REPORT ON NUCLEAR AND RADIATION SAFETY IN UKRAINE FOR 2016

The Report on Nuclear and Radiation Safety in Ukraine for 2016 has been developed by the SNRIU editorial board composed of: **Borys Stoliarchuk**, Acting Chairman, **Ganna Gavryuk**, Head of Organizational Activity and Management Support Sector, **Oleksandr Grygorash**, Deputy Director of Nuclear Installation Safety Directorate, **Oleksii Dybach,** Scientific Director of SSTC NRS, **Taras Kozulko**, Head of Information-Analytical Support and Public Relations Sector, **Iryna Kostenko**, International Cooperation and European Integration Division, **Tetiana Kytuzova**, Head of Emergency Preparedness and Radiation Protection Division, **Sergii Lopatin**, Head of Nuclear Security and Safeguards Department, **Vira Matveeva**, Head of Legal Department, **Natalia Rybalka**, Head of Radioactive Waste Management Department, **Viktor Ryazantsev**, Head of Radiation Safety Department, and **Katerina Stavnichuk**, SSTC NRS Leading Expert on Media and Public Relations.

The SNRIU expresses its gratitude for assistance in preparing the Report on Nuclear and Radiation Safety in Ukraine for 2016 to the Energoatom Company, State Agency of Ukraine on Exclusion Zone Management, and SSTC NRS. The Report on Nuclear and Radiation Safety in Ukraine for 2016 uses illustrations from open sources.

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2. YEAR 2016 IN DETAILS

Day	Month/Event
	January
16	SNRIU Order No. 228 of 21 December 2015 "On Amendment of the Procedure for State Inventory of Radioactive Waste" was registered in the Ministry of Justice of Ukraine by No. 83/28213
	SNRIU Order No. 233 of 24 December 2015 "On Approval of Requirements for Systems for Nuclear Fuel Emergency Cooling and Heat Removal to Ultimate Heat Sink" was registered in the Ministry of Justice of Ukraine by No. N 77/28207
	SNRIU Order No. 234 of 24 December 2015 "On Approval of Power Supply Systems Important to Safety of Nuclear Power Plants" was registered in the Ministry of Justice of Ukraine by No. 77/28208
27	Cabinet Resolution No. 89 "On Amendment of the Procedure for Development and Approval of Regulations, Rules, and Standards on Nuclear and Radiation Safety" was approved
	February
4	Based on SSE ChNPP application and respective documents, SNRIU issued individual permit series OD No. 000033/10 for operation of the Shelter Integrated Automated Monitoring System (IAMS)
11	SNRIU Order No. 15 approved amendments to the "Requirements for Safety Assessment of Nuclear Power Plants" (NP 306.2.162-2010), which was registered in the Ministry of Justice of Ukraine on 29 February 2016 by No. 303/28433
29	SNRIU Order No. 15 of 11 February 2016 "On Amendment of Requirements for Safety Assessment of Nuclear Power Plants" was registered in the Ministry of Justice of Ukraine by No. 303/28433
	March
8-10	Ukrainian delegation headed by SNRIU Chairman, Serhii Bozhko, took part in the NRC's 28th Regulatory Information Conference (RIC 2016) held in Washington D.C. (USA)
21	SNRIU Order No. 39 approved the "Instruction on Keeping Records of Citizens' Appeals at the State Nuclear Regulatory Inspectorate of Ukraine", which was registered in the Ministry of Justice of Ukraine on 8 April 2016 by No. 529/28659
25	SSE CRME received License No. OV 001050 for treatment and storage of radioactive waste in operation of the centralized facility for long-term storage of spent radiation sources regarding comprehensive hot tests
	April
8	SNRIU Order No. 39 of 21 March 2016 "Instruction on Keeping Records of Citizens' Appeals at the State Nuclear Regulatory Inspectorate of Ukraine" was registered in the Ministry of Justice of Ukraine by No. 529/28659
14	SNRIU issued individual permit series OD No. 000040/9 for operations on unloading of damaged spent nuclear fuel from power units 1 and 2 and its transfer to the wet interim spent fuel storage facility (ISF-1) for safe placement and storage

May	
31-2	SNRIU experts participated in general anti-diversion and emergency exercises at Khmelnitsky NPP involving full activation of the SNRIU IEC
June	
8	Cabinet of Ministers adopted Resolution No. 358 "On Functioning of Territorial Bodies of the State Nuclear Regulatory Inspectorate of Ukraine", according to which SNRIU territorial bodies were transformed to structural subdivisions of the SNRIU headquarters
July	
1	Cabinet Resolution No. 405 "On Amendment of the Procedure for Using Funds Envisaged in the State Budget for Keeping the State Register of Radiation Sources" was approved
27	Joint Order 724/110 of the Ministry of Internal Affairs and SNRIU approved the "Procedure for Information Interaction between the State Emergency Service of Ukraine and State Nuclear Regulatory Inspectorate of Ukraine for Prevention of and Response to Emergencies" (NP 306.1.207-2016), which was registered in the Ministry of Justice of Ukraine on 23 August 2016 by No. 1175/29305
August	
23	Order 724/110 of the Ministry of Internal Affairs and SNRIU of 27 July 2016 "Procedure for Information Interaction between the State Emergency Service of Ukraine and State Nuclear Regulatory Inspectorate of Ukraine for Prevention of and Response to Emergencies" was registered in the Ministry of Justice of Ukraine by No. 1175/29305
30	SNRIU held public hearings on long-term operation of ZNPP unit 1 in the town of Energodar, Zaporizhzhya region
September	
5-9	SNRIU and SSTC NRS representatives took part in a workshop under the joint Ukrainian–US project on construction of a dry spent fuel storage facility held in Chicago, Illinois (USA)
13	Positive findings of the NRS regulatory review for the Periodic Safety Review Report and comprehensive inspection convinced the SNRIU Board that safe operation of Zaporizhzhya NPP unit 1 at power levels determined in the design is justified until 23 December 2025
19	SNRIU held public hearings on long-term operation of ZNPP unit 2 in the town of Energodar, Zaporizhzhya region
26-29	SNRIU experts took part in practical training in real contamination conditions in the Chornobyl exclusion zone, which involved 12 mobile laboratories for radioactivity measurement in the environment
27-29	Self-assessment of Ukrainian regulations on decommissioning for compliance with the WENRA reference levels was presented at the 37th meeting of the WENRA working group
	Retrieval of radioactive waste from the Vakulenchuk disposal facility in the Zhytomyr region, resulting from the former USSR's military programs, was started
October	
3	Positive findings of the NRS regulatory review for the Periodic Safety Review Report and comprehensive inspection convinced the SNRIU Board that safe

	operation of Zaporizhzhya NPP unit 2 at power levels determined in the design is justified until 19 February 2026
5	SNRIU amended License EO No. 001018 of 10 October 2013 for construction and commissioning of the neutron source based on a subcritical assembly driven by an electron accelerator. The amendments extended the license until 1 December 2018
5-6	SNRIU experts took part in the ConvEx-2d emergency exercises on the scenario of a simulated accident at Cernavoda NPP in Romania conducted by the IAEA's Incident and Emergency Center under the Convention on Early Notification of a Nuclear Accident and Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, involving partial activation of the SNRIU IEC and application of the RODOS system
11	Cabinet Resolution No. 702 "On Amendment of Cabinet Resolutions No. 1471 of 25 December 1997 *On Approval of the Procedure for Verification of Individuals to Issue Permits for Special Activities at Nuclear Facilities with Nuclear Materials, Radioactive Waste, and Other Radiation Sources* and No. 625 of 26 April 2003 *On Approval of the Procedure for Determining the Level of Physical Protection of Nuclear Facilities, Nuclear Materials, Radioactive Waste, and Other Radiation Sources According to Their Category*" was approved
17	SNRIU Order No. 175 approved the "Requirements for Seismic Design and Seismic Hazard Assessment of Nuclear Power Plants", which were registered in the Ministry of Justice on 7 November 2016 by No. 1449/29579
18	SNRIU Order No. 176 approved the Procedure for Preparation, Approval, State Registration, and Accounting of Regulations on Nuclear and Radiation Safety and cancelled the following SNRIU Orders: - No. 66 of 23 May 2003: On Approval of the Procedure for Development and Issue of Regulations and Standards on Nuclear and Radiation Safety by the State Nuclear Regulatory Committee of Ukraine; - No. 48 of 22 March 2004: On Amendment of the Procedure for Development and Issue of Regulations and Standards on Nuclear and Radiation Safety by the State Nuclear Regulatory Committee of Ukraine, approved by SNRIU Order No. 66 of 23 May 2003; - No. 78-a of 4 May 2004: On Amendment of the Procedure for Development and Issue of Regulations and Standards on Nuclear and Radiation Safety by the State Nuclear Regulatory Committee of Ukraine; - No. 107 of 17 June 2004: On Amendment of the Procedure for Development and Issue of Regulations and Standards on Nuclear and Radiation Safety by the State Nuclear Regulatory Committee of Ukraine
November	
3	SNRIU Board Resolution No. 8 agreed conclusions of the NRS regulatory review for the Preliminary Safety Analysis Report on the Centralized Spent Fuel Storage Facility
22	New Agreement on Cooperation between the State Nuclear Regulatory Inspectorate of Ukraine and Swedish Radiation Safety Authority in the Field of Nuclear and Radiation Safety was signed
29	The Arch was moved from the installation site and placed above the Shelter in its design position

December	
1	Board meeting was convened to address approaches to licensing of NSC operation
6	SSE ChNPP decision "On Recognition of ChNPP Units 1, 2, and 3 as Radioactive Waste Management Facilities in the Decommissioning Process" was agreed
9	SNRIU Order No. 15 approved amendments of the "Requirements for NPP On-Site and Off-Site Emergency Centers" (NP 306.2.02/3.077-2003), which were registered in the Ministry of Justice of Ukraine on 28 December 2016 by No. 1725/29855
28	SNRIU Order No. 201 of 9 December 2016 "On Amendment of the Requirements for NPP On-Site and Off-Site Emergency Centers" was registered in Ministry of Justice by No. 1725/29855

3. SAFETY OF NUCLEAR INSTALLATIONS

Ukraine operates 15 power units, ranks the tenth in the world for this indicator, and takes the seventh place in the installed capacity. The only operator of all operating nuclear power plants in Ukraine is the National Nuclear Energy Generating Company Energoatom. The Energoatom Company manages four nuclear power plants.

The total installed capacity of operating Ukrainian nuclear power units is 13,835 MW.

In 2016, NPPs produced 81.2 billion kW*h of electricity, constituting 52.4% of the total electricity production in Ukraine. The NPP installed capacity factor was 66.6% in 2016.

Ukraine ensures stable and safe operation of NPPs under the Law of Ukraine "On Nuclear Energy Use and Radiation Safety" and the Convention on Nuclear Safety. Safety improvement measures are under implementation at operating NPPs of Ukraine on a systematic basis in compliance with national regulations and standards on nuclear and radiation safety and recommendations of the International Atomic Energy Agency (IAEA), taking into account best international practices.

Peer reviews of WANO[1] and IAEA confirmed operational safety of Ukrainian NPPs and validity of safety upgrades implemented under safety improvement and long-term operation programs.

3.1. NPP Safety Improvement

The safety improvement measures at Ukrainian NPPs are under implementation in compliance with the "Comprehensive (Integrated) Safety Improvement Program for Operating Nuclear Power Units" (C(I)SIP), approved by Cabinet Resolution No. 1270 of 7 December 2011. The Cabinet Resolution of 30 September 2015 extended the C(I)SIP by 2020. The C(I)SIP objective is to:

- further improve operational safety of NPP units;
- decrease risks of NPP accidents during natural disasters or other hazards;
- improve the effectiveness in management of design-basis and beyond design-basis accidents at NPPs and minimize their consequences.

The C(I)SIP is based on safety improvement measures of the previous program "Concept for Safety Improvement of Operating Nuclear Power Units" (approved by the Cabinet Resolution on 13 December 2005) that had not been implemented by the operating organization by the end of the Concept and safety upgrades for Khmelnitsky-2 and Rivne-4 that were implemented during commissioning of these units.

The C(I)SIP also takes into account results and recommendations of the IAEA design safety review mission conducted at all NPPs under the Memorandum of Understanding in the Field of Nuclear Energy between Ukraine and EC.

After the Fukushima accident, the program included additional measures upon extraordinary in-depth safety reassessment for Ukrainian NPPs (stress tests) and additional fire safety measures. Safety improvement measures are among conditions for long-term operation of NPPs. The design-basis lifetime of seven Ukrainian NPP units expires in a period from 2016 to 2020 (see Table 3.1).

[1] WANO is the World Association of Nuclear Operators

Table 3.1. **Data on Ukrainian NPP Units**

NPP	Unit No.	Reactor Type	Expiration of design-basis/long-term operation period
ZNPP	1	VVER-1000/320	23.12.2015/23.12.2025
	2	VVER-1000/320	19.02.2016/19.12.2026
	3	VVER-1000/320	05.03.2017
	4	VVER-1000/320	04.04.2018
	5	VVER-1000/320	27.05.2020
	6	VVER-1000/320	21.10.2026
SUNPP	1	VVER-1000/302	02.12.2013/02.12.2023
	2	VVER-1000/338	12.05.2015/31.12.2025
	3	VVER-1000/320	10.02.2020
RNPP	1	VVER-440/213	22.12.2010/22.12.2030
	2	VVER-440/213	22.12.2011/22.12.2031
	3	VVER-1000/320	11.12.2017
	4	VVER-1000/320	07.06.2035
KhNPP	1	VVER-1000/320	13.12.2018
	2	VVER-1000/320	07.09.2035

In 2016, within C(I)SIP regulatory support, SNRIU agreed 63 reports on implementation of safety measures. As a total, 92 measures were planned for 2016.

According to C(I)SIP schedules, the main efforts of the operating organization in 2016 were focused on the development and implementation of measures for ZNPP units 2 and 3 and RNPP unit 3 within long-term operation activities. The experience in measures taken at the so-called pilot units is further extended to other operating power units.

Modifications important to safety of nuclear installations (change in nuclear installation configuration, bringing a nuclear installation into compliance with current regulations and standards, changes in operational documents, modification of the operating organization's structure) are implemented upon agreement with the SNRIU.

SNRIU constantly monitors all stages of modifications (concept development, installation and pre-commissioning, introduction into trial and/or commercial operation) through safety assessment of submittals and agreement of appropriate technical decisions, as well as through direct supervision over modifications, introduction of changes to operational documentation and staff training. The results are discussed at open meetings of the SNRIU Board involving all stakeholders, including the public and mass media.

During the year, the SNRIU conducted comprehensive inspections of each NPP site, international experts being involved as well. One of the main tasks is to verify implementation of safety improvement measures.

At the beginning of 2013, the SNRIU jointly with the Ministry for Energy and Coal Industry, Ministry of Defense, Ministry for Environment and Natural Resources and State Agency on Exclusion Zone Management developed the National Action Plan upon Stress-Test Results aimed at improving the safety of Ukrainian NPPs.

This document was developed in compliance with the National Action Plan (NAcP) Guidance as directed within the ENSREG Stress Test Action Plan.

The National Action Plan upon Stress-Test Results incorporates:

- ENSREG recommendations and proposals set forth in the “Compilation of recommendations and suggestions. Peer review of stress tests performed on European nuclear power plants” in areas such as external extreme hazards, loss of safety functions, and management of severe accidents;
- basic issues of the Extraordinary Meeting of the Contracting Parties to the Convention on Nuclear Safety (August 2012, Vienna, Austria) in areas such as national organizations, emergency preparedness and response, and international cooperation.

The draft National Action Plan was presented on 5 March 2013 at the open meeting of the SNRIU Board with involvement of interested ministries/departments/organizations and the public. The National Plan revised to incorporate stakeholder’s proposals was submitted by the SNRIU to ENSREG for further joint discussion by all ‘stress-test’ countries in Brussels in April 2013.

The National Plan of Ukraine was positively evaluated by the ‘stress-test’ countries, recognized as transparent and complying with the structure proposed by ENSREG, and covering all the aspects mentioned in the ENSREG action plan. The National Plan was discussed and approved at an ENSREG public meeting with stakeholders, including non-governmental organizations and mass media.

EU states and neighboring countries that took part in the stress tests (Ukraine and Switzerland) reached agreements for further periodic exchange of information on the implementation of the National Action Plans and transparency and openness of the process.

The status of national action plans upon stress tests of the participating countries was reviewed and discussed at the ENSREG workshop in April 2015. In preparation for the ENSREG workshop, the National Action Plan upon Stress-Test Results (2013) was updated to take into account recommendations set forth in the “ENSREG Post-Fukushima National Action Plans Workshop 20-24 April 2015. Terms of Reference”. It should be noted that the number of measures planned for operating NPPs and Chornobyl NPP and the scope of measures remained unchanged in the updated National Action Plan. The updated National Action Plan specified the status of safety upgrades and their schedule.

The updated National Action Plan upon Stress-Test Results can be found on the SNRIU official website.

3.2. Safety Review and Long-Term Operation of Nuclear Installations

3.2.1. Safety Review and Long-Term Operation of NPPs

Thirty-year design-basis life is established for Ukrainian NPPs. Eleven power units were commissioned in the 1980s–1990s. The Government of Ukraine decided to continue operation of NPP units as reflected in the "Energy Strategy of Ukraine until 2030" and "Comprehensive Work Program for Long-Term Operation of Nuclear Power Plant Units".

In a period from 2017 to 2020, the design-basis life of six NPP units in Ukraine (see Table 3.1) expires. SNRIU will be required to make decisions on life extension for two power units at the same time.

In accordance with current legislation, a decision on long-term operation of a power unit is made by the SNRIU based upon conclusions of state nuclear and regulatory safety review of the periodic safety review report (PSRR) by amending the license for its operation. Long-term operation may be allowed only if the safety level of the NPP unit is not lower than that established by current regulations and rules on nuclear and radiation safety.

The PSRR is based upon a substantial scope of efforts, in particular, related to:

- assessment of current technical condition of power unit components and structures and their lifetime extension;
- elimination of deviations from NRS regulations, rules and standards adopted during the last years;
- implementation of safety upgrades planned under C(I)SIP;
- implementation of measures upon results of the Fukushima events and stress tests;
- equipment qualification for harsh environments and seismic events and seismic evaluation of NPP piping, buildings and structures;
- implementation of the ageing management program for NPP components and structures;
- in-depth safety analysis applying deterministic and probabilistic methods;
- enhancement of operational safety through improvement of operational and emergency documentation;
- improvement of the management system to be in compliance with NRS regulations and rules, IAEA recommendations and best international practices;
- improvement of emergency preparedness system.

In accordance with NRS regulations, rules and standards, the PSRR is finalized as individual reports based upon assessment of 14 safety factors:

- plant design;
- current condition of systems and components;
- equipment qualification;
- ageing;
- deterministic safety analysis;
- probabilistic safety assessment;
- internal and external hazard analysis;
- safety performance;
- use of experience from other plants and research findings;
- organization and administration;
- operating procedures;
- human factor;
- emergency preparedness and response;

- environmental impact.

This approach complies with IAEA recommendations and best international practices and allows a comprehensive assessment of the power unit safety to make a sound decision on further operation of the power unit, including long-term operation.

For Zaporizhzhya NPP units 1, 2, and 3 and Rivne NPP unit 3 with VVER-1000/320 reactors, whose design-basis life expires in 2016–2017, Energoatom chose the "second option" for their lifetime extension in compliance with NP 306.2.099-2004 "General Requirements for Long-Term Operation of Nuclear Power Plant Units Based on Periodic Safety Review" such as: "shutdown of the power unit after its design-basis life expires and implementation of organizational and technical measures to continue and recommence operation". For each of the above-mentioned units, the SNRIU agreed long-term operation programs and licensing plans, in compliance with which Energoatom conducts respective activities and submits associated reports to the SNRIU.

The results of these activities serve as the basis for PSRR submitted to the SNRIU for consideration and NRS regulatory review.

3.2.2. Long-Term Operation of Zaporizhzhya NPP Units 1 and 2

In the framework of long-term operation of ZNPP units 1 and 2, the SNRIU agreed all technical decisions on lifetime extension of equipment, piping, and civil structures of the power units and agreed results of the following activities in full scope:

- equipment qualification for harsh environments and seismic impacts;
- assurance of seismic stability of equipment, piping and structures.

