as follows:

Slovenia received 13 individual applications and two group applications for training of foreign experts in our country in 2011. Nine trainings were implemented, three training applications were withdrawn by the IAEA and one individual application will be implemented in 2012. Another six training applications from 2010 were realized in 2011. In 2011, two fellows completed their training that they started one year earlier.

Slovenia submitted one new proposal for a research contract, which was prepared at the University of Ljubljana. Fifteen research contracts were in progress from the previous years. The cooperating counterparts are the Jožef Stefan Institute, the Institute for Biostatistics and Medical Informatics and the Institute of Oncology Ljubljana.

Following the thorough preparation of a new biennial technical cooperation cycle that started already in 2009, the Board of Governors approved 4 new technical assistance project proposals, which will be carried out at the Jožef Stefan Institute, the Department for Nuclear Medicine of the University Medical Centre, the Agency for Radwaste Management and the Biotechnical Faculty. Financial resources for the first three national projects will be ensured by the Agency, while the project of the Biotechnical Faculty will need to find a donor, since it will not be possible to carry it out otherwise. Activities under the approved projects will start in the beginning of 2012.

Slovenia continues with its active policy of hosting activities organized by the IAEA. In 2011, Slovenia hosted six such events in the form of workshops, courses and meetings.

In 2011, the experts from Slovenia, appointed to the Nuclear Safety Standards Committee (NUSSC), Waste Safety Standards Committee (WASSC) and Radiation Safety Standards Committee, actively participated in the activities of the three committees.

For more than five years, the Slovenian Radiation Protection Administration (SRPA) has been actively involved in an IAEA project on the optimization of medical use of ionizing radiation. During the first phase of the project, the SRPA's efforts were dedicated to radiation protection in intervention procedures with an emphasis on interventional cardiology. In a few years a good overview over the situation in Slovenia has been established and optimization has been carried out where needed. Recently, the SRPA's focus within this project has moved towards the optimization of computed tomography (CT) procedures with an emphasis on examinations of pediatric patients. In 2010 and 2011, the optimization process was conducted at the Institute of Radiology of the University Medical Centre Ljubljana. In next phases, the project will expand to other institutions within the University Medical Centre Ljubljana with the Institute of Radiology as a centre of reference.

In 2011, the Board of Governors convened at five regular sessions, once as the Board of Governors' Programme and Budget Committee and once as the Board of Governors' Technical Assistance and Cooperation Committee. The Board of Governors considered the following important topics: budget proposal for 2012, the IAEA Annual Report, the Report on Technical Cooperation, the Safeguards Implementation Report, the importance and contribution of nuclear technology in the areas of human development, the control of nuclear sources in Iran and Syria and the lack of cooperation of Democratic People's Republic of Korea with the IAEA. Most importantly, the Board of Governors considered the report on circumstances in the Fukushima Nuclear Power Plant and its surroundings, Action Plan on Nuclear Safety as well as nuclear security in the light of the tenth anniversary of the terrorists' attack in New York.

### IRRS Mission

From 25 September to 4 October 2011, an international team of fourteen experts conducted an Integrated Regulatory Review System (IRRS) mission in Slovenia. The experts reviewed the Slovenian regulatory framework for safety. The team gave special attention to all areas of work of the SNSA and also visited a number of other organizations. The review considered the implementation of administrative requirements in nuclear and radiation installations of Slovenia. Further, the team reviewed the emergency response after the Fukushima nuclear accident.

The IRRS Mission assessed the situation in Slovenia as appropriate. The SNSA's work is considered efficient within its responsibilities. Other regulatory bodies also have a role in the control of operators of nuclear installations in Slovenia and the SNSA has been maintaining an adequate level of communication with these organizations. The team complemented Slovenia's prompt and effective response to the accident at the Fukushima Daiichi power plant. The mission recognized that public information, development of actions for improvement in the NPP and international coordination were adequate. The findings and conclusions of nuclear profession after the accident will further have to be adequately addressed.

The IRRS mission identified several good practices that could be taken up in other countries including the SNSA management system, which enables the SNSA to improve its effectiveness, comprehensive information system that assists the SNSA in carrying out its responsibilities, the implementation of a comprehensive programme of monitoring of radioactivity in the environment as well as the monitoring of environmental data and their transparent publication.

