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Ukrainian Regulatory Threat Assessment 2021

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Emneord

atomarv, trusselvurdering, regulatoriske utfordringer og myndighetssamarbeid

Resymé

Denne rapporten revurderer de viktigste kjernefysiske og strålingstruslene mot sikkerhet i Ukraina fra et regulatorisk perspektiv og identifiserer de nåværende hovedutfordringene, truslene og hullene i det ukrainske regelverket unner ansvaret til State Nuclear Regulatory Inspectorate of Ukraine.

Reference

Sneve M, Gorashchenkova A, Siegien K, Yesypenko Y. Ukrainian Regulatory Threat Assessment 2021. DSA Report 2022:1. Østerås: Norwegian Radiation and Nuclear Safety Authority, 20XX. Language: Norwegian.

Key words

Nuclear legacy, threat assessment, regulatory challenges, regulatory cooperation.

Abstract

This report analyses the current nuclear and radiation threats to safety and security in Ukraine from a regulatory perspective and identifies main challenges, threats and gaps in the Ukrainian regulatory framework within the responsibility of the State Nuclear Regulatory Inspectorate of Ukraine.

Godkjent:

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Content

1 PREFACE AND INTRODUCTION

A bilateral cooperation program between DSA and SNRIU, implemented in accordance with the provisions of Agreement [1], has been ongoing since 2014. The cooperation is carried out as part of the Norwegian Nuclear Action Plan with funding from Norwegian Ministry of Foreign Affairs. According to the Agreement [1], among other activities, the development and issue of NRS regulations is performed in the following spheres:

- → safety of nuclear facilities;
- → radioactive waste (radwaste) management, including disposal;
- → safety and security of radiation sources;
- → emergency preparedness and response;
- → remediation of legacy sites, in particular uranium mining and uranium processing plants;
- → radiation protection;
- → transport of radioactive materials;
- → management of radioactive materials containing naturally occurring radionuclides;
- → medical exposure to radiation; and
- → nuclear security.

Periodically, based on assessment of the current and anticipated state of NRS regulation in Ukraine (Regulatory Threat Assessment Reports [2] and [3] and this Report), the tasks and scope of specific projects aimed at developing and strengthening SNRIU regulatory capabilities in the indicated areas are jointly developed and implemented under DSA expert and financial support. Thus, during the period of cooperation to date, 12 projects have already been completed and further 3 projects are currently at different stages of implementation. Despite restrictions imposed and the negative consequences of the COVID-19 pandemic at the world level, 4 more new projects were launched at the end of 2020 as a result of the coordinated joint actions of DSA and SNRIU in planning and implementing the most recent roadmap for cooperation [3]. Details of all these projects are presented in the following sections of this Report. The main focus of the implemented and ongoing projects is on developing and enhancing the national regulatory framework for NRS and ensuring its compliance with current International Atomic Energy Agency (IAEA) standards and best world safety regulation practices. Due to DSA support, and as a result of these projects, Ukraine has already implemented top-level regulations [4] – [11] that establish general safety provisions for:

- → institutional control of uranium sites;
- → activities associated with uranium ore mining and processing;
- → use of radiation sources in medicine, particularly in brachytherapy;
- → predisposal radwaste management and radwaste management during disposal;
- → decommissioning of nuclear facilities; and
- → transport of radioactive materials.

The implementation of these regulations eliminated several threats in regulation identified by the assessments [2] and [3]. For the same purpose, within the current cooperation projects between DSA and SNRIU, about 15 more regulations are in the process of being developed, whose provisions establish the legal basis to enhance NRS in various areas (radiation protection; emergency preparedness and response; nuclear security, etc.). In addition to rulemaking, under the cooperation SNRIU also obtains DSA support to perform other functions, such as using best practices to analyze human and organizational factors and

safety culture during oversight, strengthening practical emergency response skills through joint emergency exercises, etc.