The results of the above activities served as the basis for PSRR of ZNPP units 1 and 2, which passed NRS review.

The open meetings of the SNRIU Board on 13 September and 3 October 2016 were held to discuss the topics "On Long-Term Operation of Zaporizhzhya Unit 1 Based on Periodic Safety Review" and "On Long-Term Operation of Zaporizhzhya Unit 2 Based on Periodic Safety Review". The meetings were attended by Board members and SNRIU staff, Energoatom executive staff, authorized representatives of the Ministry for Energy and Coal Industry and Ministry for Environment and Natural Resources, representatives of SSTC NRS, Verkhovna Rada Committee for Fuel and Energy System, Nuclear Policy and Nuclear Safety, EBRD, public organizations, and mass media.

Positive findings of the NRS regulatory review for the Periodic Safety Review Reports and comprehensive inspections at Zaporizhzhya units 1 and 2 convinced the SNRIU Board that safe operation of Zaporizhzhya NPP unit 1 is justified until 23 December 2025 and that of Zaporizhzhya NPP unit 2 until 19 February 2026.

Based on review of Energoatom Application No. 6801/06 of 8 May 2015 for amendment of License No. 000196 for operation of Zaporizhzhya NPP nuclear installations in connection with long-term operation of ZNPP unit 1 at established power levels after expiration of its design lifetime, on 14 September 2016 the SNRIU amended License EO No. 000196 and issued License No. EO001052 for operation of Zaporizhzhya NPP unit 1.

Based on review of Energoatom Application No. 9607/06 of 3 July 2015 for amendment of License No. 000196 for operation of Zaporizhzhya NPP nuclear installations in connection with long-term operation of ZNPP unit 2 at established power levels after expiration of its design lifetime, on 3 October 2016 the SNRIU amended License EO No. 000196 and issued License No. EO001055 for operation of Zaporizhzhya NPP unit 2.

3.2.3. Preparation of Nuclear Power Plant Units for Long-Term Operation and Safety Review

During 2016, efforts for preparation of ZNPP unit 3 and RNPP unit 3 for long-term operation were continued.

Activities at ZNPP unit 3 are conducted in compliance with the “Program for ZNPP Unit 3 Preparation for Long-Term Operation. 03.MP.00.PM.21-16/N” and “Licensing Plan for Long-Term Operation of Zaporizhzhya NPP Unit 3. 03.OK.PN.05-15”, which were agreed by the SNRIU.

For ZNPP unit 3 components and structures, the SNRIU agreed all working programs on assessment of their technical condition and service life. Based on the results of these activities, 29 technical decisions on their lifetime extension (out of 46) were agreed by the SNRIU.

ZNPP unit 3 equipment qualification for harsh environments and seismic impacts is underway (within C(I)SIP measure No. 10101).

The results of activities on confirmation of seismic resistance of ZNPP unit 3 buildings and structures were agreed by the SNRIU.

Assessment of ZNPP unit 3 equipment and piping seismic resistance is underway (within C(I)SIP measure No. 18101).

Activities at RNPP unit 3 are conducted in compliance with the “Program for RNPP Unit 3 Preparation for Long-Term Operation. 191-19-PR-PSE-13” and “Licensing Plan for Long-Term Operation of Rivne NPP Unit 3. 191-01-PL-PSE-14”, which were agreed by the SNRIU.

For RNPP unit 3 components and structures, the SNRIU agreed all working programs on assessment of their technical condition and service life and 10 technical decisions on their lifetime extension (out of 45).

RNPP unit 3 equipment qualification for harsh environments and seismic impacts is underway (within C(I)SIP measure No. 10101).

The results of activities on confirmation of seismic resistance of RNPP unit 3 buildings and structures were agreed by the SNRIU.

Assessment of RNPP unit 3 equipment and piping seismic resistance is underway (within C(I)SIP measure No. 18101).

In addition, as of the end of 2016, within periodic safety review of NPP units, the SNRIU:

1) Conducted state nuclear and radiation safety review of reports on assessment of 11 of the 14 safety factors in the ZNPP-3 PSRR, among them the reports on eight safety factors (plant design, safety performance, use of experience from other plants and research findings, organization and administration, operating procedures, human factor, emergency preparedness and response, environmental impact) were agreed by the SNRIU after the operating organization resolved comments of the NRS review. The operating organization is revising the reports on assessment of three safety factors (deterministic safety analysis, probabilistic safety assessment, internal and external hazard analysis) to incorporate comments of NRS review and is developing reports on assessment of three safety factors such as current condition of systems and components, equipment qualification, and ageing, as well as the "Comprehensive Safety Analysis" Chapter;

2) Conducted state nuclear and radiation safety review of reports on assessment of 9 of the 14 safety factors in the ZNPP-4 PSRR, among them the reports on seven safety factors (safety performance, use of experience from other plants and research findings, organization and administration, operating procedures, human factor, emergency preparedness and response, environmental impact) were agreed by the SNRIU after the operating organization resolved comments of the NRS review. The operating organization is revising the reports on assessment of two safety factors (plant design, deterministic safety analysis) to incorporate comments of NRS review and is developing reports on assessment of five safety factors (probabilistic safety assessment, internal and external hazard analysis, current condition of systems and components, equipment qualification, ageing) and the "Comprehensive Safety Analysis" Chapter;

3) Conducted state nuclear and radiation safety review of reports on assessment of 11 of the 14 safety factors in the RNPP-3 PSRR, among them the reports on seven safety factors (safety performance, use of experience from other plants and research findings, organization and administration, operating procedures, human factor, emergency preparedness and response, environmental impact) were agreed by the SNRIU after the operating organization resolved comments of the NRS review. Nuclear and radiation safety review of reports on assessment of three safety factors (current condition of systems and components, equipment qualification, ageing) has been started. The operating organization is revising the reports on assessment of four safety factors (plant design, deterministic safety analysis, probabilistic safety assessment, internal and external hazard analysis) to incorporate comments of NRS review and is developing the "Comprehensive Safety Analysis" Chapter.

The safety review of Ukrainian NPPs and preparation for long-term operation undertaken by the operating organization are under strict supervision of the SNRIU.

3.3. NPP Operational Events (2000-2016)

Operating experience feedback is one of the key methods to ensure and further improve operational safety of NPPs, which includes recording and analysis of operational events and implementation of corrective measures to mitigate the causes and prevent the recurrence of events. NPP operational events are among the most important indicators of operational safety.

In 2016, 12 operational events occurred at 15 VVER units in commercial operation in Ukraine. There were no events at the Chornobyl NPP in 2016.

Distribution of events by NPP sites is as follows:

- 6 events at ZNPP (6 power units in commercial operation);
- 5 events at SUNPP (3 power units in commercial operation);
- no events at KhNPP (2 power units in commercial operation);
- 1 event at RNPP (4 power units in commercial operation).

Figure 3.3.1 presents the distribution of operational events at Ukrainian NPPs (without ChNPP) from 2000 to 2016. There were 12 operational events at Ukrainian NPPs in 2016.

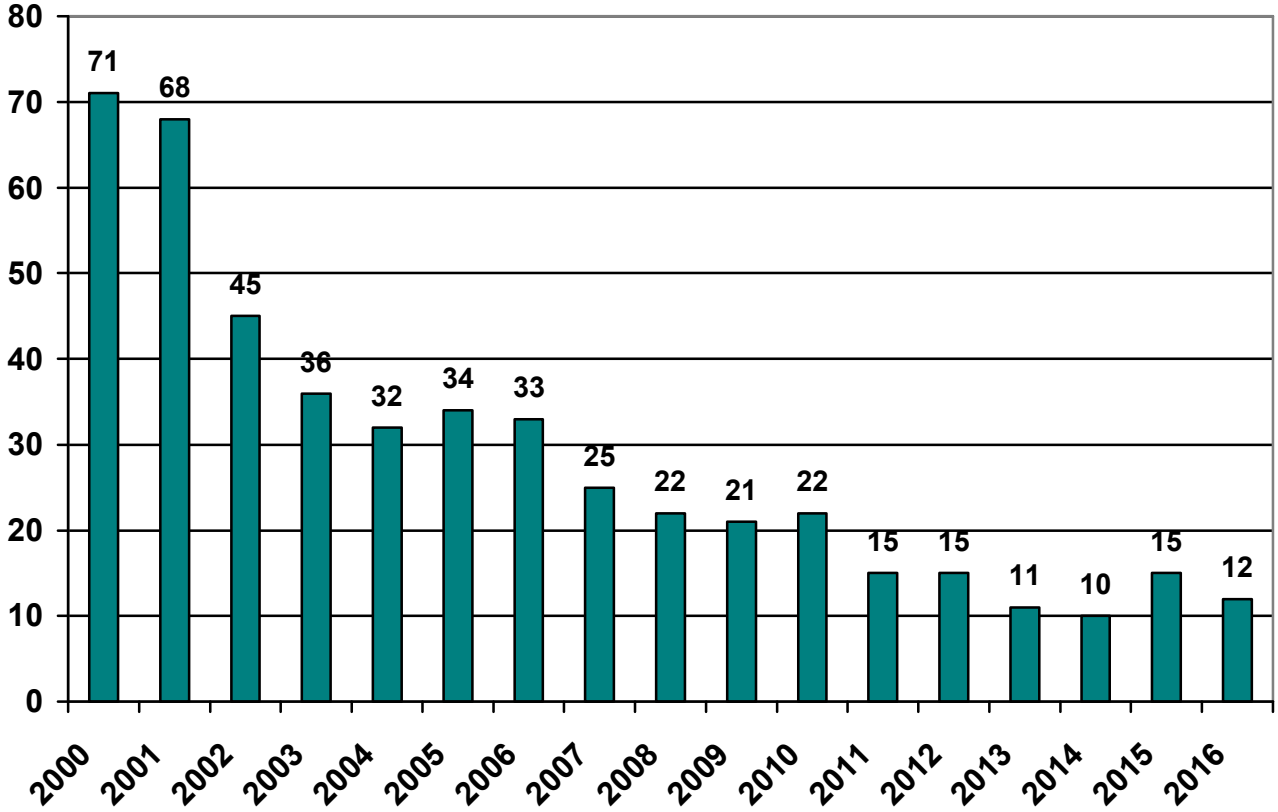


Figure 3.3.1. **Number of operational events at Ukrainian NPPs in 2010-2016**

Figure 3.3.2 presents distribution of events by NPP sites in 2000-2016.

As compared to the previous year, the number of events in 2016 decreased at ZNPP and increased at SUNPP and RNPP. There were no events at KhNPP in 2016.

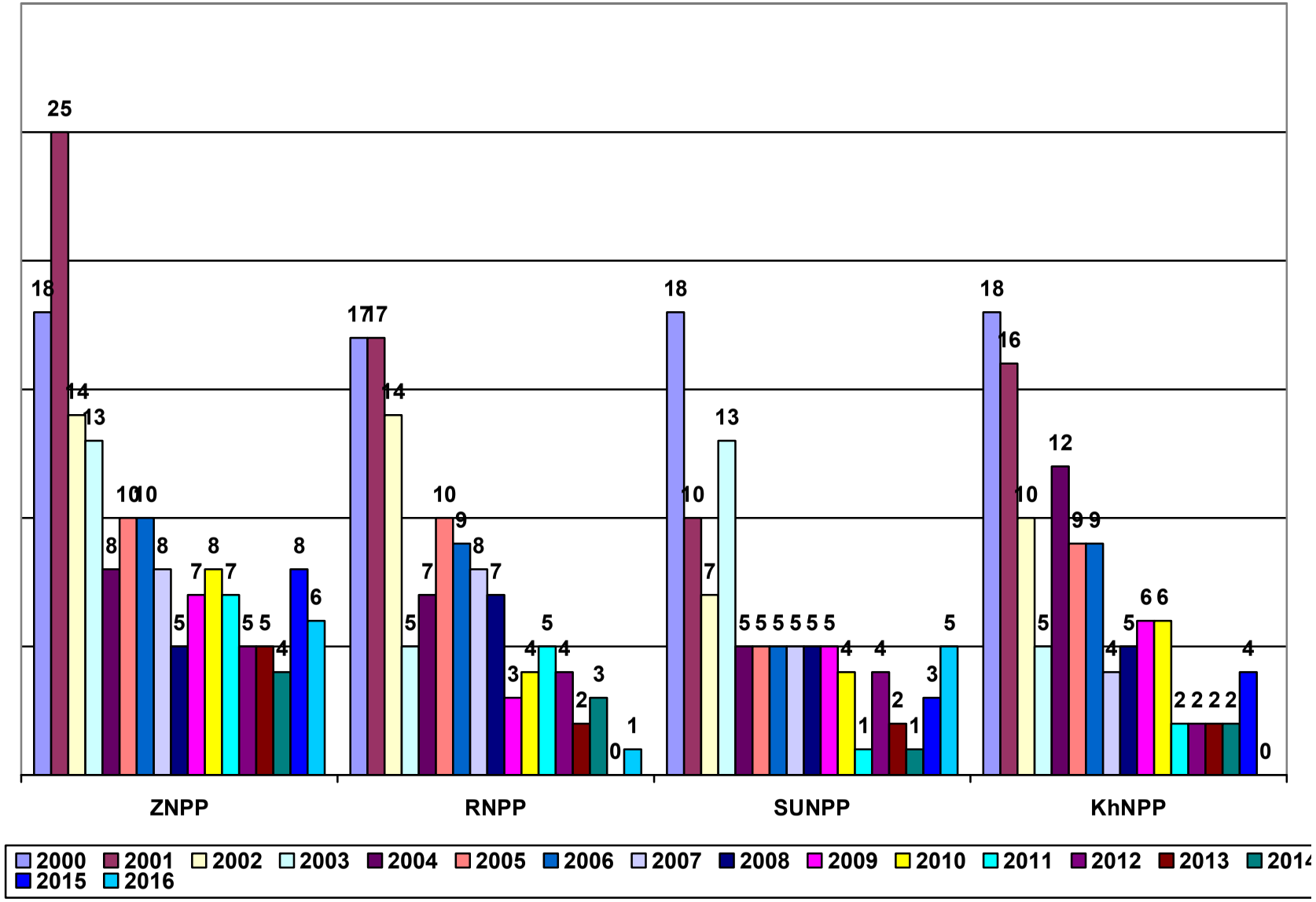


Figure 3.3.2. **Distribution of events by NPP sites in 2000-2016**

According to INES, the worldwide instrument developed to inform the public on significance of nuclear and radiological events for safety, all events were classified as “below scale/level 0” (insignificant for safety) in 2016. Figure 3.3.3 presents the number of operational events at Ukrainian NPPs in 2000-2016 classified on the INES scale, which shows that there have been no safety-significant events in the recent years.

In 2016, there were no events that caused overexposure of personnel or radioactive release to the environment. Safe operation limits and conditions were complied with in NPP operation. Neither were there events associated with unavailability of safety systems or events that caused drop and/or damage of fuel assemblies and fuel rods.

Depending on features and consequences, NPP operational events in 2016 included the following:

- reactor shutdown with scram, preventive protection, power limiter – 2 events – 17%;
- power unit disconnection from the grid by emergency automatics, turbine and turbine generator protection – 3 events – 25%;
- failure of equipment and piping important to safety – 1 event – 6%;
- power decrease by 25% $N_{ELECT}P$ and higher – 3 events – 25%;
- unavailability of a safety system train (trains) over a period that does not exceed the one allowed in the Technical Specifications on Safe Operation – 3 events – 25%.

NPP operational events are accompanied by deviation from normal operation (abnormal event) that can be caused by equipment failure, external impact, human error or procedural drawbacks. Figure 3.3.4 presents the distribution according to systems that failed or were affected during abnormal events in 2016.

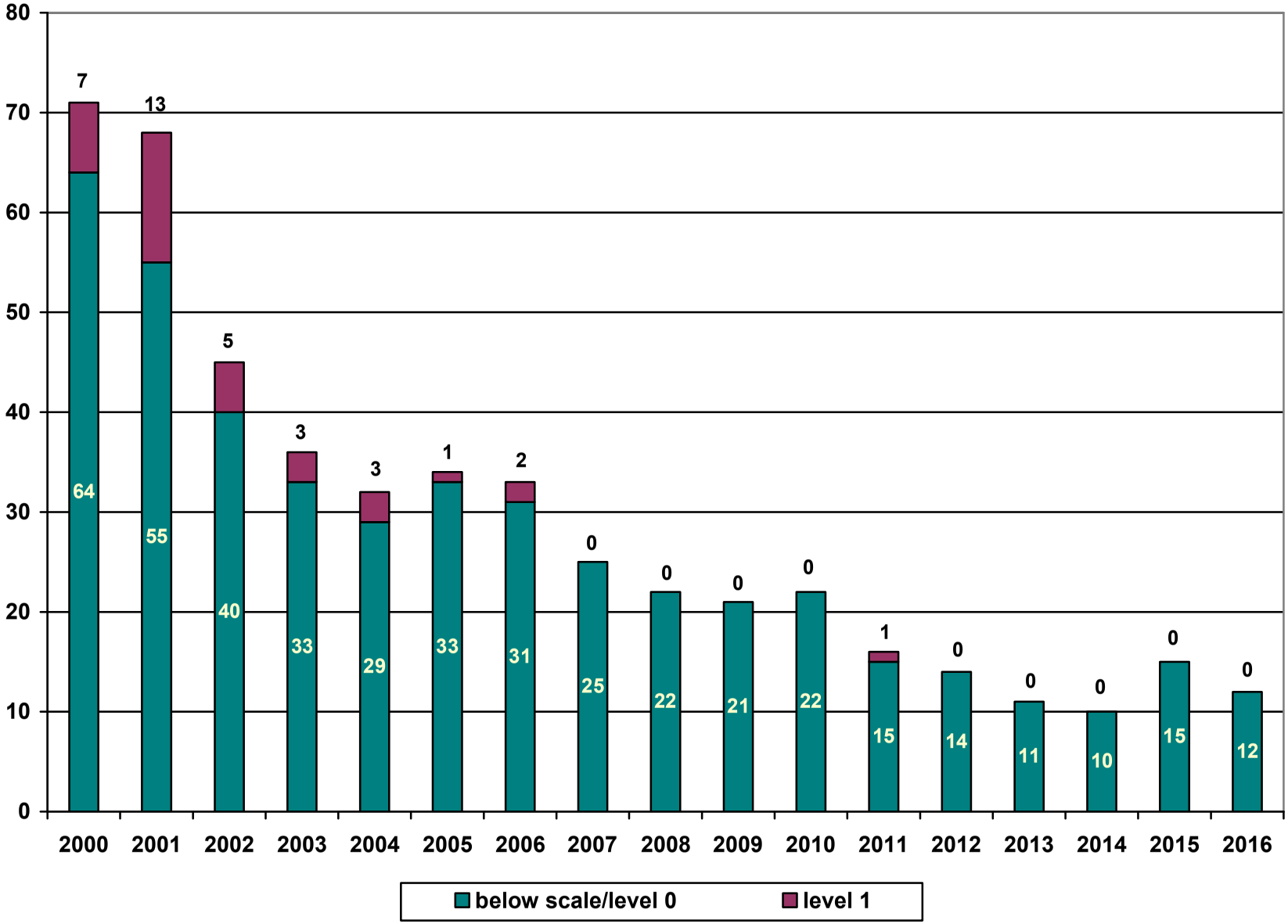


Figure 3.3.3. **Number of operational events at Ukrainian NPPs classified on the INES scale in 2000-2016**

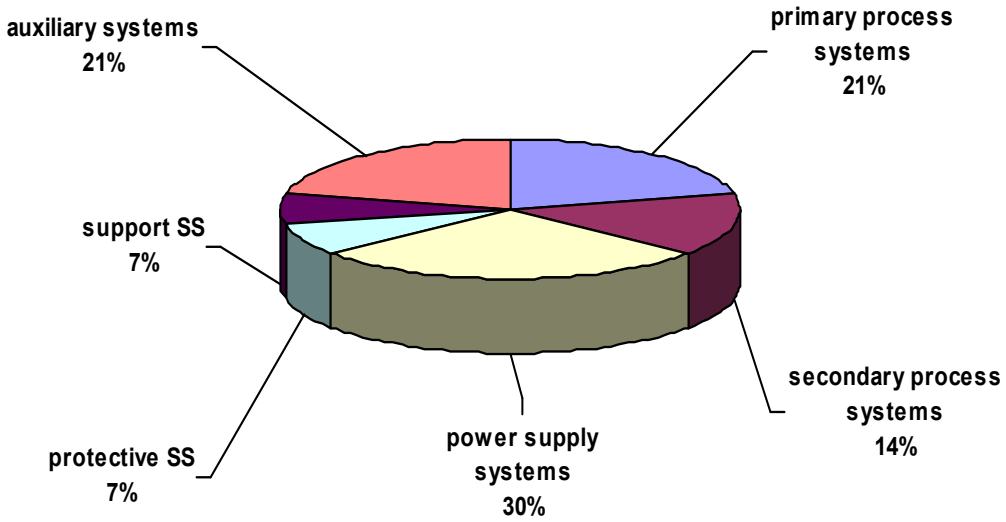


Figure 3.3.4. **Distribution by systems failed or affected in abnormal events**

In 2016, four events (30%) occurred at power supply systems and three events (21%) occurred both on primary process systems and on auxiliary systems that support operability of the main equipment. Two events occurred at secondary process systems and one event both at protective and at supporting safety systems.