The mission also made 9 recommendations and 29 suggestions for more effective administrative control which included developing a national policy and strategy for nuclear safety; exploring alternative possibilities of financing the SNSA; developing and implementing a process for carrying out a systematic review of the SNSA's organizational structure, competencies and resources; developing a long-term plan to prepare practical guidelines, which will facilitate the clients' understanding of legal requirements in the field of nuclear and radiation safety; ensuring the construction of a repository of low and intermediate level radioactive waste when necessary; promoting the organization of full scope field exercises more frequently in the field of emergency preparedness and response.

The IRRS mission members visited the Krško Nuclear Power Plant, TRIGA Research Reactor and Central Interim Storage at Brinje. Further, they paid a visit to the Ministry of Economy, the Ministry of the Environment and Spatial Planning, the Slovenian Radiation Protection Administration and the Administration for Civil Protection and Disaster Relief.

## 9.3 Cooperation with the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development

In 2011, the Republic of Slovenia continued its well-developed co-operation with the Nuclear Energy Agency (NEA) of the Organization for Economic Co-operation and Development (OECD). The mission of the NEA is to assist its member countries 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. The agency has a network of co-operation with the Atomic Energy Agency in Vienna and European Commission in Brussels and Luxembourg. The NEA implements specific scientific projects, including verification and benchmarking of scientific results, which will pave the way to further progress.

In terms of organisation, the agency has seven standing technical committees working under the auspices of the governing body of the NEA called the Steering Committee for Nuclear Energy, which reports directly to the OECD Council. The standing technical committees are comprised of experts from Member States and observers. The committees represent a specific international forum for exchange of experiences and knowledge regarding specific technical issues.

After Slovenia attained full membership in the OECD, it applied in August 2010 for membership in NEA. The Secretary-General of the OECD, Angel Gurria, informed the Nuclear Energy Agency and NEA initiated the process for admission. In January 2011, Slovenia hosted a three-member mission of the NEA, whose task was to assess the preparedness for the admission to the NEA. The report, prepared by the mission, was positively accepted in the NEA Committee on 29 April 2011. On 11 May 2011, the OECD Council confirmed the recommendation of the committee and adopted the decision on Slovenia's accession to the NEA and its databank. Thus, Slovenia became the 30$^{th}$ member of the NEA. At Slovenia's accession to the NEA, the director of the SNSA, Dr. Andrej Stritar, pointed out that the membership in the NEA brings new challenges and mutual benefit. He commended NEA as a politically neutral organization that promotes cooperation of technologically most advanced countries and enjoys a high reputation among experts for nuclear and radiation safety.

Krško NPP and the SRPA continue to participate in the International System of Occupational Exposure (ISOE). ISOE is an information system on occupational exposure in nuclear power plants, supported by the OECD/NEA and IAEA. Information system is maintained by the technical centres with the support of above mentioned organizations and with the cooperation of nuclear power plants and regulatory authorities.

## 9.4 Cooperation with Other Associations

### Western European Nuclear Regulator's Association (WENRA)

WENRA is an informal association consisting of representatives of nuclear regulatory authorities of European countries with nuclear power plants. The main objectives of WENRA are to develop a common approach to nuclear safety and to exchange experiences between the chief nuclear safety regulators in Europe.

In 2011, WENRA and its sub-committee dealt mainly with the so-called stress tests, which were conducted after the events in Japan. They have prepared a detailed basis for a programme of such stress tests. In November 2011, the WENRA Association held 24th plenary meeting. Jukka Laaksonen, the Director-General of the Finnish regulatory body STUK, handed over the management of the association to Hans Wanner, the Director-General of the Swiss Federal Nuclear Safety Inspectorate ENSI. At this meeting, members got acquainted with the work of working groups, which was followed by a discussion. The working groups were working on instructions for the harmonization of safety reference levels, which will include new power plants, reference levels for radioactive waste repository and reference levels for decommissioning.

### CAMP

Under the agreement with the US NRC (Federal administrative authority for nuclear safety of the U.S.), the SNSA participates in international research and development activities, coordinated by the US NRC in the CAMP programme (Code Application and Maintenance Programme). CAMP programme facilitates cooperation in the field of maintaining and using software to prevent and control accidents and abnormal events in nuclear power plants. Under the agreement of 2008, Krško NPP and the Jožef Stefan Institute (IJS) cooperate in this programme besides the SNSA. National coordinator for the CAMP programme is IJS, which regularly monitors CAMP activities and reports on them. With its contributions, the institute also actively participates in the development and use of the NRC computer programmes.