Since the last regulatory threat assessment, many important steps have been taken in the national nuclear sector of Ukraine, including:

- → Adoption of the Law on implementing the provisions of Council Directive EU 2013/59/Euratom [12] by the Verkhovna Rada of Ukraine (May 2019). This law establishes safety requirements for occupational and medical exposure in planned exposure situations, protection of the public in existing exposure situations and establishes safety provisions for the management of uranium ores.
- → Adoption of the Law 'On Amendments to Certain Laws of Ukraine on Safety of Nuclear Energy Use' by the Verkhovna Rada of Ukraine (May 2020). This law resumes the independence of the state nuclear regulatory body in making decisions on supervisory and licensing activities.
- → SNRIU as a member of the Western European Nuclear Regulators Association (WENRA) takes an active part in the activities of its working groups. SNRIU recent activities within the WENRA Working Group on Waste and Decommissioning were focused on self-assessing compliance of the national regulatory framework with the reference levels for spent fuel storage and radwaste management. An important component of this self-assessment was the presence of the high-level regulatory document 'General Safety Provisions for Decommissioning of Nuclear Facilities' [10] as another step in the transfer of Ukraine to the best international standards in NRS regulation.
- → In November 2020, Ukraine obtained an observer status in the European Nuclear Safety Regulators Group ENSREG. According to the results of the first thematic ENSREG peer review on aging management of Nuclear Power Plants, SNRIU jointly with the operator (Energoatom) and the Nuclear Research Institute (NRI) of the National Academy of Sciences of Ukraine developed a National Action Plan [13]. This document defines a number of regulations, whose revision or development will be aimed at improving the regulatory framework on aging management. This year (2021), SNRIU has started preparation for the participation of Ukraine in the second topical peer review of ENSREG on fire protection;
- → According to the procedure established by law and under continuous oversight of SNRIU since 2010, the operator carries out activities to ensure the safety on long-term operation for power units of Ukrainian nuclear power plants (NPPs). Currently, this decision has already been justified and adopted for 12 of the 15 power units;
- → Westinghouse fuel is licensed in Ukraine in accordance with the regulations, standards and rules on NRS. Nuclear fuel manufactured by Westinghouse is operated in mixed cores at 4 units of Ukrainian NPPs. Unit 3 of the South-Ukraine NPP (SUNPP) and Unit 5 of Zaporizhzhya NPP (ZNPP) are fully loaded with Westinghouse assemblies. In accordance with the actions and plans of the operating organization approved by SNRIU, it is also planned to load Westinghouse fuel for Unit 3 of Rivne NPP (RNPP). SNRIU also licenses local modifications for equipment and systems of power units required for safe and reliable operation of new fuel;
- → National Science Center 'Kharkiv Institute of Physics and Technology' (KIPT) commissions 'Neutron Source Based on a Subcritical Assembly Driven by a Linear Electron Accelerator' Nuclear Subcritical Facility (the neutron source) within the final part of the international joint project of Ukraine and USA. To date, the construction and installation process has been completed at the site and commissioning activities are underway. Under SNRIU regulatory oversight, comprehensive tests of the facility have been successfully conducted. SNRIU issued the permit to the licensee for the first supply of nuclear fuel for the neutron source, which has been delivered to the site. The estimated commissioning of the neutron source is 2021;
- → A centralized spent nuclear fuel storage facility (CSFSF) for spent fuel of RNPP, KhNPP and SUNPP is under construction in the Chornobyl Exclusion Zone using Holtec International (USA) technologies

for dry surface storage using a two-barrier spent fuel isolation system. Construction activities are currently underway at the CSFSF site and Holtec International has manufactured almost the entire set of equipment needed to prepare spent fuel for storage and transport containers for spent fuel. Under SNRIU oversight, factory acceptance tests for the indicated equipment have been completed;

→ In November 2016, the New Safe Confinement (NSC) was successfully placed over both the Shelter and destroyed Unit 4 of the Chornobyl NPP (ChNPP). This event was a key step towards completing the international program to transform ChNPP into an environmentally safe system. Current activities at NSC focus on functional testing of all systems and equipment to prepare NSC for commissioning. The next steps will be the dismantling of unstable Shelter structures and monitoring and removal of fuel-containing materials and other radwaste from the Shelter. SNRIU plans to issue a license for NSC operation to the State Specialized Enterprise 'Chornobyl Nuclear Power Plant' (SSE ChNPP), considering it a radwaste management facility.