In 12 operational events at Ukrainian NPPs in 2016, 14 abnormal events were recorded and 14 root causes were identified for them. Figure 3.5 shows the contribution of each group of root causes to the total number of operational events in 2000-2016.

The highest contribution is conventionally made by causes associated with equipment failures (86%). As compared to the previous year, there were no root causes associated with documentation. The percentage of causes associated with personnel and management system decreased to 14% in 2016 versus 24% in 2015.

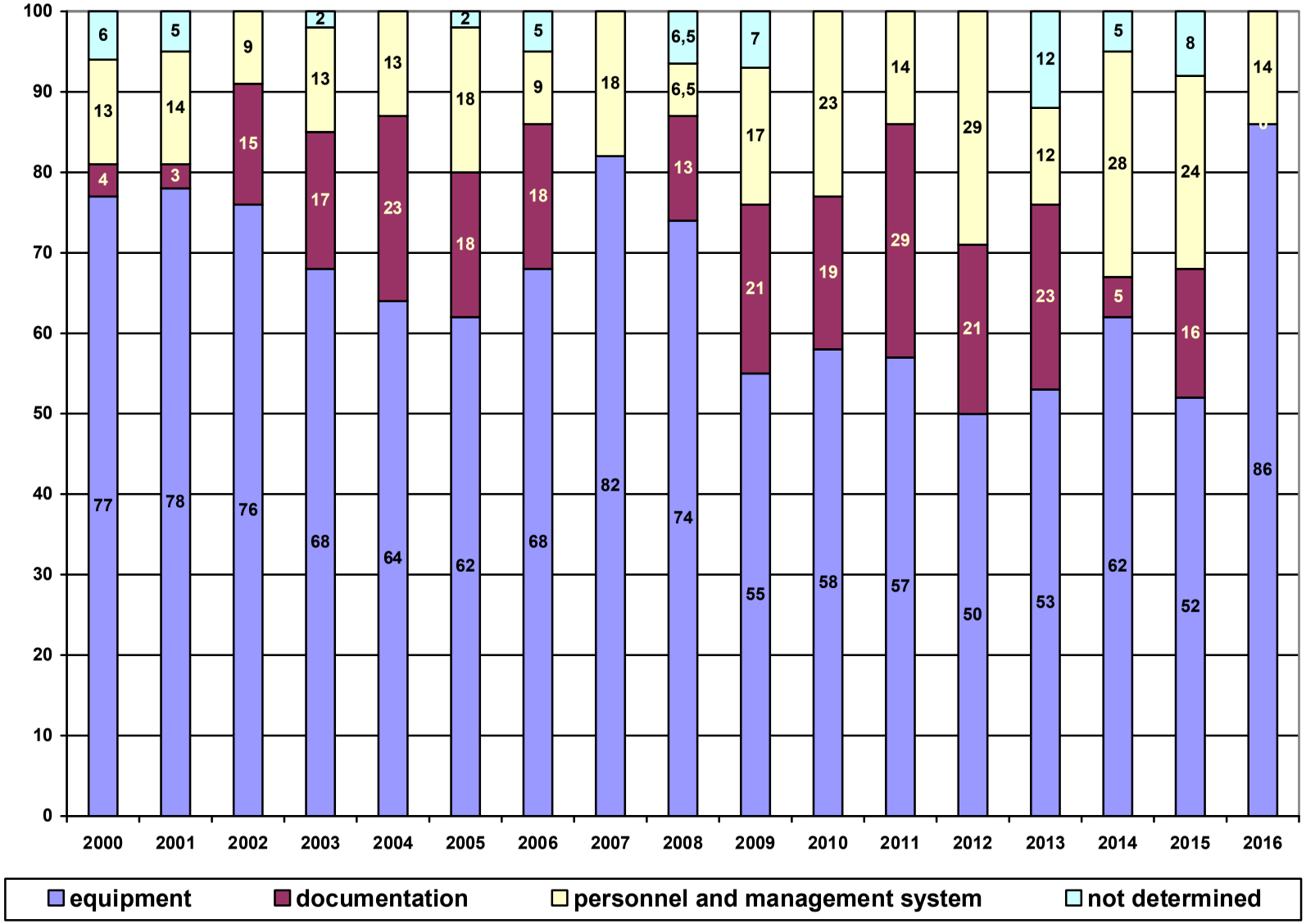


Figure 3.3.5. **Distribution of root causes of abnormal events in 2000-2016**

3.4. NPP Radiological Impact Assessment

NPP environmental impact is assessed through analysis of radiological and non-radiological factors.

Impact of NPP radiological factors is assessed from data on airborne releases and water discharges into the environment, doses of NPP personnel and radiological state of environmental objects in the NPP observation areas.

The main criterion for assessing radiological impact is doses of personnel and the public determined by routine measurements and calculations.

The NPP Radiation Monitoring Procedures developed in compliance with technical safety justifications, regulatory requirements, and plant designs establish the scope, types, and periodicity for measurements and observations for the purpose of radiation monitoring.

The NPP radiation monitoring systems (RMS) are an important technical feature for ensuring radiation safety and a part of the NPP instrumentation and control systems and are designed to perform informational, calculational, diagnostic, and auxiliary functions in normal operation and emergencies.

The NPP RMS include monitoring subsystems for:

- condition of protective barriers;
- technological processes and process media;
- individual dose control;
- prevention of radioactive contamination spread;
- environmental objects;
- NPP heat supply systems.

In parallel with RMS, there are automated radiation monitoring systems (ARMS) within the NPP observation areas. ARMS provides on-line (real-time) collection, long-term storage, and transfer of current and retrospective data on radiation situation in the areas around NPPs.

Radioactive Airborne Releases to Atmosphere

Each Energoatom NPP has limits and control levels of radioactive airborne releases to the environment approved according to the established procedure. Their values for the main release sources are shown in Table 3.4.1.

Table 3.4.1. **Reference levels (RL) and limits of airborne releases (LR) for inert radioactive gases (IRG), long-lived nuclides (LLN) and iodine radionuclides from nuclear power plants to the environment in 2016**

Monitored parameter		ZNPP	RNPP	SUNPP	KhNPP
IRG, TBq/day	RL	0.8	1.9	1.2	1.3
	LR	*69*	*67*	*45*	*46*
Iodine, MBq/day	RL	24.0	170.0	140.0	34.0
	LR	*6 000*	*5 500*	*3 900*	*4 100*
LLN, MBq/day	RL	8.8	5.5	4.3	6.6
	LR	*2 200*	*370*	*750*	*1 000*

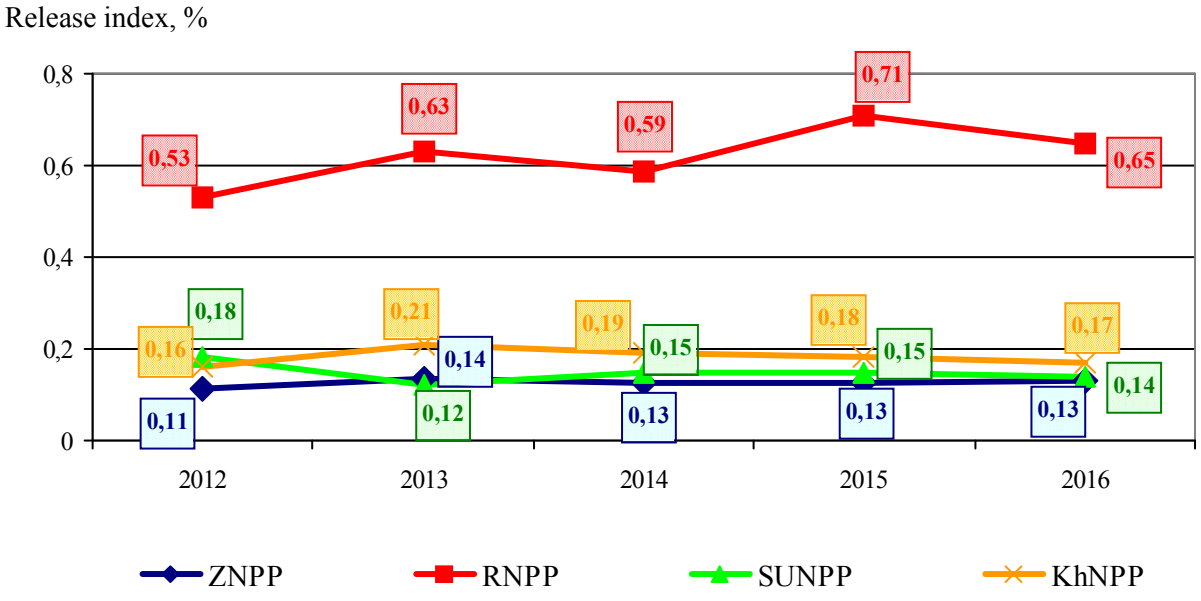
Cs-137, MBq/month	RL	120.0	42.0	55.0	80.0
	LR	*28 590*	*10 500*	*13 500*	*20 100*
Cs-134, MBq/month	RL	130.0	48.0	55.0	85.0
	LR	*30 420*	*12 000*	*13 500*	*21 300*
Co-60, MBq/month	RL	65.0	54.0	39.0	45.0
	LR	*16 120*	*5 100*	*9 600*	*11 300*

According to the report on radiation safety and Energoatom NPP impact assessment for 2016, the levels of NPP airborne releases to the atmosphere were determined upon:

- continuous monitoring of inert radioactive gases, long-lived aerosols and iodine radionuclides in NPP ventilation stacks by automated airborne release monitoring systems and regular automated radiation monitoring equipment;
- gamma spectrometry of aerosol samples deposited on AFA-RMP-20 filters taken from NPP ventilation stacks;
- gamma spectrometry of gas and aerosol fractions of radioactive iodine taken from NPP ventilation stacks. Iodine was deposited on SFL20-I-50 band or selective sorbent (ZNPP).

Therefore, the total indexes of radioactive airborne releases from NPPs to the environment remained low and changed insignificantly in the recent years, being no more than one percent of permissible limits.

Figure 3.4.1 graphically shows the total indices of radioactive airborne releases to the environment from Energoatom NPPs for the last five years:



Airborne releases of long-lived nuclides to the environment from the Chornobyl NPP are shown in the Table below:

Radionuclide	RL of airborne release to atmosphere*
Ventilation stack	
^{90}Sr	19.6 GBq/month
^{137}Cs	62.3 GBq/month
^{60}Co	700 MBq/month
α-emitting	595 MBq/month
New ventilation stack	
^{90}Sr	12.6 GBq/month
^{137}Cs	39.9 GBq/month
^{60}Co	455 MBq/month
α-emitting	385 MBq/month
Interim Spent Fuel Storage Facility–1	
^{90}Sr	0.28 GBq/month
^{137}Cs	0.91 GBq/month
^{60}Co	10.5 MBq/month
α-emitting	9.1 MBq/month

** reference levels in accordance with the "Reference Levels of Radiation Safety"*

Reference levels for radioactive releases to the atmosphere were not exceeded in 2016.

Radioactive Water Discharges to External Ponds

Water discharges of radionuclides from NPPs to external ponds (cooling ponds) are mainly formed by residual waters from chemical demineralization tanks and blowdown of essential spray ponds.

Table 3.4.2 shows reference levels and limits for radioactive water discharges to open ponds that were in force at Energoatom NPPs in the reporting year.

Table 3.4.2. **Reference levels/limits for water discharges of reference radionuclides to Energoatom NPP open ponds (MBq/y)**

Radionuclide	ZNPP	RNPP	SUNPP	KhNPP
^{137}Cs	364 / 91 000	2 800 / 83 000	1 440 / 16 000	170 / 41 000
^{60}Co	4 400 / 1 100 000	250 / 52 000	252 / 31 000	220 / 55 000
^{3}H	104 E+6/1900 E+6	26 E+6 / 2400 E+6	31E+6 /120 E+6	8.0E+6/ 2000E+6

Figure 3.4.2 graphically shows the total indices of radionuclide water discharges reliably recorded by NPPs in the last years:

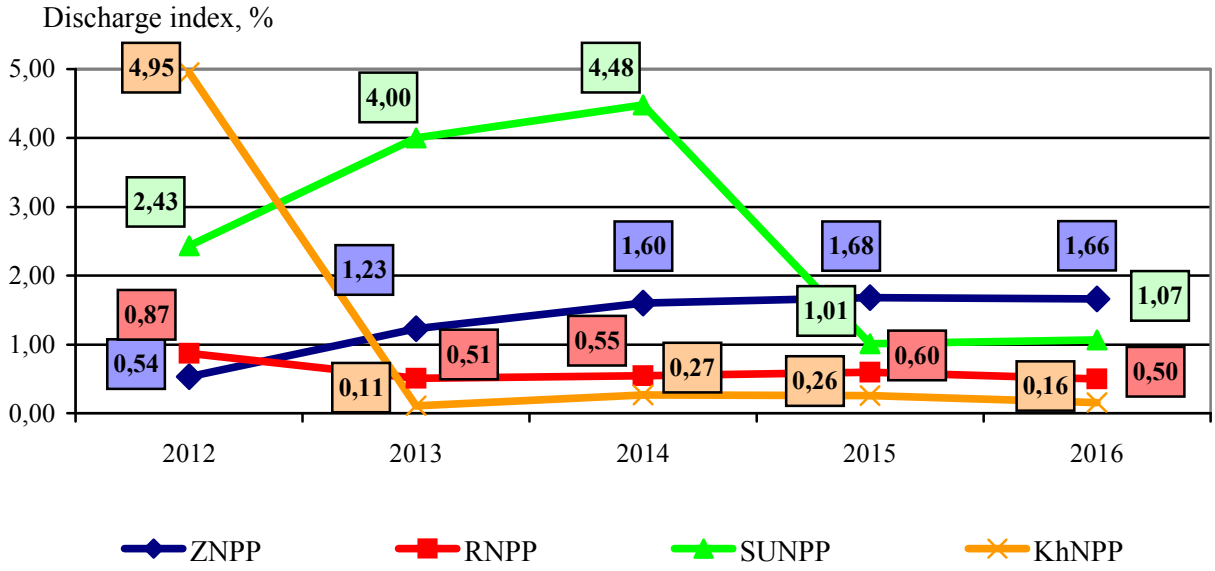


Table 3.4.3 shows indices for individual radionuclides and total indices for Energoatom NPP water discharges to external ponds in 2016.

Table 3.4.3. **Indices for water discharges of reference radionuclides to external ponds of operating NPPs in 2016 (%)**

NPP	**^{3}H**	**^{137}Cs**	**^{134}Cs**	**^{60}Co**	**^{90}Sr**	**^{54}Mn**	***Total index***
ZNPP	1.455	0.074	0.105	0.005	0.015	0.002	***1.656***
RNPP	0.260	0.158	0.020	0.014	0.033	0.002	***0.500***
SUNPP	0.636	0.050	0.022	0.014	0.347	0.002	***1.071***
KhNPP	0.115	0.027	0.007	0	0.010	0	***0.159***

Limits for radioactive water discharges to open ponds at Energoatom NPPs were not exceeded in 2016.

The maximum index of water discharges of radionuclides at ZNPP was 1.66%.

The SSE Chornobyl NPP has no radioactive discharges to open ponds. Radioactive discharges to the cooling pond are due to waters used to flush general accident-related contamination from the territory of the ChNPP industrial site through the industrial sewage system. The ChNPP cooling pond is both a nature conservation and process reservoir.

Reference levels are established in the document “Reference Levels of Radiation Safety”. Permissible levels are established in the “Permissible Radioactive Water Discharges of the SSE Chornobyl NPP” (radiation health and safety regulation of the first group).

Parameter	**Actual value**	RL, **GBq/y**
Water discharge volume, m^{3}	1517748	-
Total activity of ^{90}Sr discharges, GBq	6.4	14.0

Total activity of ^{137}Cs discharges, GBq	10.4	45.5
Total activity of α-emitting nuclide discharges**, GBq	4.5E-2	0.46

*** discharge is quantified as half the actual minimally detectable level (para. 4.3, "Permissible Radioactive Water Discharges of the SSE Chornobyl NPP" (radiation health and safety regulation of the first group)*

Reference levels of radioactive discharges were not exceeded in 2016.

NPP Personnel External Doses

Table 3.4.4 shows administrative process levels for individual doses of Energoatom NPP personnel and reference levels of annual collective doses for two groups of personnel whose individual dose exceeds 6 mSv/y (RL_6) and 15 mSv/y (RL_{15}).

Table 3.4.4. **Administrative process (administrative) levels for individual effective doses of NPP personnel and reference levels for annual collective doses of NPP personnel with individual doses higher than 6 mSv/y (RL_6) and 15 mSv/y (RL_{15})**

Plant	Administrative process levels for individual doses of personnel		Reference levels for annual collective doses of personnel, man·Sv/y	
	Personnel, mSv/y	Women under 45 years, mSv	RL_6	RL_{15}
ZNPP	15.0 (18.5*)	-	4.50	1.80
RNPP	15.0 (19.0*)	1.90 (for 2 consecutive months)	3.20	0.64
SUNPP	15.0	1.40 (for 2 consecutive months)	2.40	0.48
KhNPP	14.0	1.40 (for 2 consecutive months)	1.60	0.32

** for personnel involved in hazardous radiological work*

Table 3.4.5. **Distribution of individual effective external doses of Energoatom NPP personnel including staff of external organizations (temporary duty staff), collective and average individual doses for 2016**

NPP	Number of persons monitored men/year	Number of persons exposed as of 1 January 2017									Doses for 2016	
		<1 mSv	1-2 mSv	2-6 mSv	6- 10 mSv	10-15 mSv	15-20 mSv	20-30 mSv	30-50 mSv	>50 mSv	Collective man mSv/y	Average indiv., mSv/y
ZNPP	**4992**	**4051**	**283**	**436**	**131**	**91**	**0**	**0**	**0**	**0**	**4387.42**	**0.879**
including temporary duty staff	***818***	***651***	***64***	***84***	***19***	***0***	***0***	***0***	***0***	***0***	***582.21***	***0.712***
RNPP	**4050**	**3560**	**226**	**242**	**22**	***0***	***0***	***0***	***0***	***0***	**1622.37**	**0.400**
including temporary duty staff	***987***	***916***	***42***	***28***	***1***	***0***	***0***	***0***	***0***	***0***	***244.29***	***0.248***
SUNPP	**3040**	**2473**	**200**	**287**	**67**	**13**	***0***	***0***	***0***	***0***	**2192.99**	**0.721**
including temporary duty staff	***619***	***525***	***33***	***43***	***13***	***5***	***0***	***0***	***0***	***0***	***430.81***	***0.696***
KhNPP	**2795**	**2419**	**220**	**149**	**7**	**0**	**0**	**0**	**0**	**0**	**1138.52**	**0.407**
including	***669***	***614***	***35***	***20***	***0***	***0***	***0***	***0***	***0***	***0***	***137.61***	***0.206***

temporary duty staff												
Energoatom	**14877**	**12503**	**929**	**1114**	**227**	**104**	**0**	**0**	**0**	**0**	**9341.30**	**0.628**
including temporary duty staff	**3093**	**2706**	**174**	**175**	**33**	**5**	**0**	**0**	**0**	**0**	**1394.92**	**0.451**

Table 3.4.5 shows that none of the staff members received an individual effective dose in the range 15-20 mSv, which is close to individual effective dose limit DL_{20} (20 mSv), in 2016.