### Association of the Heads of European Radiological Protection Competent Authorities – HERCA

The SRPA collaborates with the Association of the Heads of European Radiological Protection Competent Authorities (HERCA). In 2011, HERCA prepared an outline draft of the document, which a patient will receive at discharge from the hospital after treatment in nuclear medicine. The document will include data on dates and activities of administered radioisotope. Members of the association signed an agreement with manufacturers of computer tomography equipment on uniform record of information relating to the exposure due to medical examinations, in order to allow comparison among them. Moreover, HERCA actively participated in the exchange of relevant data related to the accident at the nuclear power Fukushima.

### European ALARA Network

As one of 20 European countries, Slovenia is participating in the European ALARA Network (EAN). The EAN is dedicated to optimisation of radiation protection and sharing good ALARA practice in industry, research and medicine. In the EAN framework, international workshops in specific fields are organised. In addition, the EAN issues a newsletter with information on practical implementation of the ALARA principle, examples of good practice and other news. The EAN has an active role in studies conducted by the European Commission and other international organisations in radiation protection. It is also involved in other aspects of implementation of the ALARA principle in practice. In the EAN framework, there are several sub-networks. The SRPA is active in the ERPAN (European Radioprotection Authorities Network), which is dedicated to operational informational exchange on surveillance and measures in radiation protection. In 2011, the EAN organized a workshop on the application of the ALARA principles within the health sector, where the representative of the SRPA was also present.

### ESOREX

For several years, the SRPA has been involved in the European Study of Occupational Radiation Exposure (ESOREX) project. The ESOREX project is dedicated to collecting, processing and comparison of occupational doses at the international level. In the project framework, countries share experience on organisations of individual monitoring and national data registry administration. The project is supported by the European Commission, but it is not confined only to EU Member States.

## 9.5 Co-operation in the Framework of International Agreements

Slovenia is a party to numerous bilateral and multilateral agreements in the field of nuclear and radiation safety, safeguards of nuclear materials, notification and response during a nuclear accident, physical protection of nuclear objects, nuclear non-proliferation and nuclear liability.

### Bilateral Co-operation

In May 2011, a quadrilateral meeting with the Czech Republic, the Slovak Republic and Hungary was organized in Kranjska Gora. The main topics of the meeting were administrative activities in each country and administrative work associated with the eventual construction of new nuclear power plants. The developments in European affairs (WENRA, ENSREG, Hungarian experience with the EU presidency) were presented and a few words were said about the IAEA. Since it was impossible to avoid the topic of the accident in Fukushima, an extensive discussion on the EU response and, at that time, planned stress tests, radiological situation in the world after the accident in Japan, on actions taken in other countries and lessons learned, was held.

In November 2011, the annual bilateral meeting between Austria and Slovenia took place in Krško. During this thirteenth bilateral meeting, both sides described the main developments in the field of legal frameworks, administrative work, radiation monitoring, emergency preparedness and waste management. The Slovenian side presented the amendments of the Ionising Radiation Protection and Nuclear Safety Act and implementing regulations, which brought changes in the field of nuclear safety, radioactive waste and radiation protection management, liability insurance for nuclear damage, and provided training for workers in radiation and nuclear facilities. In connection with emergency preparedness, the Slovenian delegation summarized the events surrounding three incidents, namely the fire in a hot cell at the Jožef Stefan Institute, the activation of the emergency preparedness system during the Fukushima accident and automatic shut down of the Krško NPP due to loss of external load - disconnection of lines. The delegation also stressed the importance of the revised National Protection and Rescue Plan and described the course of the exercise INEX-4. Since the last bilateral meeting, the new important issue was the introduction of so-called stress tests. Austrians had questions concerning the periodic safety review of the Krško NPP and the extension of the service life as well as the replacement of reactor's head and generator stator. A special feature of this meeting was reporting of the Slovenian delegation on the experience with IRRS mission and visit of the Krško NPP.