General trends in changes of absolute values of collective doses for NPP personnel and their contribution to the total dose for Energoatom NPPs for the recent decade are presented in Figure 3.4.3.

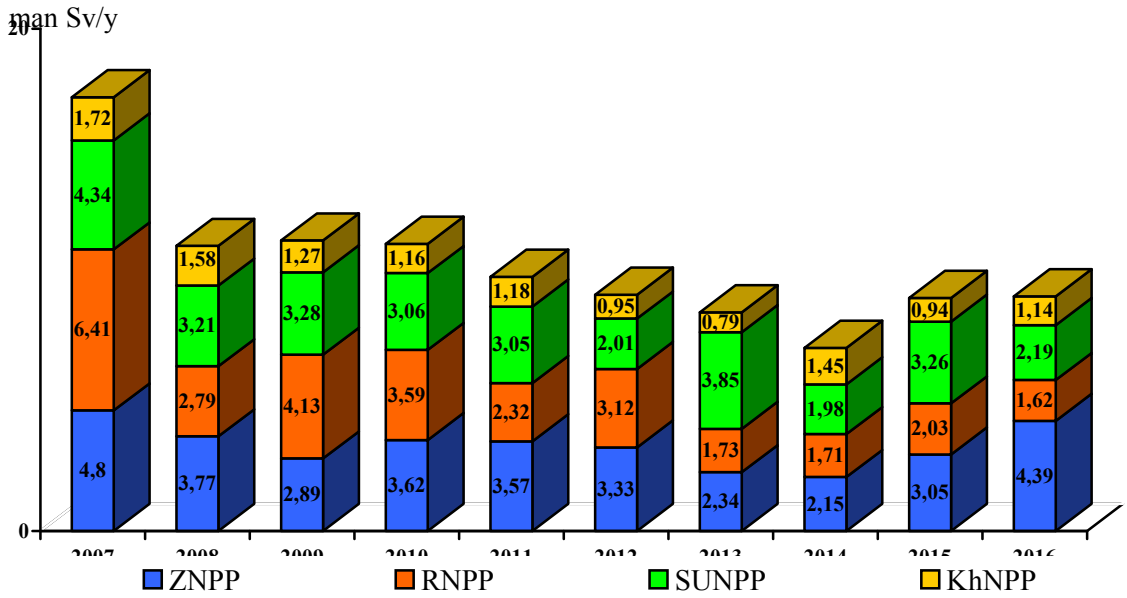


Figure. 3.4.3. **Annual collective doses for Energoatom NPP personnel (including temporary duty staff) for 2007 - 2016**

The dynamics in collective doses per Energoatom NPP unit shown in average values for three consecutive years along with the trend line for 2007–2016 is provided in Figure 3.4.4.

The trend line demonstrates a general stable positive tendency to decrease in the average annual collective doses per NPP unit for the last ten years of Ukrainian NPPs' operation.

The average individual doses of personnel at operating NPPs in 2016 were as follows: 0.879 mSv/man per year at ZNPP, 0.400 mSv/man per year at RNPP, 0.721 mSv/man per year at SUNPP, and 0.407 mSv/man per year at KhNPP.

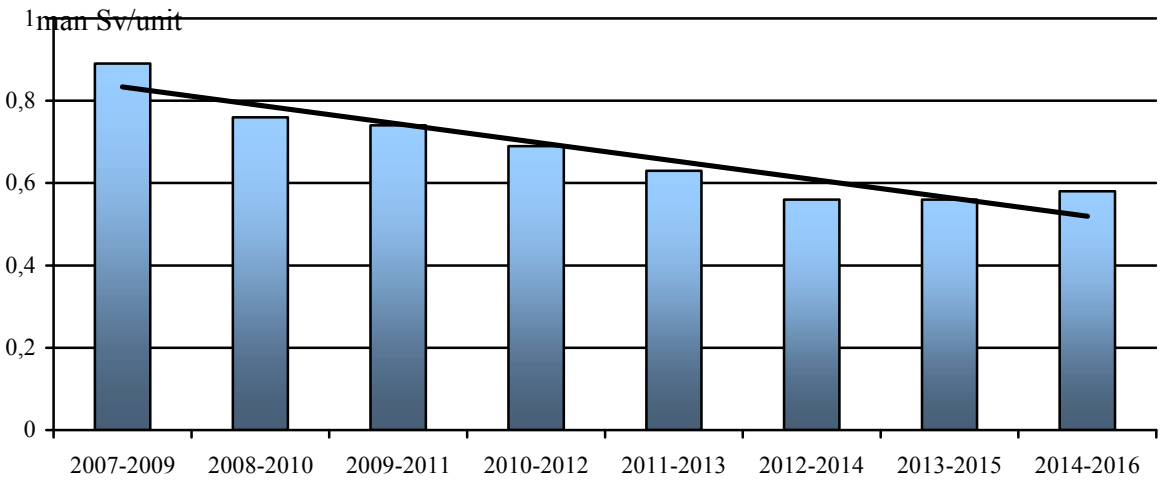


Figure. 3.4.4. **Dynamics in collective doses per NPP unit in average values for 2007 – 2016**

In 2016, the total collective dose of Energoatom NPP personnel was 9341.30 man·mSv, which is insignificantly higher (by 64.45 man·mSv) than the value in 2015, when the total collective dose of Energoatom NPP personnel was 9276.85 man·mSv.

The total collective dose mainly increased due to greater scope of maintenance connected with lifetime extension measures or long-term operation arrangements at NPPs.

In the reporting year, administrative process levels were not exceeded at any NPP and there were no cases when the limit of annual intake of monitored cesium, cobalt-60 and iodine-131 radionuclides by NPP personnel was exceeded.

Biophysical examination of 19432 persons (including 5820 persons from external organizations) using whole body counters showed that limits of annual intake of monitored cesium, cobalt-60 and iodine-131 radionuclides by NPP personnel were not exceeded in 2016.

The reports on radiation safety and radiation protection at Energoatom NPPs are submitted to the SNRIU every quarter and information on radiation safety is publicly available on the Energoatom official website.

4. IMPLEMENTATION STATUS OF NEW BUILT PROJECTS

4.1. Construction of Khmelnitsky NPP Units 3 and 4

The activities on KhNPP units 3 and 4 were suspended after development of the feasibility study to construct KhNPP units 3 and 4 and its approval according to the established procedure by Cabinet Resolution No. 498-r of 4 July 2012, as well as the adoption of Law "On the Siting, Design and Construction of Khmelnitsky NPP Units 3 and 4" No. 5217 -VI of 9 June 2012 by the Verkhovna Rada of Ukraine. This was because the above-mentioned documentation was based on the Russian VVER-1000/392 design.

Taking into account political relations between Ukraine and the Russian Federation, the Verkhovna Rada of Ukraine adopted the following Laws of Ukraine on 16 September 2015 (whose drafts were agreed by the SNRIU):

- "On Recognizing Invalidity of the Law of Ukraine "On the Siting, Design and Construction of Khmelnitsky Nuclear Power Plant Units 3 and 4";
- "On the Termination of the Agreement between the Cabinet of Ministers of Ukraine and the Government of the Russian Federation on Cooperation in Construction of Khmelnitsky NPP Units 3 and 4".

After approval of Conceptual Decision "Construction of Khmelnitsky NPP Units 3 and 4 at" of 17 October 2014, Energoatom Company took measures in 2015-2016 on the construction of KhNPP-3 and 4 with VVER-1000/320 reactor produced by AT Skoda JS a.s (Czech Republic), namely:

- amendment of the feasibility study;
- development of Draft Law of Ukraine "On the Siting, Design and Construction of Khmelnitsky NPP Units 3 and 4" No. 5217-VI;
- development of technical specifications for the reactor.

Based on the above-mentioned measures, the Energoatom Company developed document "Technical Specifications for VVER-1000 for KhNPP-3, 4" approved by the SNRIU on 22 March 2016.

4.2. Construction of Neutron Source Based on Subcritical Assembly Driven by Linear Electron Accelerator

The neutron source based on a subcritical assembly driven by a linear electron accelerator (neutron source) is under construction at the National Scientific Center 'Kharkiv Institute of Physics and Technology' (KIPT) in accordance with the agreements of the Washington Summit set forth in the Joint Statement of the Presidents of Ukraine and the United States in April 2010 and the Memorandum of Understanding between the Government of Ukraine and the Government of the United States of America on Cooperation in Nuclear Safety signed on 26 September 2011. The project is implemented under support of the Argonne National Laboratory, USA.

The neutron source is intended for scientific and applied studies in the field of nuclear physics, radiation materials science, biology, chemistry and production of medical radioisotopes.

On 10 October 2010, the SNRIU issued a license (EO No. 001018) to the operating organization for construction and commissioning of the neutron source.

In accordance with license conditions, the KIPT, as the operating organization, performed installation and construction activities during 2013-2016. In addition, the

development and SNRIU agreement of technical specifications for equipment important to safety, as well as the operational documentation of the neutron source, were continued.

At the same time, within the license, the KIPT has to obtain three individual permits for:

- first transfer of nuclear fuel for the neutron source to the KIPT industrial site;
- initial criticality of the neutron source;
- trial and commercial operation of the neutron source.

As of 31 December 2016, the SNRIU did not receive an application from the KIPT to obtain these permits. On 5 October 2016, the SNRIU amended the license (EO No. 001018) of 10 October 2013. In accordance with the amendments, the license was extended until 1 December 2018.

5. NUCLEAR FUEL MANAGEMENT

5.1. Diversification of Nuclear Fuel Supply

Within nuclear fuel diversification for Ukrainian NPPs, the SNRIU reviewed the documentation of the operating organization that justified safety of Westinghouse fuel and modification of other related systems important to safety during 2016.

In particular, based on the state nuclear and radiation safety review, the SNRIU agreed documentation in 2016 regarding:

- loading of the next reload batch consisting of FA-WR to the core of ZNPP-3;
- safety justification for extension of FA-WR trial operation to ZNPP-5;
- modification of the in-core instrumentation system SVRK-M to monitor the core with FA-WR of ZNPP-1-6 with integration of BEACON-TSM physical calculation subsystem and start of its trial operation;
- safety justification of Traveller-VVER to transport fresh FA-WR;
- modernization of the systems for refueling, fuel storage and transport in SUNPP and ZNPP fresh fuel areas as regards implementation of the NT-P3 up-ender for Traveller-VVER container and putting it into trial operation;

Therefore, as of 31 December 2016:

- Westinghouse nuclear fuel is operated at SUNPP-3 and ZNPP-5;
- state nuclear and radiation safety review of the documentation justifying safety of Westinghouse nuclear fuel operation is underway at ZNPP-3 and SUNPP-2.

5.2. Spent Nuclear Fuel Management Facilities

Spent nuclear fuel (SNF) generated during energy production in nuclear reactors is one of the important components in NPP process cycle.

The period of nuclear fuel use in reactors is determined by the permissible burnup of fissile isotopes. After reaching the planned burnup, nuclear fuel is unloaded from the reactor and is considered waste, since it may not be directly used for energy production.

After unloading from the reactor core, SNF is loaded to spent fuel pools. In these pools, SNF is cooled for the period necessary to reduce energy release caused by radioactive decay of fissile products to the allowable values. After SNF cooling in spent fuel pools for a limited period, spent fuel assemblies (SFAs) shall be removed from the NPP unit and sent for storage (disposal) or processing. This is because the capacity of NPP spent fuel pools is limited and there shall always be free volume for nuclear fuel unloading from the reactor core or periodic inspections of VVER reactor pressure vessel and reactor internals.

At the same time, in SNF management, it is necessary to consider factors determined by specific features of this material: high radioactivity level and valuable components (uranium, plutonium, germanium, erbium, palladium, zirconium, etc.) that may be used in future also in nuclear cycles (nuclear fuel for fast-neutron reactors, MOX fuel for light-water reactors). Taking into account the above mentioned, SNF does not belong to radioactive waste.

The state of nuclear energy in the world shows that final conclusions on the economic expediency of SNF processing or disposal, i.e. the final stage of nuclear fuel cycle, cannot be made at current level of technology development. In this regard, Ukraine, as well as most of the countries developing nuclear energy, made the so-called “deferred decision” envisaging long-term storage of spent nuclear fuel. This “deferred

decision" allows making a decision later on the final stage of nuclear fuel cycle taking into account technology development in the world and economic benefits for the state.

Currently, two facilities for temporary storage of SNF are operated in Ukraine: wet spent fuel storage facility – ISF-1 at ChNPP – and dry spent fuel storage facility– DSFSF at ZNPP.

In addition, two more storage facilities are under construction in Ukraine: dry storage facility: ISF-2 at ChNPP and centralized storage facility for VVER SNF: CSFSF.

5.2.1. VVER Spent Nuclear Fuel Management

Zaporizhzhya NPP was the first that faced the lack of free space in NPP spent fuel pools. In 1996, ZNPP launched the DSFSF project to solve this issue.

The Zaporizhzhya DSFSF was designed on the basis of licensed and appropriately proven technology of spent nuclear fuel storage by Duke Engineering & Services (USA). The principle of storage is as follows: 24 low-energy release assemblies (<1 kW) after five years of cooling in the spent fuel pool are placed in a special basket filled with helium (inert gas of high thermal conductivity) and sealed, then the basket is placed in a concrete ventilated storage cask (VSC). The storage facility is designed for 380 VSC, which may contain 9000 assemblies with SNF.

Zaporizhzhya NPP Stage 1 with a capacity of 100 VSC was commissioned in 2001 and Stage 2 with a capacity of 280 VCS was commissioned at the end of 2011.

Figures 5.1 and 5.2. **Zaporizhzhya DSFSF**

As of 1 January 2017, 139 ventilated concrete casks were located at the Zaporizhzhya DSFSF site.

During 2016, the SNRIU considered and agreed four technical decisions "On the Content of Multiplace Sealed Baskets Loaded with Spent Nuclear Fuel".

In addition, in August 2016, the SNRIU approved the PSRR for Zaporizhzhya DSFSF. The next safety review for this storage facility will be performed in 2025.

SNF of Rivne, Khmelnitsky and South Ukraine NPPs is currently transported to the Russian Federation. VVER-1000 SNF is transferred for storage; VVER-440 SNF (RNPP-1, 2) is transferred for reprocessing.

To fulfil "The Action Plan for 2006-2010 on Implementing the Energy Strategy of Ukraine until 2030" (approved by Cabinet Resolution No. 427 of 27 July 2006), the Energoatom Company concluded a contract with the U.S. Holtec International Company for the construction of a centralized storage facility for spent fuel from Rivne, Khmelnitsky and South Ukraine NPPs based on the dry storage technology already proven at ZNPP.

In accordance with legislative requirements, the operating organization developed the "Feasibility Study of Investments in the Construction of a Centralized Storage Facility for VVER Spent Nuclear Fuel (CSFSF) of Ukrainian NPPs", approved by Cabinet Resolution No. 131-r of 2 April 2009 after a comprehensive state expert review.

This feasibility study proved economic expediency of long-term spent fuel storage in Ukraine compared to its transport to the Russian Federation for reprocessing and justified construction of one centralized storage facility compared to any other options of SNF storage.

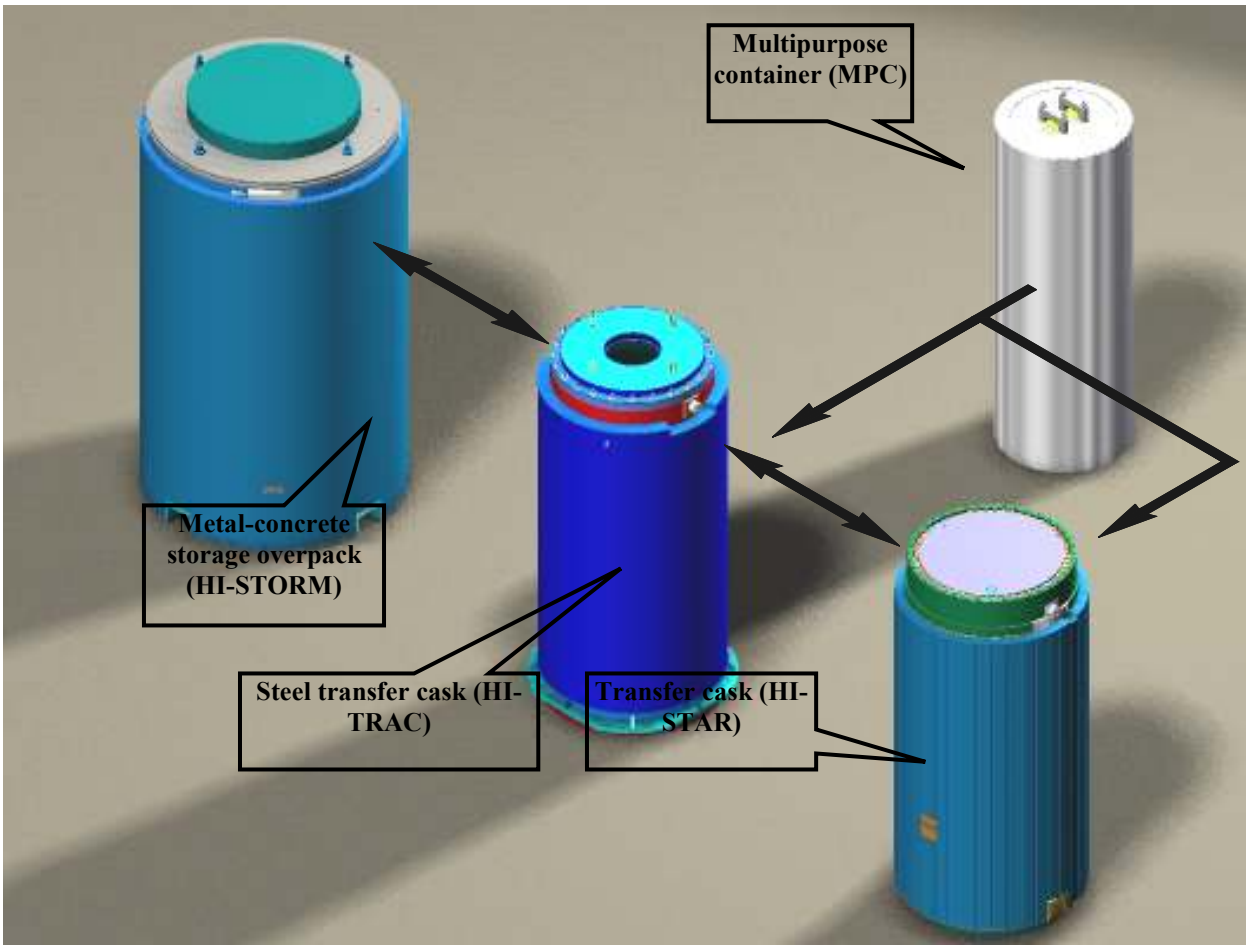


Figure 5.3. **CSFSF major equipment**

It is planned to store 12500 VVER-1000 SFAs and 4000 VVER-440 SFAs for 100 years in the CSFSF.

On 9 February 2012, the Verkhovna Rada of Ukraine adopted a decision to construct the CSFSF in the exclusion zone. This is reflected in Law of Ukraine No. 4383-VI "On Spent Nuclear Fuel Management as Regards Siting, Design and Construction of a Centralized Storage Facility for VVER Spent Fuel of Ukrainian NPPs".

On 30 April 2013, the SNRIU approved the "Technical Specifications for Modifying the Technology of Spent Fuel Transfer from VVER-1000 Power Unit (320) to the CSFSF". The document was developed by the Energoatom Company.

On 23 April 2014, according to Cabinet Resolution No. 399-r, the operating organization obtained a permit to develop a land management plan for allocation of land plots with a total area of 45.2 hectares located between former villages Stara Krasnytsia, Buryakivka, Chystogalivka and Stechanka of the Kyiv region (now it is the Chornobyl exclusion zone) for the construction of the CSFSF and rail access.

On 22 July 2015, the SNRIU approved the updated "Licensing Plan for Construction of a Centralized Spent Fuel Storage Facility" (PN-D.0.46.527-15) developed to replace PN-D.0.46.527-11.

On 23 July 2015, the SNRIU agreed proposals of the operating organization on composition and content of the Explanatory Note "Project for Construction of the Centralized Storage Facility for VVER Spent Nuclear Fuel of Ukrainian NPPs" and gave recommendations on CSFSF design.