In April 2011, at the edge of Review Meeting of the Parties to the Convention on Nuclear Safety, the chairman of the regulatory authority of the USA, Mr. Gregory Jaczko, and the SNSA director, Dr. Andrej Stritar, signed the fourth five-year agreement on cooperation and information exchange between the two institutions.

In September 2011, the director of SNSA, Dr. Andrej Stritar, and Acting Director of the Agency for Radiation and Nuclear Security of Bosnia and Herzegovina, Jovica Bošnjak, signed a Memorandum of Understanding on the exchange of information between the two authorities. Signed Memorandum will allow closer cooperation in the education of staff, especially in the field of inspection and radiation protection, and the transfer of experience in harmonizing domestic legal order with the European legislation.

## Convention on Nuclear Safety

From 4 to 14 April 2011, the fifth Review Meeting of the Parties to the Convention on Nuclear Safety (CNS) was held in Vienna, at the headquarters of the IAEA. The first week was dedicated to presentations of individual state parties. Dr. Andrej Stritar, director of the SNSA, had a presentation on 5 April. Dr. Stritar talked about key elements of the national report, prepared in mid 2010 (published on SNSA web pages), as well as about novelties that occurred from the issue of the report. He also presented answers to rapporteur's report from the previous review meeting, important events, good practices, measures planned to improve nuclear safety and summary of responses to questions, which Slovenia received to the fifth national report.

Delegates have also set the main topics for extraordinary review meeting on the consequences of accident in Fukushima, which will be held in August 2012.

## Intergovernmental Agreement on the Co-ownership of the Krško NPP

Krško NPP authorities, the Assembly, Supervisory Board and Management Board, co-exist on a parity basis and operate in accordance with the competences and responsibilities laid down in the Intergovernmental Agreement.

In 2011, the Assembly of the NPP convened three times. On the basis of Article 49 of the Intergovernmental Agreement, the Assembly inter alia adopted the Krško NPP annual report, appointed members of the Supervisory Board and gave the consent for agreements on servitudes on the plot no. 372/21 on the cadastral municipality of Stara vas for walking, driving and other emergency interventions for the construction, maintenance and repairs of power facilities »KB 20 kV Courier Krško - TP Nuclear village« in favour of the servitude beneficiary Elektro Celje.

In 2011, the Supervisory Board held six meetings. It also monitored the operation and supervised the management of the company. The basis for its work was written materials prepared by the Management Board. At each meeting, the Supervisory Board followed up the adopted decisions and views.

The Supervisory Board of the NPP has considered and adopted, in particular:

- information about economic operations,
- the long-term investment plan,
- monthly reports of the independent safety evaluation group (ISEG),
- economic plans,
- report on the status of modifications,
- report on activities and progress on the procedures for extending the service life.

It also expressed a positive opinion about the annual report.

On the basis of the fifth point of Article 40 of the Intergovernmental Agreement, the Supervisory Board gave the administration approval for the supply and replacement of the main generator rotor, the replacement of original equipment in a transformer field AC01 and the reconstruction of federal field AC02 in a new transformer field as well as for the optimization of the primary system temperature measurement.

The NPP Management Board had following members:

- Stanislav Rožman, President of the Board,
- Hrvoje Perharić, Member of the Board.

In accordance with the Intergovernmental Agreement, preparation of the Krško NPP Decommissioning Programme concluded, but it has not been confirmed by an expert council, since the Slovenian part wants to exclude one of the scenarios, which does not comply with Slovenian legislation. Negotiations have stalled due to elections in both countries. In case of a common agreement, the new harmonized Krško NPP Decommissioning Programme needs to be sent in the international review (International Atomic Energy Agency). Afterwards, the Interstate Commission of the Krško NPP has to confirm the Decommissioning Programme, which will than be the basis for setting a new contribution that companies GEN-energija d.o.o. and HEP, d.d., pay for every kWh of electricity from the Krško NPP

In 2011, the Interstate Commission for monitoring the Intergovernmental Agreement did not hold any meeting.

# 10 USE OF NUCLEAR ENERGY IN THE WORLD

At the end of 2011, there were 31 countries operating 435 nuclear reactors for electricity production. In 2011, seven new nuclear power plants were put in operation, one in Russia, one in Iran, one in India, one in Pakistan and three in China. Four nuclear power plants in Japan, one in Great Britain and eight in Germany ceased operation. The construction of 4 new nuclear power plants started in 2011, of which 2 were in India and two in Pakistan.