On 12 October 2015, according to Energoatom Order No. 926, a Steering Committee was established on implementing the Holtec technology for spent fuel

management at RNPP, KhNPP, and SUNPP. It included SNRIU and SSTC NRS representatives.

On 24 December 2015, the SNRIU sent the Conclusion of the State Nuclear and Radiation Safety Review on project "Rail Access from the Existing Railway Branch of Vilka-Yaniv to the CSFSF Construction Site" to Ukrderzhbudekspertysa (Central Ukrainian Construction Review Service).

During 2016, the SNRIU:

- reviewed 15 packages of technical specifications for equipment important to safety and, upon review results, sent preliminary comments to the Energoatom Company;
- performed state nuclear and radiation safety review of the Preliminary Safety Analysis Report for the CSFSF, whose positive results were approved by SNRIU Board Resolution No. 8 of 3 November 2016;
- initiated state review of documentation package submitted by the Energoatom Company to justify the Application for CSFSF construction and commissioning.

Moreover, during 2016, SNRIU experts regularly participated in Steering Committee meetings on implementing the Holtec technology for spent fuel management at RNPP, KhNPP, and SUNPP.

5.2.2. RBMK Spent Nuclear Fuel Management

The following procedure for SNF management was envisaged by the RBMK design:

- after use in the reactor, nuclear fuel is transferred to spent fuel pools where it was cooled for at least 1.5 years to reduce radioactivity and residual heat release;
- after cooling, RBMK fuel was transferred to wet storage spent fuel facility.

As of 1 January 2017, all ChNPP SNF consisting of 21284 spent fuel assemblies (SFA) is stored in the ISF-1 spent fuel pool.

No SNF is present at ChNPP-1, 2, 3. No further use of spent fuel pools at these units is envisaged. No fresh nuclear fuel is present at ChNPP site.

ISF-1 is operated in compliance with SNRIU license (EO No. 000859) for operation of the nuclear facility – the spent nuclear fuel storage facility of 25 June 2008.

From 14 April to 6 June 2016, Chornobyl NPP transported all damaged SNF from the spent fuel pools at ChNPP-1, 2 to ISF-1 in compliance with the individual permit (OD No.000040/9) issued by the SNRIU on 14 April 2016.

Chornobyl NPP ISF-1

Fig 5.4. **Transfer of damaged SNF**

Fig 5.5. **Special canisters for damaged SNF management**

Currently, ChNPP implements:

- Action Plan on ISF-1 Safety Improvement agreed by the SNRIU on 24 June 2008;
- Action Plan on Safety Improvement of ChNPP Nuclear Facilities agreed by the SNRIU on 12 December 2011.

Figure 5.6. **ISF-1 room with the canyon of the cooling pool with damaged SNF**

At the same time, the ISF-2 lifetime determined by the safety review performed in 2011 expires by the end of 2025. Therefore, in order to ensure long-term safe storage of all spent fuel at ChNPP site, a new dry storage facility (ISF-2) is under construction.

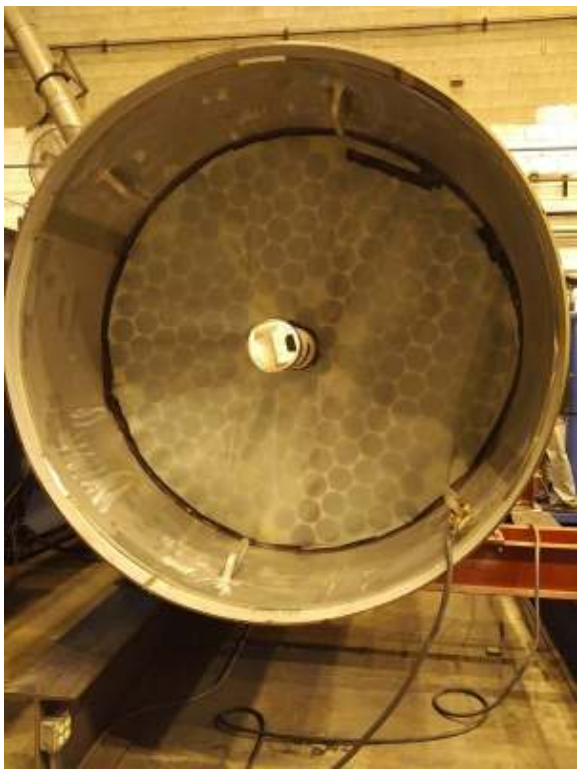
ISF-2 is constructed according to the SNRIU license (EO No. 001002) for construction and commissioning of a nuclear facility (spent fuel storage facility (ISF-2)) of 20 February 2013.

ISF-2

ISF-2 site

Vehicles to transfer SFAs from ISF-1 to ISF-2

Concrete modules for storage of SFAs



Double-wall dry shielded canister

Hot cell to dry and cut SFAs

Figure 5.7. **At ISF-2 site**

The algorithm of SNF management provided by ISF-2 design is presented in detail in the Annual Report on Nuclear and Radiation Safety for 2014.

During 2016, the Chornobyl NPP continued development and agreement of technical specifications (TS) and design documentation for systems and equipment important to safety according to the established procedure.

As of 31 December 2016, according to ISF-2 Licensing Plan, the SNRIU:

1. Preliminarily agreed:

- 7 TSs for systems important to safety of the 7 developed according to the design;
- 41 TSs for equipment important to safety of the 41 developed according to the design and one TS for equipment whose impact on safety is not defined (table for damaged SNF management).

2. Agreed 33 testing programs for equipment important to safety of the 33 planned (factory tests are not envisaged for 8 equipment pieces and individual tests will be carried out instead of them at ISF-2 site);

3. Thirty-three factory tests of systems and equipment important to safety of the thirty-three planned (23 in 2016) were carried out;

4. Two TSs were finally agreed for equipment important to safety of the 41 developed according to the design.

Figure 5.8. **Fuel cartridge for SFA storage in the double-wall dry shielded canister**

The activities on ISF-2 commissioning will be tentatively started in November 2017.

6. ARRANGEMENTS FOR DECOMMISSIONING OF OPERATING NPPS IN UKRAINE

Decommissioning of nuclear power plants is a complicated and long-lasting process, during which a set of interrelated administrative and technical measures is implemented to complete the life cycle of all nuclear facilities and other infrastructure facilities at the site.

Decommissioning shall be performed in strict compliance with all standards and regulations on nuclear and radiation safety. This will help to avoid negative impact on personnel, the public and the environment.

The Energoatom Company is responsible for the decommissioning process in Ukraine. The Company constantly performs comprehensive engineering and radiation surveys of power units, updates the decommissioning concepts and creates mechanisms for accumulation and use of financial resources in this area.

The main document according to which NPPs are prepared for decommissioning is the Decommissioning Concept for Ukrainian Operating NPPs, approved by Ordinance No. 798 of the Ministry for Energy and Coal Industry of Ukraine of 10 December 2015.

This Concept envisages lifetime extension of all operating NPPs by 20 years if there are positive results of the periodic safety review, which complies with the Energy Strategy of Ukraine until 2030.

According to international practices and IAEA recommendations, three decommissioning strategies for an individual nuclear power unit are possible:

- immediate dismounting;
- deferred dismantling;
- entombment concept.

The Concept compares the power unit decommissioning options based on expert judgements applying the multifactor analysis methodology. In selection of an appropriate option for Ukraine, immediate and deferred dismantling with different storage periods (20, 30, 40 years) were considered.

The optimum option was chosen based on the cost-benefit principle taking into account a number of key factors: compliance with safety requirements, availability of equipment and technologies for decommissioning, radiological and physical state of facility, radioactive waste management issues, social aspects, etc.

Based on the comparative analysis of strategies, it was concluded that the option of deferred dismantling of nuclear power units at Ukrainian NPPs with a storage period of 30 years is the most acceptable one (diagrams 1 and 2 below).

Total and specific costs (per unit of installed capacity) for decommissioning of NPPs with VVER-440 and VVER-1000 were also estimated.

	Total costs		**Specific costs (for one MW of installed capacity)**	
	Million UAH	Million USD	Million UAH	Million USD
VVER-440	2303.0	288.1	5.52	0.69
VVER-1000	2934.5	367.1	2.93	0.37

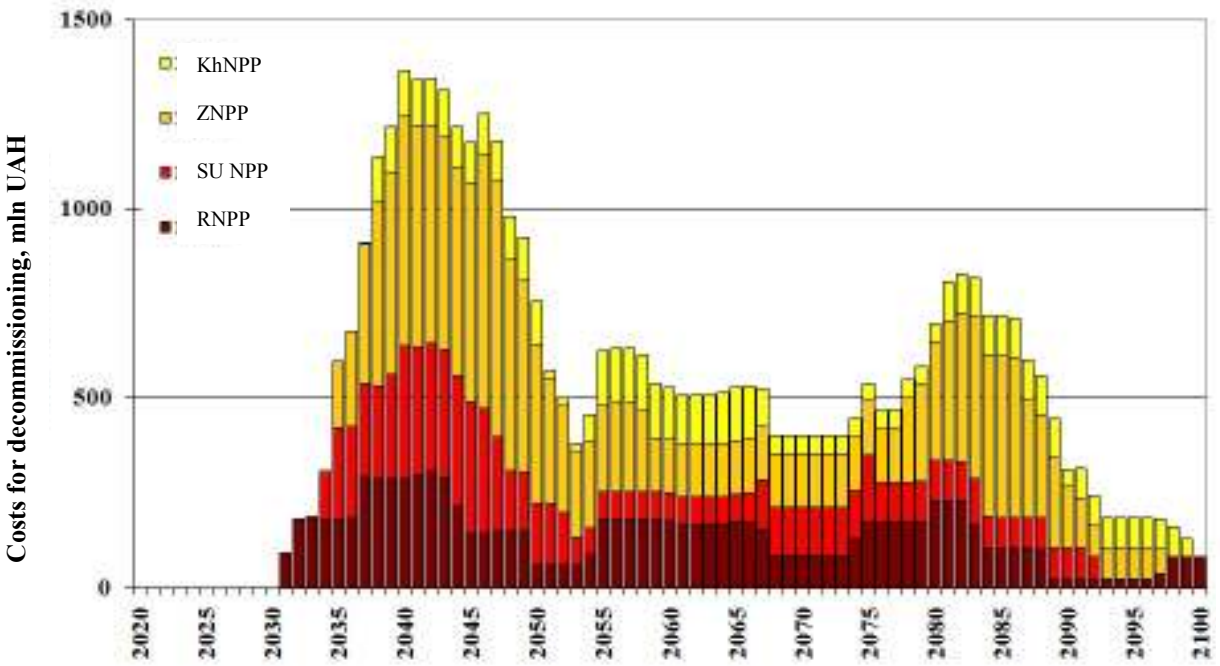


Figure **6.1. Planned annual costs for decommissioning - deferred dismantling option (taking into account NPP long-term operation for 20 years). Situation as of 31 December 2016**

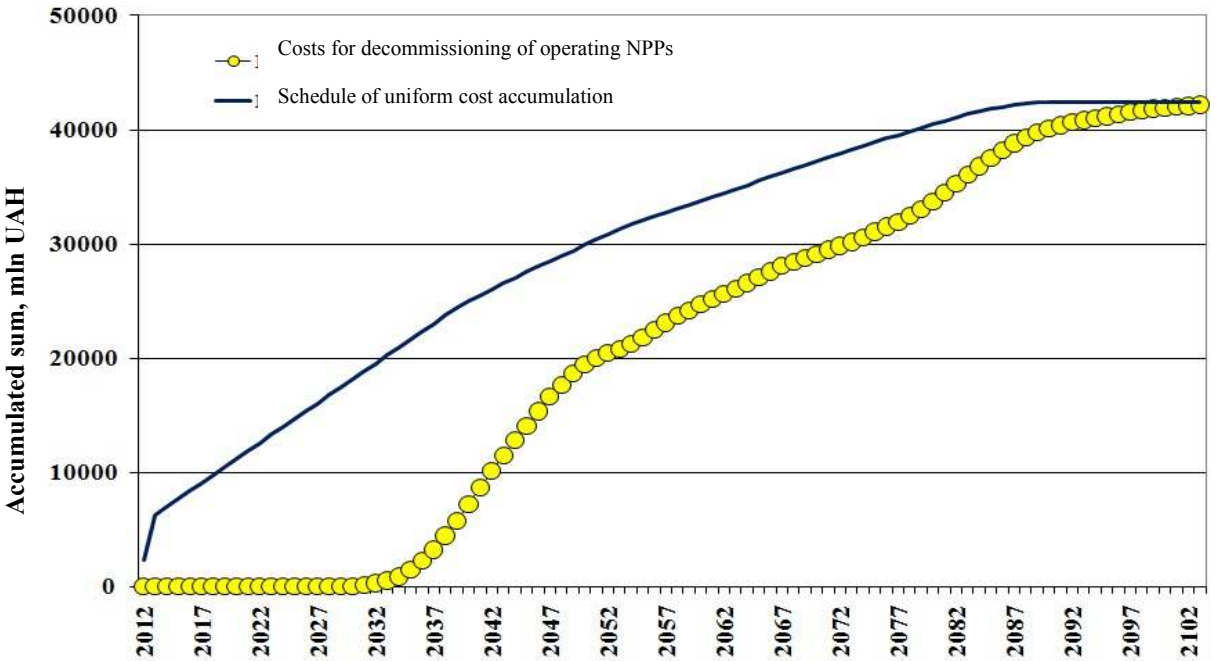


Figure 6.2. **Accumulation and expenditure of costs for decommissioning (option of deferred dismantling, long-term operation for 20 years) of operating NPPs as of 31 December 2012**

24 power units with VVER-440 and 32 power units with VVER-1000 are currently operated in Europe and Asia. 12 VVER-440 were shut down (Armenia, Bulgaria, and Germany). Planning of decommissioning activity is also at a conceptual stage for most foreign NPPs with VVER.

Two countries (Germany and Finland) made final decisions on decommissioning scenarios for NPPs with VVER. The scenario of their immediate (early) dismantling was

chosen. An important factor in favor of choosing this scenario was social and economic needs for involving NPP personnel dismissed when several power units are shut down simultaneously.

Figure 6.3. **Turbine hall of Greifswald NPP (Germany) before and after decommissioning**

In other countries (Bulgaria, Russia, Slovakia, Hungary, and Czech Republic) that operate NPPs with VVER, current decommissioning approaches are based on the deferred dismantling scenario (after safe storage for several decades). The main reason for this choice is lack of time to accumulate funds for decommissioning, as well as advantages associated with technology improvement and cheapening.

7. ACTIVITIES IN EXCLUSION ZONE

7.1. Chornobyl NPP Decommissioning

During 2016, SNRIU provided regulatory support for ChNPP decommissioning related to the final closure and safe storage of Chornobyl NPP units 1, 2 and 3 according to a separate permit issued under the license for decommissioning of ChNPP power units 1-3.

In the reporting year and according to a separate SNRIU permit, damaged spent nuclear fuel was unloaded from Chornobyl nuclear power plant units 1 and 2, and thus, all nuclear fuel was removed from all Chornobyl NPP power units.

Taking into account the above mentioned and in accordance with the Law of Ukraine "On Radioactive Waste Management", the SNRIU reviewed and agreed ChNPP Decision "On Recognition of ChNPP Units 1, 2, and 3 as Radioactive Waste Management Facilities in the Decommissioning Process".

A package of procedures and program and technical documentation of Chornobyl NPP and amendments to them on further safe decommissioning of ChNPP was revised and agreed.

It should be noted that there were deviations from the schedule for implementation of individual startup packages (SP) at the stage of final closure and safe storage in the reporting year, which are specified in the Program on Final Closure and Safe Storage of ChNPP Power Units 1 and 2. Particular attention should be paid to the implementation of SP-2 startup package "Dismantling and Processing of Technological Channels and Control Rod Channels".

The key condition related to SP-2 is the implementation of the technical project for the cutting line for long-length waste to decrease the length of special products (technological channels, control rod channels, technological channel rings) to be dismantled within SP-2, and special long-length products generated during operation of the power units.

SP-2 implementation (duration, subsequence of work, speed of dismantling) directly depends on implementation of the cutting line project that is currently suspended.

The implementation of individual SPs in time in general also depends on the presence of radwaste management infrastructure (presence of radwaste storage and disposal facilities, commissioning, operation of the existing facilities, design of new radwaste management facilities at Chornobyl NPP, etc.).

In particular, in 2016 there were problems associated with the disposal of large-size waste since the radwaste disposal facilities at Buryakivka RWDS were filled. The SNRIU proposed the following to the Chornobyl NPP to implement measures related to ChNPP decommissioning and Shelter transformation into an environmentally safe system:

- consider construction of additional temporary radioactive waste storage facilities at the site using rooms and buildings that are emptied during decommissioning;
- accelerate the start of operation of radioactive waste processing facilities at ChNPP site.

During decommissioning, a significant number of equipment and tools to be released from regulatory control is dismantled.

The SNRIU performed the state review on nuclear and radiation safety and agreed the Methodology for Radioactive Material Release from Regulatory Control developed under a Project of the European Commission Instrument for Nuclear Safety Cooperation

(INSC). This document establishes general guidelines to develop standards for specific enterprises that deal with release of radioactive materials and radioactive waste from regulatory control.

Radioactive Waste Management Facilities at Chornobyl NPP

Radioactive waste accumulated during Chornobyl NPP operation and accident mitigation in 1986 and generated during decommissioning of power units 1, 2 and 3 and Shelter transformation into an environmentally safe system is stored in radioactive waste storage facilities at Chornobyl NPP site: solid radwaste storage facility, liquid radwaste storage facility, solid and liquid radwaste storage facility[2], or is transferred for disposal to Buryakivka RWDS disposal facilities.

In 2016, 87.1 m^3 of liquid radwaste including 57.5 m^3 of evaporation bottoms and 29.6 m^3 of spent sorbents was generated at Chornobyl NPP and sent for temporary storage. As of the end of 2016, in total 13 580.90 m^3 of evaporation bottoms, 4 109.47 m^3 of spent ion-exchange resins, 2 295.88 m^3 of filter perlite powder pulp and 145.31 m^3 of radioactively contaminated oil-fuel mixture were accumulated in liquid radioactive waste storage facilities.

Low- and intermediate-level solid radioactive waste generated during decommissioning and Shelter transformation into an environmentally safe system was transferred to Buryakivka RWDS facilities for disposal. During 2016, 7.660.80 m^3 (8,261.64 g) of low-level radioactive waste and 26.00 m^3 (17.60 g) of intermediate-level solid radwaste was transferred to Buryakivka RWDS.

High-level radioactive waste is collected in special containers (KTZV-0.2) and placed into the temporary storage facility for solid high-level waste arranged in the former fresh nuclear fuel storage building. During 2016, 8.20 m^3 (3.83 tons) of unsorted and 1.82 m^3 (0.68 tons) of mixed solid high-level radioactive waste were generated and transferred for storage. No low- or intermediate-level long-lived radioactive waste was generated.

The Chornobyl NPP technical decision on long-term operation by 2025 for the temporary storage facility for solid high-level radioactive waste in building 12/2 was also agreed in the reporting period based on the NRS review results.

A range of radioactive waste management facilities was constructed and commissioned at Chornobyl NPP site under the international technical assistance projects. Commissioning of these facilities will allow processing of accumulated and generated radioactive waste to bring it to a state that is acceptable for safe storage.

Liquid Radioactive Waste Treatment Plant (LRTP) is designed for treatment of liquid radwaste accumulated in liquid waste storages and in liquid and solid waste storages, as well as liquid radwaste to be generated in decommissioning.

According to the separate permit issued on 11 December 2014 for operation of the liquid radwaste treatment plant (LRTP), the operation is possible only after obtaining a

[2] Liquid radioactive waste storage system at Chornobyl NPP consists of special interconnected piping for pumping of liquid waste:

- liquid radwaste storage facility is designed for 26 000 m^3 and includes five receiving tanks with a capacity of 5000 m^3 and two receiving tanks with a capacity of 500 m^3 made of corrosion-resistant steel;
- liquid and solid radwaste storage facility that is used only for liquid radwaste storage is designed for 12 000 m^3 of liquid waste to be stored in 12 receiving tanks made of corrosion-resistant steel with a capacity of 1 000 m^3;
- spent radioactive oil storage warehouse that consists of two tanks, the capacity of each is 72 m^3.

certificate of completed facility. To obtain the certificate, the Chornobyl NPP has to reconstruct the fire-fighting and lighting protection systems and provide thermal insulation for external walls of the plant. The SNRIU reviewed the action plan for LRTP commissioning developed by Chornobyl NPP that envisages completion of the planned activity at the end of 2017.

Liquid radwaste was not processed in 2016; equipment and systems were kept in operable condition.

Industrial Complex for Solid Radioactive Waste Management (ICSRM) on the ChNPP site combines a series of radwaste management facilities[3]. Construction of the ICSRM facilities has been completed, and they are being commissioned.

In the framework of ICSRM commissioning, the SNRIU performed the following:

- reviewed and agreed the action plan for preparation and performance of stage 3 of hot tests for solid radwaste treatment plant and radwaste retrieval facility and preparation to the initial stage of trial operation of these both facilities;
- reviewed and amended the individual permit for operation of the temporary storage facility for high-, low- and intermediate-level long-lived waste as regards changes in the conditions for acceptance of radwaste packages for storage resulting from implementation of projects at the Shelter. Such amendments were proposed to exclude delaying of activities related to the New Safe Confinement project.

7.2 Construction of Shelter New Safe Confinement (NSC)

During 2016, the SNRIU implemented its priority activities such as safety assessment and licensing under the construction of the first startup package of the New Safe Confinement (NSC SP-1).

[3] **Temporary storage facility for low- and intermediate-level long-lived and high-level waste** is designed for intermediate (30 years) storage of long-lived and high-level waste to be generated in sorting at the solid radwaste treatment plant and in preparation for construction of the Shelter New Safe Confinement. This storage facility was created by reconstruction and re-equipment of the room located at upper levels of the ChNPP liquid and solid storage which has not been in operation to date;

SRRF is a facility for retrieval of solid radwaste from the existing ChNPP solid waste storage and transfer of waste for treatment to SRTP;

SRTP is a solid radioactive waste treatment plant for sorting of solid radioactive waste of all categories and treatment (fragmentation, incineration, pressing, cementation) of low- and intermediate-level short-lived solid radioactive waste retrieved from the solid radwaste storage facility, and waste resulting from ChNPP decommissioning and Shelter transformation into an environmentally safe system. SRTP also envisages packaging of long-lived and high-level waste that will result from sorting and transport of these packages to temporary storage.

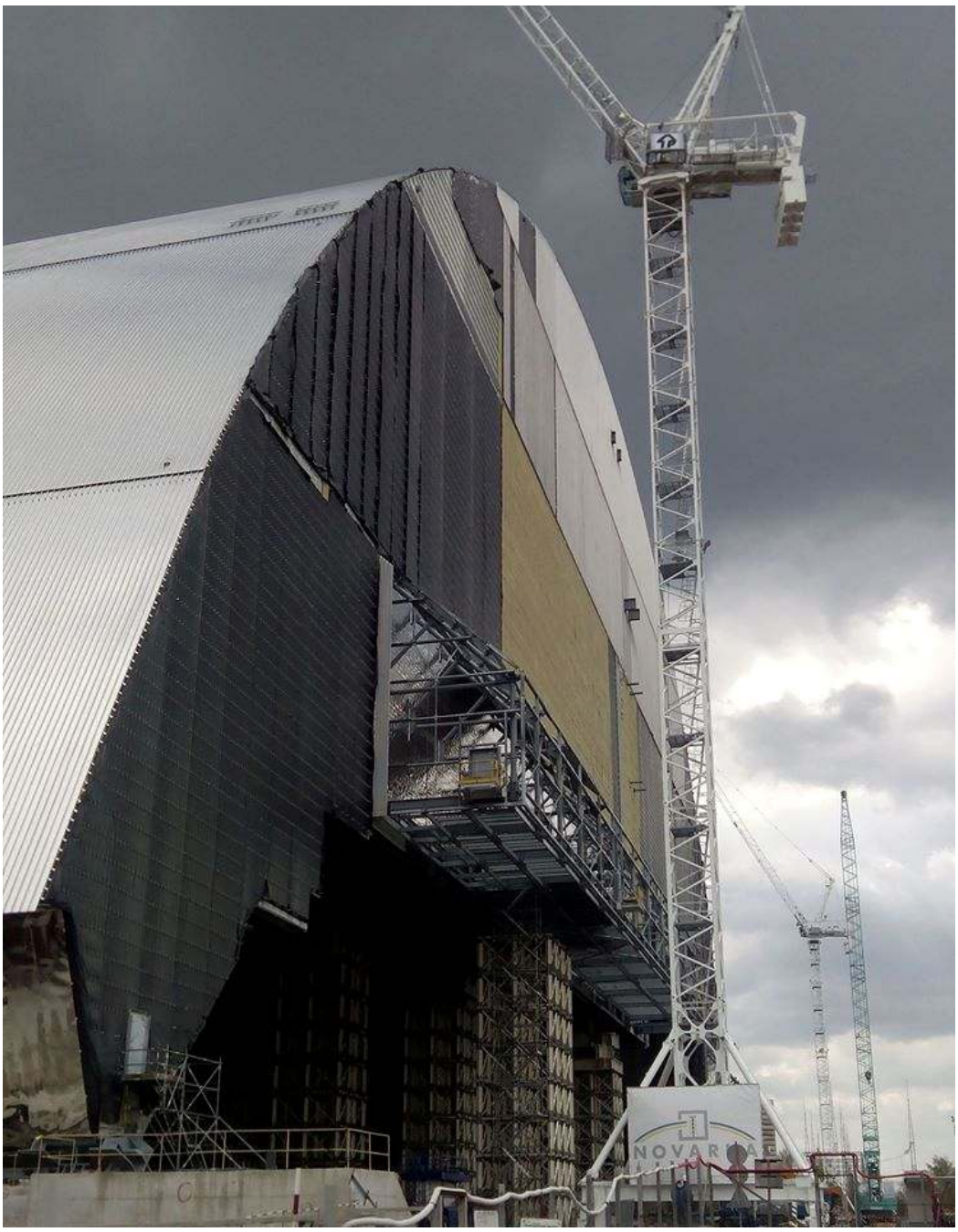


Figure 7.1. **New Safe Confinement**

The task aimed at Shelter transformation into an environmentally safe system is performed through subsequent development and implementation of individual plans, projects and programs.

One of the main Shelter projects is the construction of the New Safe Confinement (NSC).

NSC project implementation is envisaged within two startup packages (NSC SPs):

- NSC SP-1 is a protective structure with process life support systems and necessary infrastructure;
- NSC SP-2 is an infrastructure for dismantling of unstable Shelter structures.

The design lifetime of the NSC is 100 years.

Figure 7.2. **New Safe Confinement**

The first startup package of the New Safe Confinement (NSC SP-1) is currently under implementation; the contractor for NSC design, construction and commissioning is French Novarka Consortium.

During 2016, ChNPP and Novarka performed activities envisaged in the design decisions agreed previously by the SNRIU.

The arc structures were mounted at the site for NSC arc installation and in the local zone of the Shelter, such as internal and external cladding, ventilation system, special doors and swing panels, confinement anchors; mounting of components of the main crane system (MCS) was under continuation and MCS control system was tested; activities on the construction of the process building and other auxiliary buildings such as buildings of electrical and technical devices, fire-extinguishing pumping station, access gateways for fire departments were performed; strengthening and confinement of the existing structures of Chornobyl NPP Stage 2 functioning as the NSC protective circuit were continued; NSC external and internal features were installed (cable routes, engineering networks, storm water pool, walls for gallery of pivoting bearings, roads in the local zone, etc.).

Figure 7.3. **New Safe Confinement**

At the end of November 2016, an important stage within the confinement construction was completed. This unique facility with the height of 110 meters, width of 257 meters, length of 164 meters, and total weight over 36.200 tons was moved from the installation area to 327 meters and installed in the design position above the Shelter.

The SNRIU performed a preliminary review of the action plan "NSC Arc Movement and Installation into the Design Position" and other documentation of Chornobyl NPP to ensure radiation safety during the implementation of the planned activity.

The SNRIU also performed an inspection at ChNPP under the preparation for NSC Arc installation into the design position.

According to the project schedule, the completion of the New Safe Confinement and putting the systems into design mode are expected in late 2017. It should be noted that moving of the arc influenced current safety of the Shelter. After the NSC installation into the design position, the dose rate around the arc decreased more than twice, and this indicated safety improvement at the site.

Arc movement also allowed excluding penetration of atmospheric precipitation inside the Shelter, which that was previously the main degradation factor for Shelter structures, as well as spreading of radioactive substances inside the facility and beyond it.

An important factor for safety improvement of the Shelter is the absence of snow and wind load on its structures since all of them are currently covered by the arc.

Figure. 7.4. **New Safe Confinement**

In the reporting period, the SNRIU performed safety assessment of the documentation within the regulatory support to the construction of NSC SP-1:

- technical project of the NSC integrated control system was revised and agreed;
- ChNPP proposals on amending the parts of NSC SP-1 project that differ from the previous accepted design features related to power supply systems, sewage, arrangement of NSC sealing anchors and firefighting system were revised and agreed;
- state review on nuclear and radiation safety was performed and two working projects were agreed related to reinforcement and confinement of ChNPP Stage II structures that perform the function of NSC protective enclosure;
- three technical specifications for the following were revised and agreed:
  - bridge crane in MCS maintenance garage;
  - NSC sealing membrane;
  - design, production and supply of water storage tanks for firefighting;
- three technical decisions on the management of radioactive waste generated during the construction of NSC end walls were revised and agreed;
- five packages of ChNPP operating documentation on the preparation of Shelter structures and other ChNPP buildings for crane establishment (eastern and western sides of the NSC), etc., were revised and agreed;

As for NSC startup package 2 (NSC SP-2) on the infrastructure for dismantling of Shelter unstable structures, by request of Chornobyl NPP, the SNRIU revised and agreed ChNPP Project “Reconstruction of the Shelter” related to dismantling of the metal frame

for reinforcement of the southern roof in preparation for the project implementation in 2016.

However, due to the lack and uncertainty of funding, the activity related to the development of NSC SP-2 working project has not been performed.

On 1 December 2016, the SNRIU held a Board meeting during which the approaches to licensing of NSC operation were considered under the preparation for further operation of the New Safe Confinement including the Shelter.

Taking into account the NSC design and the Shelter and gradual change in the Shelter condition during its transformation within the confinement, the status of these facilities and their uniqueness, valid requirements of the regulations on issuing licenses/permits in the sphere of nuclear energy and the absence of direct provisions on licensing of activities at these facilities, the Board resolved that one of the most acceptable approaches is to issue a license for an individual activity: processing, storage of radioactive waste present or generated during the Shelter transformation into an environmentally safe system in operation of the confinement, including the Shelter.

Among other projects, it should be noted that based on review of the Chornobyl NPP application and appropriate documents, the SNRIU issued an individual permit for operation of the Shelter integrated automated monitoring system (IAMS) in February 2016.

The Shelter integrated automated monitoring system (IAMS) includes:

- radiation monitoring system;
- nuclear safety control system;
- monitoring system for civil structures;
- seismic monitoring system.

IAMS is designed to monitor safety indicators of the Shelter in automated mode. Its operation will improve nuclear, radiation and general technical safety of this facility including emergency preparedness.

7.3. Management of Radioactive Waste Resulting from Use of Radiation Sources

An important condition to ensure safety in use of radiation sources is their safe storage or disposal in case of lifetime expiration in order to avoid their possible loss and entry into places accessible to the public. Even after lifetime expiration, spent radiation sources still remain hazardous as they contain radioactive material that can cause significant harm to human health in case of its spreading or unintentional use.

Spent radiation sources are included into the category of radioactive waste and transferred to state ownership. They shall be further managed in accordance with the requirements for safe radwaste management by the state-owned specialized enterprises for radioactive waste management of the Ukrainian State Corporation Radon.

The following state interregional specialized plants (SISPs) are currently operated on the territory of Ukraine: Kyiv, Kharkiv, Dnipropetrovsk, Lviv, and Odesa SISPs.

Figure 7.5. **Radioactive waste storage facility at SISP**

These enterprises ensure collection, transport and safe storage of radioactive waste in specially designed storage facilities. SISPs also operate decontamination stations for clothes, overalls and individual protection means from medical and scientific institutions and enterprises.

Figure 7.6. **Radioactive waste storage in containers at SISP**

Since the facilities for handling radwaste management at these enterprises were constructed back in the 1960s-1970s in the former USSR, the National Program for Radioactive Waste Management provides for measures aimed at SISP re-equipment. Measures are also envisaged for radwaste retrieval from old storage/disposal facilities and re-disposal in the centralized storage facilities at Vektor site in the exclusion zone. This will allow remediation of old radwaste storage/disposal facilities that do not comply with current safety requirements and pose potential hazard of radionuclide spread into the environment related to their existence. In each specific case, such decisions shall be made based on safety review of specialized enterprises according to the SNRIU licenses. Therefore, in 2016, the safety review reports on radioactive waste storage/disposal facilities at radwaste disposal sites (RWDS) submitted by Lviv and Dnipropetrovsk SISPs were reviewed. Based upon assessment of these safety review reports, conclusions and recommendations were made on further measures to be taken to maintain safety of the existing radwaste storage facilities, and prioritize and optimize the decisions on radwaste retrieval from them. First, the accident-related radwaste shall be retrieved from the storage/disposal facilities. These are Kyiv SISP storage facilities No. 5, 6, 7, in which tritium leak and liquid radwaste media were revealed in 1995, as well as liquid radwaste storage facilities.

In March 2016, decrease in the liquid radwaste level was revealed in the liquid radwaste storage facility at Kyiv SISP (resulting from leakage). This event was qualified as an industrial radiation accident. The Kyiv SISP took emergency measures in compliance with SNRIU regulatory decisions to reinvestigate backup liquid radwaste storage facilities, pump liquid radwaste into the backup liquid radwaste storage facility, and take soil samples around the leaky storage facility (to specify places, causes and consequences of the leakage).

In 2016, in order to improve the efficiency of radiation monitoring at the sites of the specialized enterprises, the NRS review of technical documentation on the development of the integrated automated radiation monitoring system for the environment for the Radon specialized plants under EC support was performed.

The specialized plants are also involved in immediate measures by competent authorities to mitigate emergencies when orphan radiation sources are found or illicit trafficking of radiation sources is revealed. All these radiation sources are sent to the specialized plants for their safe and monitored storage and confinement to exclude their release into the environment and places accessible to the public.

7.4. Management of Radioactive Waste Resulting from Former USSR Military Programs

Since the 1970s-1980s, several legacy (storage/disposal) facilities for radioactive waste resulting from the military programs of the former USSR remained on the territory of Ukraine. The transfer of these legacy storage facilities into an environmentally safe state (remediation) through retrieval and subsequent management of radioactive waste is stipulated in Task 12 of the National Target Environmental Program for Radioactive Waste Management. In order to support this Task, the Cabinet of Ministers of Ukraine concluded an Implementing Agreement with the NATO Support and Procurement Agency (NSPA) for the management of radioactive waste resulting from military programs of the former USSR in Ukraine.

The pilot project within the Implementing Agreement was retrieval and further management of radioactive waste from Vakulenchuk storage facility in Zhytomyr region that was filled by spent radiation sources for military use in the times of the former USSR.

This work was performed from 1 September to 31 December 2016. A part of radioactive waste in form of spent radiation sources was transported for storage to Kyiv SISP. Solid radwaste in form of reinforced concrete structures of the storage facility and

cemented liquid radioactive waste was sent for disposal to Buryakivka RWDS in the Chornobyl exclusion zone.

After radwaste retrieval and cleaning of the adjacent territory, a detailed radiation survey of the site was performed to approve achievement of justified remediation criteria.

As the basic criterion for remediation of the storage facility site, the annual efficient exposure dose no more than 10 μSv/year was established for people who can live in future at the site of the decommissioned storage facility or near it, which meets the requirements of the radiation safety standards of Ukraine.

The gained experience will be used in the future to implement further projects on radwaste retrieval from legacy storage facilities.

7.5. Management of Radioactive Waste in Exclusion Zone

A key element in developing the radioactive waste management system in Ukraine is construction of a series of radioactive waste management facilities in the exclusion zone, including:

- radioactive waste management facilities at the Vektor site that shall support the final stage of radwaste management (centralized disposal and long-term storage) of all waste producers in Ukraine as well as processing of some types of radioactive waste from the exclusion zone and minor waste producers;
- construction of radioactive waste management facilities at Chornobyl NPP site;
- siting of geological repository.

According to the Radioactive Waste Management Strategy[4] and the National Target Environmental Program for Radioactive Waste Management[5], the primary task and measures aimed at developing the radwaste management system in the exclusion zone envisage the following:

- commissioning and operation of near-surface radwaste disposal facilities of Vektor Stage 1[6] and engineered near-surface radwaste disposal facility (ENSDF)[7] constructed for disposal of radioactive waste packages from Chornobyl NPP at the Vektor site;
- design and construction of pre-disposal long-term storage facilities (over 30 years) for long-lived high-level radioactive waste in geological repository within Vektor Stage 2[8] including vitrified radwaste resulting from spent fuel reprocessing to be returned from the Russian Federation, spent radiation sources and other long-lived high-level radioactive waste;
- design and construction of treatment plants for radwaste from the exclusion zone and minor waste producers within Vektor Stage 2;
- maintenance of the existing management facilities for Chornobyl-origin radioactive waste constructed during the first years of Chornobyl accident mitigation: Buryakivka RWDS[9], Pidlisny RWDS[10], ChNPP Stage III RWDS[11], RICS[12] including

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[4] Approved by Cabinet Resolution No. 990-r of 19 August 2009.

[5] Approved by Law of Ukraine No. 516-VI of 17 September 2008.

[6] Vektor Stage 1 incudes near-surface disposal facilities for low- and intermediate-level radwaste resulting from the Chornobyl disaster of two types: SRW-1 is a facility for disposal of radioactive waste in reinforced concrete containers, SRW-2 is a module-type disposal facility for unpacked large-size radioactive waste.

[7] ENSDF was constructed in 2009 under ChNPP ICSRM project for disposal of radioactive waste packages from ChNPP LRTP and SRTP with a capacity of 50 210 m^3 for radioactive waste packages, which consists of two parallel sections, each of them has 11 reinforced concrete modules, central drainage gallery and two movable frame structures with bridge cranes.

[8] Vektor Stage 2 includes long-term storage facilities for long-lived high-level radioactive waste; near-surface disposal facilities for low- and intermediate-level short-lived radioactive waste; treatment plants for Chornobyl radwaste and radwaste generated in non-nuclear sector. The Vektor Stage 2 Feasibility Study was approved by Cabinet Resolution No. 1605-r of 23 December 2009.

[9] Buryakivka RWDS is one of the main components of the management system for large amounts of accident-related radwaste that was constructed in 1987 under the emergency measures aimed at Chornobyl accident mitigation. Buryakivka provides, up to now, the disposal of a large amount of low-level radioactive waste generated during the activities performed at ChNPP site and on the contaminated territories in the exclusion zone.

[10] Pidlisny RWDS was constructed under the emergency measures aimed at Chornobyl accident mitigation. A-1, B-1 modules in this RWDS in 1986-1988 included the most hazardous high-level long-lived accident-related radioactive waste (fuel-containing materials, radioactive graphite, etc., that were thrown from the reactor during the accident).

[11] ChNPP Stage III RWDS was constructed under the emergency measures aimed at Chornobyl accident mitigation in uncompleted storage facility for radioactive waste of uncompleted ChNPP Stage 3. The reinforced concrete

their monitoring, reconstruction, stabilization, safety improvement, investigation, safety review, remediation;

- survey and research and development for siting for geological repository for long-lived high-level radioactive waste.

Implementation status

- Completion of radioactive waste disposal facilities SRW-1 and SRW-2 and other facilities of the Vektor site was stopped in 2010 and was not resumed as of the end of 2016;

- ENSDF is under operation. Since the beginning of operation, ENSDF accepted four packages (200-liter drums) for disposal from Chornobyl NPP and liquid radwaste treatment plant, and 74 radwaste packages from Kharkiv SISP;

- In 2016, a license was issued for comprehensive hot tests of the **centralized long-term storage facility for spent radiation sources (CLTSF[13]).** During the hot tests of CLTSF, protective properties of facility structures shall be confirmed, processing procedures for spent radiation source shall be worked out, operating procedures, interaction between radwaste suppliers in form of spent radiation sources, accounting and control system for such radioactive waste during the entire processing procedure from acceptance from suppliers to placement of packages for long-term storage and management of secondary radioactive waste shall be verified;

Figure 7.7. **Centralized long-term storage facility for spent radiation sources**

modules in this facility in 1986-1988 contained low- and intermediate-level accident-related waste. Over the years, there are processes of degradation of the hastily constructed dumping, which requires constant repair and maintenance.