In Europe, there are nuclear power plants under construction in Finland, France, Ukraine and Slovakia. New builds are planned in Poland, Hungary, Czech Republic and Bulgaria. Detailed data on the number and installed power of reactors by countries is given in Table 11.

**Table 11:** Number and installed power of reactors by countries

| Country | Operational | | Under construction | |
|---|---|---|---|---|
| | No. | Power [MW] | | No. |
| **Belgium** | 7 | 5,927 | | |
| **Bulgaria** | 2 | 1,906 | | |
| **Czech Republic** | 6 | 3,766 | | |
| **Finland** | 4 | 2,736 | 1 | 1,600 |
| **France** | 58 | 63,130 | 1 | 1,600 |
| **Hungary** | 4 | 1,889 | | |
| **Germany** | 9 | 12,068 | | |
| **Netherlands** | 1 | 482 | | |
| **Romania** | 2 | 1,300 | | |
| **Russia** | 33 | 23,643 | 10 | 8,188 |
| **Slovakia** | 4 | 1,816 | 2 | 782 |
| **Slovenia** | 1 | 696 | | |
| **Spain** | 8 | 7,567 | | |
| **Sweden** | 10 | 9,331 | | |
| **Switzerland** | 5 | 3.263 | | |
| **Ukraine** | 15 | 13,107 | 2 | 1,900 |
| **Great Britain** | 18 | 9,953 | | |
| **Europe total:** | 187 | 162,580 | 16 | 14,070 |
| **Argentina** | 2 | 935 | 1 | 692 |
| **Brazil** | 2 | 1,884 | 1 | 1,245 |
| **Canada** | 18 | 12,604 | | |
| **Mexico** | 2 | 1,300 | | |
| **USA** | 104 | 101,465 | 1 | 1,165 |
| **Americas total:** | 128 | 118,188 | 3 | 3,102 |
| **Armenia** | 1 | 375 | | |
| **India** | 20 | 4,391 | 7 | 4,824 |
| **Iran** | 1 | 915 | | |
| **Japan** | 50 | 44,215 | 2 | 2,650 |
| **China** | 16 | 11,816 | 26 | 26,620 |
| **Korea, Republic of** | 21 | 18,751 | 5 | 5,560 |
| **Pakistan** | 3 | 725 | 2 | 630 |
| **Taiwan** | 6 | 5,018 | 2 | 2,600 |
| **Asia total:** | 118 | 86,206 | 44 | 42,884 |
| **South Africa** | 2 | 1,830 | | |
| **World total** | 435 | 368,804 | 63 | 60,056 |

# 11 RADIATION PROTECTION AND NUCLEAR SAFETY WORLDWIDE

The International Atomic Energy Agency maintains a reporting system for significant events in nuclear power plants, research reactors and fuel cycle facilities, as well as for events associated with radiation practices and the transport of radioactive materials, which take place in member states. This system is known as The International Nuclear and Radiological Event Scale (INES).

International reporting is carried out for more significant events rated as level 2 or above and for events that have caught the interest of international public. In 2001, an internet communication system NEWS (http://www-news.iaea.org) for the publication of event reports was established.

In 2011, 34 event reports were published in the system NEWS. The earthquake and tsunami in Japan on 11 March 2011 have had consequences in three NPPs on the east coast of Japan and 10 different INES reports with ratings 2 to 7 were published for these events. From the remaining 24 event reports, 9 reports concerned events in NPPs; 3 reports dealt with events in other nuclear facilities; 1 event was connected with transport and 3 with orphan sources; and 8 reports were on the excessive radiation exposure of workers in radiation facilities or while performing radiation practices. The reports on these events were rated as level 2 or less. Higher ratings of 4 and 3 were given only for 2 events with excessive radiation exposure at work with an irradiation device and at performance of radiography.

**The events in Japanese NPPs caused by the earthquake and tsunami on 11 March 2011**

The event in the NPP Fukushima I was given the highest rating 7 (see Chapter 2.3).