[12] RICS are territories adjacent to ChNPP with a total area of about 10 hectares on which trenches and pits for radwaste confinement were constructed during the emergency measures aimed at Chornobyl accident mitigation. Such radwaste are mainly building structures, household items, upper layer of the soil, etc., contaminated in emergency release. There were from 800 to 1000 RICS trenches and pits.

[13] The Great Britain and the EC supported CLTSF construction. CLTSF operation includes acceptance, processing (conditioning) of radioactive waste in form of spent radiation sources of different types and categories and location of packages containing such radwaste according to radiation type for long-term storage during 50 years. CLTSF shall provide the capacity for centralized storage of the whole amount of spent radiation sources (about 500 000 spent radiation sources of different types and designs) accumulated currently at Radon sites and used in medicine, science and industry.

Figure 7.8. **Area for storage of spent radiation sources in CLTSF**

- in 2016, the first revision of the project **"Construction of Interim Storage Facility for Vitrified High-Level Radioactive Waste Returned from the Russian Federation after Reprocessing of Spent Nuclear Fuel from Ukrainian NPPs"** was subjected to the state nuclear and radiation safety review. This Project is being revised to incorporate review conclusions;

- within the operation of disposal facilities (trenches) for radwaste from Buryakivka RWDS, in 2016 radwaste was disposed in last trench No. 21, trench 29 was closed, and trench 30 was almost filled. Acceptance of large-sized radwaste to Buryakivka RWDS trench 21 was stopped and only bulk waste was accepted. In 2016, large-sized reinforced concrete metal structures resulting from the Shelter activities had to be placed for temporary storage at Chornobyl NPP site and Buryakivka RWDS site No. 100 because the radwaste disposal volumes at Buryakivka RWDS were filled;

- implementation of the approved project "Closure of ChNPP Stage III RWDS" for the development of additional barriers and storage facility stabilization was renewed in 2016;

Figure 7.9. **ChNPP Stage III RWDS**

- safety assessment and ranking of radwaste temporary confinement sites for making well-grounded decisions on further measures aimed at remediation and safety improvement of these facilities were performed in 2016.

8. SAFETY IN MANAGEMENT OF RADIATION SOURCES

8.1. Approaches in Safety Regulation of Radiation Sources, Conceptual Changes, and Promising Areas

The implementation of Council Directive 2013/59/Euratom establishing basic safety standards for protection against hazards caused by radiation remained one of the SNRIU priority tasks in 2016.

Taking into account that this document is primarily aimed at establishing common basic safety standards for the protection of persons under occupational and medical exposure and improving radiation safety and radiation protection in the use of radiation sources in various spheres of economy and human health and safety, the SNRIU carried out rule-making activities for appropriate harmonization of regulations on nuclear energy and radiation safety.

The implementation of the mentioned task will:

bring the national standards and rules on radiation safety into compliance with current international safety standards;

improve radiation protection in medical exposure by implementing the main safety requirements for management of radiation sources in medicine based on up-to-date IAEA and EU safety standards;

optimize personnel exposure by establishing quality control for individual dose monitoring.

In particular, work in this area was focused on developing the following draft:

Law of Ukraine "On Amendments to Certain Regulations in Nuclear Energy Use" (*approved by the Verkhovna Rada Committee on European Integration in February 2017*);

Cabinet Resolution "On Establishing a State System for Data Accounting on Individual Dose Control in Occupational Exposure";

Cabinet Resolution "On Amendments to the Criteria for Release of Activities on Use of Radiation Sources from Licensing";

joint order of the Ministry of Health of Ukraine and the State Nuclear Regulatory Inspectorate of Ukraine "On Approval of General Radiation Safety Requirements for Use of Radiation Sources in Medicine";

regulatory document defining radiation safety rules in the use of radiation sources in brachytherapy.

Along with this, activities were initiated to bring the licensing conditions on the use and production of radiation sources into compliance with the Law of Ukraine "On Licensing of Economic Activities" and development of the English-Ukrainian Glossary of Basic Terms and Definitions in Nuclear Energy Use and Radiation Safety.

The SNRIU constantly makes efforts in developing the state safety regulation system regarding authorizing activities (licensing, registration) for safety use of radiation sources in accordance with EU legislation and IAEA standards. The subsystem for regulatory control of radiation sources is one of the components in this national system. The State Nuclear Regulatory Inspectorate of Ukraine is responsible for its establishing, functioning and development.

In 2016, the SNRIU representatives took active part in the international activities to implement provisions of the Code of Conduct on the Safety and Security of

Radioactive Sources (IAEA, 2003), whose ultimate goal was to establish an appropriate system for regulatory control of radioactive sources.

The experience gained by the SNRIU experts is successfully applied, in particular in cooperation with the Pacific Northwest National Laboratory (PNNL, USA) on the extraction of the spent radiation sources from the gamma-therapeutic apparatus of the National Cancer Institute within the U.S. Government technical assistance project "Improving Security of Radiation Sources in Ukraine".

In this area, in order to ensure safety of spent high-level radiation sources, SNRIU experts efficiently cooperate with GRS (Germany) under the international project "Decommissioning of Irradiation Facilities and Safe Storage of Radiation Sources".

8.2. State Safety Regulation of Radiation Sources

The SNRIU in its activities adheres to the optimization principle of state safety regulation of radiation sources to determine the optimal safety level taking into account the potential hazard of facilities and activities with radiation sources.

This graded approach is also used for authorizing activities in nuclear energy: system, procedure, levels and criteria for release of radiation sources from regulatory control, state registration and licensing have been implemented.

This approach is incorporated in the criteria for release of activities on using radiation sources from licensing (Cabinet Resolution No. 1174 of 16 November 2011). Hence, along with the release of general educational and medical establishments, scientific institutions and industrial enterprises, customs bodies using radiation sources (X-ray rooms, dentistry, fluorography, mammography, calibration and luggage examination installations, smoke detectors, electronic microscopes and X-ray analysis devices, etc.) from licensing, institutions using high-risk radiation sources, such as oncological centers, scientific institutions with linear accelerators, and enterprises using powerful radiation sources remain responsible for state regulation (oversight and authorizing activities).

In Ukraine, 23 565 radiation sources are used including 8 736 radionuclide sources and 14 829 non-radionuclide facilities generating radiation, whose distribution by owners according to administrative territories of Ukraine is presented in Table 8.1:

Table 8.1. **Use of radiation sources**

Regions and other administrative territories	**Number**			
	Radionuclide radiation sources		**Radiation generators**	
	owners	**registered radiation sources**	**owners**	**registered radiation sources**
Vinnytsia	6	21	103	472
Zhytomyr	16	50	99	408
Kyiv	28	1 658	130	593
Cherkasy	6	47	844	359
Chernihiv	6	40	70	324
City of Kyiv	44	343	294	1644
Dnipropetrovsk	53	1192	222	1193
Kirovograd	6	40	69	327

Regions and other administrative territories	Number			
	Radionuclide radiation sources		Radiation generators	
	owners	registered radiation sources	owners	registered radiation sources
Donetsk	49	556	258	1312
Zaporizhzhya	17	528	144	685
Luhansk	18	288	159	649
Kharkiv	60	1035	244	1389
Poltava	20	392	123	531
Sumy	12	136	144	470
Rivne	7	228	105	345
Volyn	10	40	73	284
Khmelnitsky	8	162	83	405
Ternopil	3	7	71	256
Ivano-Frankivsk	12	55	98	370
Lviv	22	222	162	820
Zakarpattia	6	69	68	313
Chernihiv	7	19	56	306
Odessa	32	1 066	151	738
Mykolaiv	10	529	71	342
Kherson	5	13	76	294
Autonomous Republic of Crimea*		*139*		*804*
City of Sevastopol'*		*138*		*66*
Total in Ukraine	**893**	**8 736**	**3 157**	**14 829**

* control over the mentioned radiation sources is temporarily lost, and they are not considered in the total amount.

In 2016, 1272 radiation sources were removed from the register, among them: 953 spent radionuclide sources were transferred for storage to specialized enterprises for radioactive waste management, 19 radiation sources were returned to suppliers outside Ukraine, 13 types of sources were released from regulatory control, 287 generating units were put out of operation.

In 2016, 99 radionuclide sources for medical and industrial use were transported to Ukraine. Compared to 2015 (187 were imported), the number of imported radionuclide radiation sources has decreased only almost twice.

The main producers and suppliers of radionuclide radiation sources to Ukraine are companies of Poland, Belarus, Germany, the Netherlands, in particular the National Center for Nuclear Research (successor to the Institute of Atomic Energy POLATOM), Joint Belarusian-Russian CJSC 'Isotope Technologies', Eckert & Zeigler Nuclitec GmbH, Berthold Technologies GmbH & Co.KG, Mallinckrodt Medical BV, Environics Oy and others.

The number of radionuclide sources imported in 2016 and their applications are indicated in Table 8.2:

Table 8.2. **Number of radionuclide sources**

No	Isotope	Application	Number of radiation sources	
			pcs.	% (of imported)
1	Ir-192	Gamma therapy, Gamma radiography	42	42.4
2	Co-60	Gamma therapy, radioisotope process control devices, irradiation facilities, radiography	23	23,2
3	Cs-137	Radioisotope devices to control technological processes	10	10.1
4	Ni-63	Detectors of explosives and narcotic substances	9	9.1
5	Sr-90	Model and gauge devices	4	4.1
6	Others		11	11.1

USPE Izotop, SHIMIUKREYN LLC, and UKRIZOTOPSERVIS LLC supply radionuclide sources to Ukraine.

Approximately 75% of radionuclide sources are imported to Ukraine by USPE Izotop.

The main consumers of radionuclide radiation sources in 2016 were: industrial enterprises (nuclear energy sector, mining and enrichment, metallurgical, ship-building and ship-repairing, oil and gas, paper, cellulose and carton industries, etc.); medical oncological institutions; customs authorities.

According to applications, imported radiation sources are divided in the following way: approximately 58.6% for the use in industry; approximately 35.4% for medical purposes; approximately 6% for other purposes.

The following radionuclides within radiopharmaceuticals were supplied to medical institutions of the Ministry of Health of Ukraine: I-131, I-125, P-32, Sr-89, Sm-153, whose total activity is:

I-131 – 10034,561 GBq, I-125 – 8439,7061 MBq, P-32 – 36260 MBq,
Sr-89 – 3600 MBq, Sm-153 – 293200 MBq.

In 2016, 19 spent radiation sources were transported from Ukraine, including 10 spent radiation sources for medical purposes (returned to the producer in the Netherlands) and 9 radiation sources for industrial purposes (returned to producers in the USA and Poland).

Data on the production of generating devices in 2015 in Ukraine is presented in Table 8.3:

Table 8.3. **Generating devices**

Producer	Type of produced generator	Produced (pcs.)	including	
			for needs of Ukraine	transferred abroad
Medapparatura CJSC	RDK-VSM X-ray diagnostic system with digital image processing	11	11	-

Producer	Type of produced generator	Produced (pcs.)	including	
			for needs of Ukraine	transferred abroad
	FTsOZ fluorograph with digital image processing	10	10	-
Kvant X-ray equipment factory LLC	INDIagraf KRD-50 X-ray diagnostic system	7	7	-
	INDIascop X-ray diagnostic system	3	3	-
	INDIascan X-ray diagnostic system	6	6	-
RADMIR Company	MADIS X-ray mammographic digital complexes	9	5	4
	SIMA X-ray mammographic digital complexes	6	1	5
KRAS LLC	Aspect X-ray digital unit	3	3	-
	12F9 Ukraiina X-ray digital unit	27	27	-
	MEDIKS X-ray diagnostic system	12	12	-
	LYBID diagnostic mammography unit	2	2	-
Teleoptik LLC	KRDTs X-ray digital diagnostic system	7	7	-
	VATEL X-ray system for veterinary	2	2	-
Elvatekh LLC	SER-01 and SER-02X-ray spectrometer	134	8	126
Institute of Analytical Control Methods LLC	Expert 4L X-ray fluorescence element alloy analyzers	2	1	1
	Expert Mobile X-ray fluorescence element alloy analyzers	1		1

9. PHYSICAL PROTECTION AND NUCLEAR SECURITY

Six state inspections of physical protection systems were carried out in 2016.

The SNRIU participated in inspecting the efficiency of administrative procedures and personnel immediate actions of KhNPP Physical Protection Service through command-and-staff training and tactical exercises.

At the same time, efficiency of the Interaction Plan in case of sabotage regarding nuclear facilities and nuclear materials at KhNPP and its compatibility with the Emergency Response Plan were inspected through joint field training exercises. Tactical exercises were performed at the regional level involving the units of the National Guard of Ukraine, Security Service of Ukraine, National Police of Ukraine, State Emergency Service of Ukraine, district administrations, etc.

Within implementation of the Global Threat Reduction Initiative and enhancing the security of radiation sources, surveys were conducted and a decision was made to upgrade engineering features of the physical protection systems of the following institutions:

- Grygoriev Institute for Medical Radiology (Kharkiv);
- Sumy Regional Clinical Oncology Center;
- Poltava Regional Oncology Center;
- Kirovohgrad Regional Oncology Center;
- Volyn Regional Oncology Center;
- Chervonohrad Central City Hospital;
- Rivne Regional Clinical Oncology Center;
- Ternopil Regional Oncology Center;
- Lviv State Interregional Specialized Plant;
- Lviv Regional Diagnostic and Treatment Oncology Center;
- Centralized Radioactive Waste Management Enterprise (Chornobyl);
- Melitopol Oncology Center;
- Zaporizhzhya Regional Clinical Oncology Center;
- 5th City Clinical Emergency Hospital.

According to the results of surveys, projects to upgrade the physical protection system and engineering features for protection of facilities are developed.

The following centers were commissioned with connection to the central station for monitoring of engineering features of the physical protection systems:

- Kryvyi Rih Oncology Center;
- Oleksandriia Oncology Center.

SNRIU central monitoring station currently connected to 17 entities and Vektor CRME monitoring station connected to one entity were commissioned.

In 2016, efficient measures taken by internal defense detachment No. 3 of the Department of Physical Protection and Protection of Chornobyl Exclusion Zone Facilities, violations at the protection sites were prevented and security of radioactive waste was ensured. During the year, 24 unlawful entries to the restricted access facilities in the exclusion zone were stopped and 53 detainees were transferred to police officers to make further decision on their offenses in accordance with current legislation.

Statistics on the illicit trafficking of nuclear and other radioactive materials

Within the information exchange with the IAEA database on incidents and illicit trafficking of nuclear and other radioactive materials (ITDB), information on 33 cases when illicit trafficking of radioactive materials was detected in Ukraine was sent (4 cases according to standard information form and 29 according to package form).

The information on these cases was posted on the SNRIU website during the year. Since November 2014, the IAEA has been informed using a new electronic form. Ukraine became the second country among ITDB member states that started applying the new information transfer form.

SNRIU experts constantly participated and arranged training courses, workshops, meetings on physical protection of nuclear facilities, nuclear materials, radioactive waste and radiation sources under cooperation with the IAEA, European institutions, representatives of the regulatory bodies of other states and central executive authorities of Ukraine. Considerable attention was paid to detection and response to illicit trafficking of radioactive materials. Thus, in January 2016, a series of workshops on the Procedure for Interaction of Local and Central Executive Authorities in Response to the Detection of Radioactive Materials in Illicit Trafficking was conducted, which were attended by experts of relevant ministries and departments.

10. EMERGENCY PREPAREDNESS AND RESPONSE

In order to provide timely response to a nuclear or radiological emergency of any nature and level, the SNRIU maintains proper competence of its personnel and efficiency of relevant information and communication systems. The state of emergency preparedness of nuclear entities and their ability to mitigate the consequences of accidents is subject of regulatory assessment and is verified during state oversight of compliance with nuclear and radiation safety requirements, as well as by observing the training of licensees and practicing the interaction with other participants of emergency response at the state and international level.

In particular, joint order of the Ministry of Internal Affairs and the SNRIU approved the "Procedure for Information Interaction between the State Emergency Service of Ukraine and State Nuclear Regulatory Inspectorate of Ukraine for Prevention of and Response to Emergencies" of 27 July 2016.

In order to meet the Convention on Early Notification of a Nuclear Accident, Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency and relevant intergovernmental bilateral agreements with other countries, the SNRIU participated in IAEA emergency exercises in 2016:

- ConvEx-2a (17 February 2016) on inspecting procedures for information exchange and requests for assistance;
- ConvEx-1a (23 March 2016) on testing continuous availability of national contact points to receive notifications;
- ConvEx-1c (11 May 2016) on testing the access rights of administrators of the IAEA Unified System for Information Exchange in Incidents and Emergencies (USIE) to USIE WebIE Web Portal;
- ConvEx-2b (21-23 June 2016) on testing request and assistance mechanisms with the participation of the State Emergency Service of Ukraine;
- ConvEx-1b (20 September 2016) on testing permanent access to national communication points and the ability of national competent authorities to respond promptly to received notification ;
- ConvEx-2d (5-6 October 2016) with IEC partial activation on testing mechanisms in case of a transnational nuclear emergency (according to the scenario of a simulated accident at Cernavoda NPP in Romania with predictive assessment of transboundary radiation consequences of the simulated accident based on actual weather data).

From 31 May to 2 June 2016, the SNRIU jointly with the Energoatom Company took part in general plant anti-sabotage and emergency training of KhNPP with full activation of the IEC, with presence of observers from Norway and USA.

During the training, in addition to testing the interaction plans in case of sabotage and NPP emergency plan, the SNRIU worked out its own functions on the oversight of security and emergency preparedness of NPP and operating organization, early notification of radiation accidents through mass media (conditionally, during training), early notification and periodic notification of the Cabinet of Ministers of Ukraine, other central executive bodies and services having appropriate responsibilities for response to emergencies at NPP including physical protection during incidents. The training also included international information exchange under the Convention on Early Notification of a Nuclear Accident and relevant bilateral agreements with other countries using the

IAEA Unified Information System for Information Exchange in Incidents and Emergencies (USIE).

SNRIU IEC experts analyzed operational data on the state of nuclear facilities and simulation of processes and development of events at the site of a conditionally emergency NPP, in particular forecasting of directions and distances of radioactive contamination transfer and dose characteristics using RODOS automated decision support system based on actual weather data received from the Ukrainian Hydrometeorological Center.

On 26-29 September 2016, the SNRIU representatives together with the crew of SSTC NRS SONNI mobile laboratory and RNPP participated in the exercises of the German Federal Agency for Radiation Protection (BfS) conducted in real conditions of radiation contamination of the Chornobyl exclusion zone on radiation measurements in the environment.

Thirty-six experts from Germany and Ukraine had the opportunity to improve their qualification, exchange experience and test spectrometric equipment of the mobile laboratories, whose mission is to promptly diagnose or refute assumptions about radioactive contamination.

In 2016, staged implementation of RODOS decision support system for radiation accidents at nuclear facilities in Ukraine continued within European Commission INSC projects. On 30 June, representatives of the European Commission, central executive authorities, Academy of Sciences of Ukraine and mass media participated in the presentation of RODOS-Ukraine project outputs.

In December 2016, EC project “Extension of the RODOS Decision Support System in Ukraine for the Chornobyl Exclusion Zone” was launched. The project envisages

adaptation of the system to specific conditions of the Chornobyl exclusion zone, training of experts, integrated testing of the system and dissemination of project outputs for other users of the RODOS Decision Support System.

On 5 October 2016, under NRPA support, the SNRIU held a workshop on urgent issues of emergency preparedness and response, during which the mechanisms of early interaction at departmental, regional and international levels were discussed; emergency preparedness issues were identified, in particular in medical support, iodine prophylaxis, immediate assessment of contamination degree for food products and natural environments.

In October 2016, the State Emergency Service completed the registration of Ukraine's national potential in the IAEA RANET network on specialized assistance at the request of other states under the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency.

Under SNRIU support and in cooperation with other public authorities, since July 2016, the Ukrainian Hydrometeorological Center has provided the presence of Ukraine in the European Radiological Data Exchange Platform (EURDEP), which will provide citizens with free access to radiological information and is a real step for Ukraine on the way toward the European integration in nuclear and radiation safety.

Under support of the U.S. Defense Threat Reduction Agency, project “Modernization of the SNRIU Information and Emergency Center” was launched in July 2016 in the framework of initiative “Global Partnership against the Proliferation of Weapons and Materials of Mass Destruction” aimed at forming up-to-date communication and information systems and optimizing interaction between participants of the response to nuclear and radiation incidents of any nature.

Response in accordance with the Convention on Early Notification of a Nuclear Accident

No events that would be accompanied by releases/effluents of radioactive materials beyond the regulatory limits occurred at state oversight facilities within the territory of Ukraine in the reporting period.

In accordance with the Convention on Early Notification of a Nuclear Accident, the SNRIU analyzed notifications on the incidents in other countries using the IAEA Unified Information System for Information Exchange in Incidents and Emergencies (USIE).

The information on events that occurred outside the territory of Ukraine and caused increased public interest or risk of transboundary impact was posted promptly on the SNRIU official website.

Thus, on 25 October 2016, information on radioactive iodine release resulting from technical failure during nuclear fuel management of the research reactor in the Institute for Energy Technology in Halden, Norway, was posted on the SNRIU website. According to the Norwegian Radiation Protection Agency (NRPA), the radioactive release was assessed as minor and not detrimental to human health and the environment outside the site. It was also reported that the Norwegian regulatory authority received notification of the incident from the operator on 24 October.

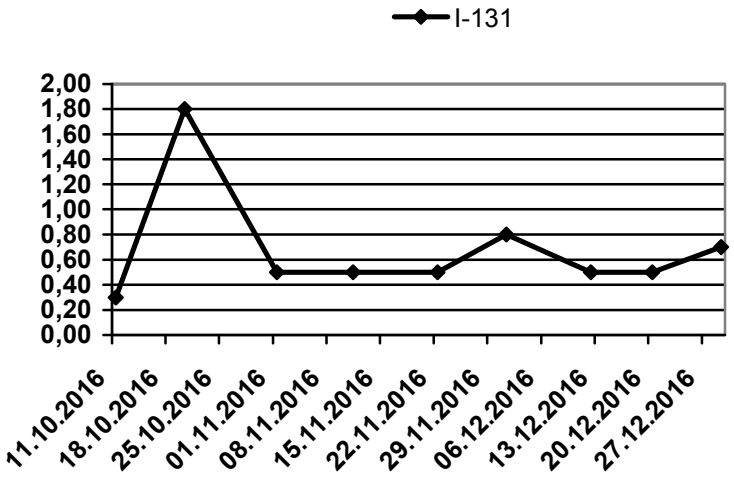
In compliance with the Agreement between the Government of Ukraine and the Government of the Kingdom of Norway on early notification of nuclear accidents and information exchange on nuclear facilities, SNRIU sent a request to the NRPA to clarify the information on incident causes and circumstances.

At the same time, several Eastern European countries informed that their national radiation monitoring systems registered isotope I-131 in the atmospheric air in quantities that are not hazardous for human health, but differ from the minimum detected activity of day-to-day observations.

In Ukraine, during 11-25 October, isotope I-131 with an activity of 1.3 ÷ 2.7 Bq/m^3 was detected on the aerosol filters of RNPP observation area. Within the same period, iodine I-131 was identified at one of the observation posts of SSE Ecocenter in the ChNPP exclusion zone, as well as in Poland, the Baltic and Scandinavian countries.

The diagram below shows an example of changes in aerosol concentration in the lowest atmospheric air at 'Aeroport' check point in the 4th quarter of 2016 according to the RNPP automatic radiation monitoring system (ARMS), station No. 21, coordinates 51021'36 "N, 25055 ' 12 "E, height of 180 m above sea level.

The filters are exposed continuously for 8-12 days (the time of removal of one filter from the exposure coincides with the beginning of the exposure of the next one). Measurement is carried out for 3-5 days. The measurement time is 60,000 - 100,000 seconds. Spectrometer calibration error is 10%. The minimum registered activity is determined by a statistical error of 50% and a probability of 0.95.

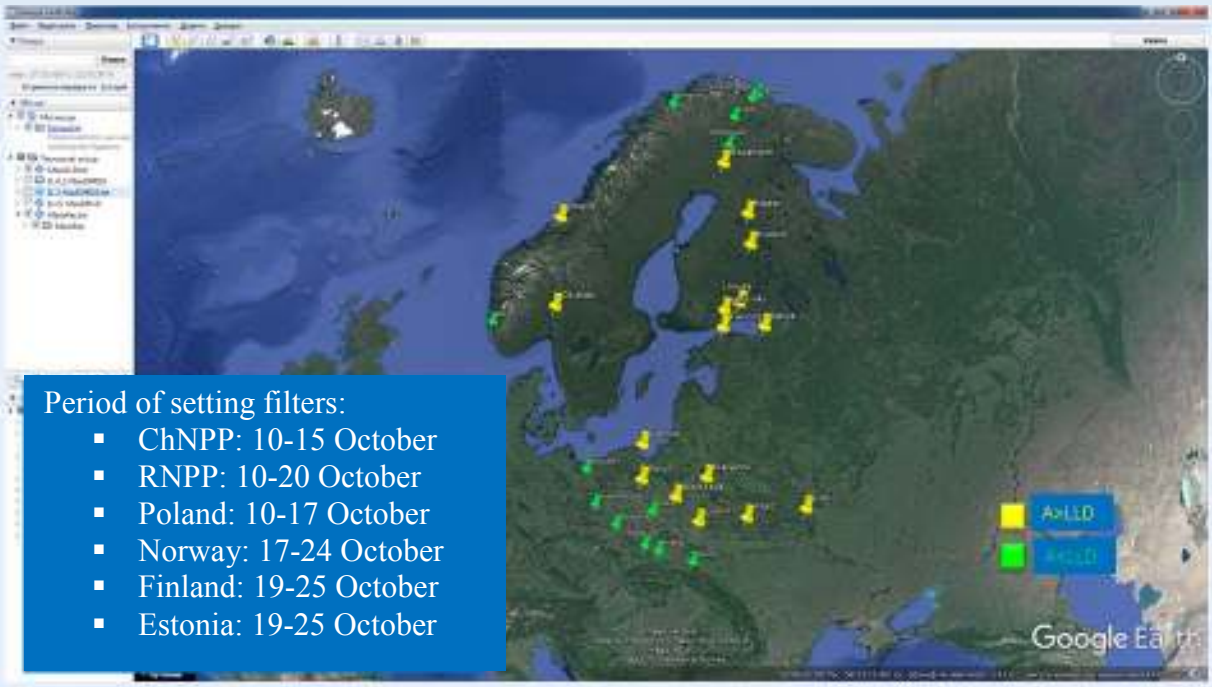


According to investigation of the incident in the Institute for Energy Technology in Halden (Norway), which were reported on USIE site in March 2017, it was found that fuel assembly unloading and reactor shutdown occurred on 17 October. However, the operator informed on fuel depressurization and radioactivity release only on 24 October, and the ventilation system was disconnected on 25 October 2016.

In compliance with the investigation report, the tentative iodine isotope releases to the air as a result of the incident are equal to 5% of the annual allowable releases, discharges are equal to 23% of the annual allowable discharges. The NRPA classified the incident as level 1 by INES, since the main radioactivity was retained by protection barriers within the reactor compartment and disconnected ventilation system.

This example shows that current national radiation monitoring systems are able to register the smallest changes in the radiation situation, while interpreting the results and identifying release source will require time, interaction and information exchange between a wide range of participants at the national and international levels. Taking into account the lessons of the Fukushima accident and global models of atmospheric transfer, they shall be optimized in order to respond promptly and impartially to events of any nature in the interests of public safety.

REGISTRATION OF I-131 IN THE ATMOSPHERIC AIR OF EUROPE IN OCTOBER 2016



Period of setting filters:

- ChNPP: 10-15 October
- RNPP: 10-20 October
- Poland: 10-17 October
- Norway: 17-24 October
- Finland: 19-25 October
- Estonia: 19-25 October

11. PUBLIC HEARINGS ON LONG-TERM OPERATION OF ZAPORIZHZHYA NPP UNITS 1 AND 2

In order to involve the public in discussing the issues that could affect the environment and provide free access to information on activities of executive bodies, the State Nuclear Regulatory Inspectorate of Ukraine held public discussions on long-term operation of the following nuclear facilities:

from 8 August to 7 September 2016 – ZNPP-1 including public hearings in Energodar on 30 August 2016;

from 18 August to 25 September 2016 – ZNPP-2 including public hearings in Energodar on 19 September 2016.

The public hearings conducted by the SNRIU on 30 August and 19 September 2016 in Energodar with the participation of Energoatom that requested draft decision became an important stage of active dialogue with the society.

The event caused a considerable interest of the audience. In general, 508 participants were officially registered for the hearings: residents of ZNPP region, representatives of public organizations, and journalists from central and regional mass media.

Figure. 11.1. **The public hearings on ZNPP-1**

The following documents were published on official websites of the regulatory body and the operating organization and distributed to the participants of the public hearings on ZNPP-1, 2 long-term operation:

- Draft decisions of the SNRIU;
- Comprehensive safety analysis of ZNPP-1, 2;
- Non-technical summary. Documents on LTO safety case of ZNPP-1, 2;

- Periodic Safety Review. Safety Factor No. 14. Environmental Impact;
- Report “Development of Environmental Impact Assessment of ZNPP Operation”;
- Non-technical summary. Report “Development of Environmental Impact Assessment of ZNPP Operation ”;
- Conclusion of the state nuclear and radiation safety review on the Periodic Safety Review Report for ZNPP-1, 2;
- certificate on comprehensive inspection of Energoatom Company preparedness for ZNPP-1, 2 long-term operation;
- Report on public discussions of the safety case for ZNPP-1, 2 long-term operation (from 19 August to 28 October 2015).

Figure 11.2. **The public hearings on ZNPP-2**

“We live in the rule-of-law state where everyone: the Government, executive bodies, local self-government bodies, enterprises and the public are well aware of the importance of the rule of law”, SNRIU Chairman Serhii Bozhko said during the public hearings. "I urge all participants of the hearings to be tolerant and listen to a different point of view. For my part, I promise to ensure the participation of every citizen in the decision-making process. Especially when it concerns such an important issue as safety of nuclear power unit long-term operation”.

Figure 11.3. **The public meeting in Nikopol**

The SNRIU Chairman noted that the Inspection meets all the requirements envisaged by the law for ZNPP-1, 2 long-term operation, which fully comply with the international standards of the IAEA and WENRA. The public discussion was preceded by the state nuclear and radiation safety review of the Periodic Safety Review Report and inspection of unit 2.

The documents developed on the results of the public discussions were published on SNRIU official website and the results of public hearings were considered on 13 September and 3 October 2016 during open meetings of the SNRIU Board on the decision to ensure ZNPP-1, 2 long-term operation.

12. INTERNATIONAL COOPERATION IN NUCLEAR AND RADIATION SAFETY

In 2016, SNRIU international cooperation was intensive and marked by a number of events of particular importance for the development of an independent nuclear and radiation safety regulation system in Ukraine and its integration into the European space. During a year, the cooperation developed actively both in bilateral and multilateral formats, in particular through the interaction with international organizations and associations, as well as fulfillment of obligations under the international agreements to which Ukraine is a party.

After signing the Association Agreement in 2014, cooperation with the EU and its bodies and institutions became a priority in the SNRIU's international activities.

Since 2007, the SNRIU has been successfully cooperating with the **European Commission** under the INSC program established to continue the TACIS program (Technical Assistance for CIS countries). Current INSC projects cover such areas as nuclear safety improvement at nuclear power plants, strengthening the regulatory body and technical support organizations, reducing the consequences of the Chornobyl accident, management of radioactive waste and spent nuclear fuel, adapting the EU legislation to the national legislation.

During 2016, the implementation of eight INSC projects continued. The aim of current projects was to support the regulator in the areas of regulating radioactive waste management safety, reactor operation safety, licensing new nuclear facilities, harmonizing regulatory requirements for nuclear and radiation safety, conducting regulatory activities in commissioning radioactive waste processing facilities at RNPP and ZNPP, regulating safety issues of reactor pressure vessel operation, etc.

SNRIU and SSTC NRS experts conducted activities in 2016 within the European Commission's project for the Republic of Belarus to provide support and assistance in strengthening the capabilities of the Belarusian regulatory authority in licensing and oversight during construction of a nuclear power plant.

In 2016, the SNRIU continued active cooperation with the Western European Regulators' Association (**WENRA**) whose full member it is since 26 March 2015. The activities are in progress in two WENRA working groups: Reactor Harmonization Working Group (**RHWG**) and Working Group on Waste and Decommissioning (**WGWD**).

During the year, implementation of two Grant Agreements with the **European Bank for Reconstruction and Development (EBRD)** were provided: Grant Agreement (Chornobyl NPP Nuclear Safety Project) between the European Bank for Reconstruction and Development (as the Administrator of Grant Funds from Nuclear Security Account), the Cabinet of Ministers of Ukraine and the State Nuclear Regulatory Inspectorate of Ukraine (as the Recipient), which was signed on 8 July 2009 and ratified by the Law of Ukraine No. 1813-VI of 20 January 2010 and Grant Agreement “Chornobyl Shelter Fund: Licensing Consultant”, which was signed on 11 May 1998 between the EBRD as the Administrator of Grant Funds provided from the Chornobyl Shelter Fund and the Nuclear Regulatory Administration of the Ministry of Environmental Protection and Nuclear Safety of Ukraine.

The Seventh National Report of Ukraine on the fulfillment of obligations under the Nuclear Safety Convention placed on nonpublic IAEA website was developed within

the Seventh Review Cycle of the SNRIU Nuclear Safety Convention with the involvement of the Energoatom Company, Ministry of Energy and Coal Industry, SEZA.

In 2016, the implementation of the projects within the trilateral Swedish-Norwegian-Ukrainian Initiative launched on the results of the Hague Nuclear Security Summit in March 2014 was completed. Among seven projects agreed for Ukraine, two projects were aimed at supporting the SNRIU, namely:

- "*Technical support to the SNRIU in developing requirements for licensing of new and modified fuel".* Project implementation is in active phase. Documentation is developed according to the schedule.
- *"Strengthening of SNRIU capabilities in conducting periodic safety assessment using current computer codes".* Within the project, in early 2015, the SNRIU received the Risk Spectrum/Risk Watcher computer codes free of charge and in early March 2015, a training on the application of the mentioned software was planned by Swedish experts for the first time.
- *"Modernization of the applied software for the information system of the State Register of Radiation Sources (Register)".*

Other four projects are implemented to support the Energoatom Company and Ukrainian NPPs.

On 19-22 January 2016, the Ukrainian delegation headed by SNRIU Chairman Serhii Bozhko was sent to the Kingdom of Sweden to discuss the results of cooperation within the trilateral Initiative and to discuss the bilateral cooperation between the SNRIU and SSM. Based on the results of project discussion, meeting participants developed and agreed an information booklet on implementing the projects within the Initiative. This booklet was presented to the participants in the Nuclear Security Summit held from 31 March to 2 April 2016 in Washington, DC (the USA).

The SNRIU together with the SSTC NRS and the **Norwegian Radiation Protection Agency (NRPA)** implemented the following three cooperation projects in 2016 to continue cooperation initiated in 2014:

- Development of regulatory requirements for safety of predisposal radioactive waste management and radioactive waste management during final disposal;
- Support to the SNRIU in developing regulatory documentation on radiation protection in medicine to put the requirements of the national legislation into compliance with IAEA standards and EU Directive 2013/59/EURATOM requirements;
- Support to the SNRIU in developing regulatory documentation on strengthening the institutional control of uranium mining and processing plants.

The parties agreed to initiate new cooperation projects based on the hazards identified in the relevant report on regulatory activities and based on the Roadmap of the bilateral cooperation.

During 2016, the SNRIU implemented active cooperation on nuclear and radiation safety with the **Swedish Radiation Safety Authority (SSM)**. On 22 November 2016, a new Cooperation Agreement between the State Nuclear Regulatory Inspectorate of Ukraine and the Swedish Radiation Safety Authority on cooperation in the field of nuclear and radiation safety was signed.

The following projects were implemented:

- Information support to the State Nuclear Regulatory Inspectorate of Ukraine, development and filling of an independent web resource on nuclear safety, radiation protection and nuclear non-proliferation - www.Uatom.org;
- Upgrade of applied software for the information system of the State Register of radiation sources;
- Technical support to the SNRIU in keeping a database on nuclear material accounting (STAR).

In 2016, active cooperation with the **United States of America** was carried out.

In 2016, in response to the SNRIU project proposals submitted under the Global Partnership Initiative, within the Joint Threat Reduction Program of the **U.S. Department of Defense**, two projects were initiated on emergency response and nuclear terrorism headquarters training and improvement of the SNRIU Information and Crisis Center.

During the year, the SNRIU hold consultations with representatives of the **U.S. Department of Energy** on the construction of the Centralized Spent Fuel Storage Facility (CSFSF) and the possibility of providing the SNRIU with consulting, software and analytic support in fulfilling regulatory functions during facility construction.

Under the cooperation with the U.S. Nuclear Regulatory Commission in 2016, a number of important measures were taken in addition to scheduled activities at the level of technical experts.

On 8-10 March 2016, the 28th Annual Regulatory Information Conference (RIC 2016) was held in Washington, DC. Approximately three thousand participants from more than 30 countries participated in the conference. The Ukrainian delegation included SNRIU and SSTC NRS representatives headed by SNRIU Chairman Serhii Bozhko. As part of the conference, the Ukrainian delegation hold a series of meetings with U.S. NRC senior management and officials. The parties discussed urgent issues on nuclear and radiation safety in Ukraine, outputs of current joint projects, as well as promising cooperation areas.

On 9 March 2016, during the RIC 2016, a Memorandum of Understanding between the Nuclear Regulatory Commission and the SNRIU was signed.

In the framework of **bilateral cooperation** in 2016, **the Agreement on cooperation between the State Nuclear Regulatory Inspectorate of Ukraine and the Hungarian Atomic Energy Agency in the field of nuclear and radiation safety, the Memorandum of Understanding between the State Nuclear Regulatory Inspectorate of Ukraine and the Ministry of the Environment of the Republic of Moldova** represented by the National Agency for Nuclear and Radiation Regulation, on cooperation in the field of nuclear and radiation safety and security, and the **Agreement between the State Nuclear Regulatory Inspectorate of Ukraine and the Nuclear Regulatory Authority of the Republic of Armenia on cooperation in nuclear safety and radiation protection** were also signed.

List of Abbreviations

C(I)SIP	–	Comprehensive (Integrated) Safety Improvement Program for Nuclear Power Plants
ChNPP	–	Chornobyl Nuclear Power Plant
CRME	–	Centralized Radioactive Waste Management Enterprise
CSFSF	–	Centralized Spent Fuel Storage Facility
DSFSF	–	Dry Spent Fuel Storage Facility
IAEA	–	International Atomic Energy Agency
ICSRM	–	Industrial Complex for Solid Radioactive Waste Management
IEC	–	Information and Emergency Center
INES	–	International Nuclear and Radiological Event Scale
ISF	–	Interim Spent Fuel Storage Facility
KhNPP	–	Khmelnitsky Nuclear Power Plant
LRTP	–	Liquid Radioactive Waste Treatment Plant
NPP	–	Nuclear Power Plant
NRS	–	Nuclear and Radiation Safety
NSC	–	New Safe Confinement
PSRR	–	Periodic Safety Review Report
Radwaste	–	Radioactive Waste
RNPP	–	Rivne Nuclear Power Plant
RWDS	–	Radioactive Waste Disposal Site
SFA	–	Spent Fuel Assembly
SNF	–	Spent Nuclear Fuel
SP	–	Startup Package
SSE	–	State Specialized Enterprise
SUNPP	–	South Ukraine Nuclear Power Plant
VSC	–	Ventilated Storage Cask
VVER	–	Water-Cooled Water-Moderated Power Reactor
ZNPP	–	Zaporizhzhya Nuclear Power Plant