Because of the earthquake and the tsunami, the NPPs Fukushima II and Onagawa were also endangered. On 11 March 2011, the tsunami flooded the sea water cooling pumps on the Units 1, 2 and 4 of the Fukushima II NPP and consequently, the reactors lost ultimate heat sink. The safety systems managed to maintain the cooling of the nuclear fuel, but they also stopped working later on. In the meantime, the NPP personnel managed to restart the sea water cooling pumps and thus establish a normal way for cooling the reactors. Because of loss of nuclear fuel decay heat removal function, all three of these events (with a separate report for each unit) were rated as level 3 on the INES scale.

At the time of the earthquake and tsunami on 11 March 2011, the Unit 2 of the NPP Onagawa was in the process of start-up when the tsunami flooded the sea water cooling pumps room and through an underground shaft also the component cooling pumps and high pressure reactor core injection pumps of the safety train B. The train A pumps were not flooded and continued to cool off the core. Because of degradation of the defence in depth, the event was rated as level 2 on the INES scale.

**Review of the other INES reports in the year 2011**

An event in Bulgaria where workers were excessively exposed while handling an irradiation device was rated as level 4. In a radiation facility, there were 12 sealed radiation sources of $^{60}$Co with a total activity of 421 TBq enclosed in irradiation device. Because of inadequate safety measures and human errors made while handling sources, the workers inadvertently extracted a source and put it against the wall. They were exposed for 25 to 30 minutes. During this time the workers were exposed to several Sv and the irradiation had deterministic effects.

An event of level 3 occurred while handling a radiographic camera, when a radiography trainee touched the radiation source. The result were deterministic effects (blistering) on exposed fingers that touched the source.

Seven other events of level 2 were reported with excessive exposure of workers while carrying out radiography, maintenance works at a NPP, work at or repair of an accelerator, repair of industrial irradiation device and work with isotopes in a medical laboratory.

Among events with orphan sources, there was an event of level 1, which received a lot of public attention, when the radiation source of $^{226}Ra$ of estimated activity 660 MBq was found in a children playground (Figure 28, from http://www.sujb.cz/?c_id=1118). Elevated radiation in the children playground was accidentally measured by a citizen who had a wristwatch with a radiation measurement device. The measurement of contact dose rate was 150 mSv/h. In the past, the source was probably used in radiotherapy. The event analysis showed that no health effects of the source to the population can be expected.

**Figure 28:** Source $^{226}Ra$ found in a children playground

An event involving improper handling of a radiation source $^{226}Ra$ was rated with level 1. The source was removed from a lightning rod, disassembled and placed under a desk of a worker for a period of one month without any shielding, which resulted in excessive exposure of the worker. Another level 1 event occurred in a foundry, where a $^{137}Cs$ source with estimated activity of 1.5 GBq was melted in an electric furnace. This caused the scattering of the source and the contamination of equipment and products, while workers were not exposed. An event when radiographic equipment was stolen from a parked truck was rated with level 2. Inside the stolen radiographic camera was a $^{192}Ir$ source with activity of 1.25 TBq.

In the USA, a strong earthquake on 23 August 2011 caused a shut down of two Units of NPP North Anna. The event was rated as level 0. Due to loss of offsite power to the plant, an emergency was declared with the level of alert. Other twelve NPPs and two research reactors on the East of the USA declared emergencies of the lowest level, unusual event after the earthquake, but these emergencies were terminated shortly after the facilities were inspected.

At NPPs in France safety inspections of spent fuel pools were performed in the scope of measures resulting from the Fukushima accident. Two of the pools turned out not to be in compliance with the design which could result in draining out the pools in the case of an earthquake. Based on degradation of defence in depth, the event was rated with the level 2. Three other events in NPPs were rated with a level 2 due to the degradation of safety systems or incorrect settings that were not sufficient to fulfil design requirements for safety systems.

An event which occurred during EURATOM and IAEA nuclear materials safeguards inspection was rated with level 2. During the inspection, a vessel containing plutonium felt on the ground, due to which the contamination spread in the room and adjacent rooms. Three persons, two inspectors and a worker of the company, were contaminated in the event. Estimated doses due to external and internal contamination were small and would not reach the limit of 20 mSv in a period of 50 years. There were also two level 1 reports on events in facilities for the treatment of radioactive waste. One was an explosion in a furnace, while another was a fire in the filtration unit of the decon—tamination machine.

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