The above examples characterize a general range of tasks on which SNRIU focused its activities on the last years. Most of these tasks remain relevant now. The uniqueness and complexity of these tasks, as well as existing political, security and economic situation in Ukraine, deepen the existing challenges and give rise to a significant number of new challenges that affect regulatory activities. Considering the need to continue cooperation between DSA and SNRIU on an impartial and timely basis and to ensure an efficient response to existing or new threats, the parties defined the need for a new Ukrainian regulatory threat assessment. The results are set forth in this Threat Assessment Report. Sections 2-8 of the Report analyze the current situation with state regulation of safety in nuclear energy in Ukraine in the areas defined in Agreement [1]. The main attention was focused on the progress reached in these areas in the last years, description of changes that took place in the national nuclear sector, and definition of current and potential impact of these changes on SNRIU activities. Section 9 provides the following information for each threat identified in the assessment:

→ description of a threat with a reference to the relevant section(s) of the Report with justification on the current existence of the presented threat;

→ potential measures to eliminate the threat or to minimize its impact and priorities of these measures; and

→ possible risks caused by the threat and their increase if the threat is not eliminated.

Section 10 of this Report then focuses on the analysis of projects that are ongoing or planned by 2025 that are aimed at eliminating the threats identified. Section 10 also presents results and information on the status (as of the beginning of 2021) of projects within the bilateral cooperation between DSA and SNRIU. It also describes other projects carried out or planned within cooperation between the SNRIU and relevant institutions of other countries, international organizations and relevant activities of the SNRIU and SSTC NRS through their own resources. The Conclusions present a brief description of the conducted activities with specification of the main results obtained.

2 ORGANIZATION AND GENERAL PRINCIPLES FOR ACTIVITIES OF THE REGULATORY AUTHORITY

2.1 General Organizational Aspects of SNRIU Activities

The previous Regulatory Threat Assessment Reports [2] and [3] describe basic principles pertaining to state regulation of nuclear and radiation safety in Ukraine, as well as obligations and tasks entrusted to the SNRIU in accordance with current legislation. These data have not changed and remained relevant in the development of this Report. Further updated information on organizational aspects of current SNRIU activities is provided in this section.

The main functions of the nuclear regulatory authority established by the Convention on Nuclear Safety [14] and the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management [15] are entrusted to the SNRIU as a central executive authority whose activities are directed and coordinated by the Cabinet of Ministers of Ukraine and which acts in compliance with the Statute of the State Nuclear Regulatory Inspectorate of Ukraine [16].

The main SNRIU functions are to:

- → identify safety criteria and requirements to be legally established in the use of nuclear energy (rule-making);
- → issue permits and licenses for activities in the area of nuclear energy (licensing/authorization);
- → conduct state oversight of compliance with laws, regulations, rules and standards on nuclear and radiation safety and apply enforcement measures according to legislation in case of incompliance (oversight).

The main SNRIU tasks are to:

- → establish and implement state policy for the safe use of nuclear energy;
- → exercise state regulation of nuclear energy safety;
- → exercise powers of a competent authority on physical protection of nuclear material and nuclear facilities in compliance with the Convention on the Physical Protection of Nuclear Material and Nuclear Facilities [17], on safe transport of radioactive material in compliance with [9], and on emergency notification in compliance with the Convention on Early Notification of a Nuclear Accident [18].

As of the beginning of 2021, the SNRIU conducts state NRS regulatory control of:

- → 15 operating nuclear power units, Khmelnitsky NPP (KhNPP) Units 3 and 4 in construction and ChNPP Units 1-3 in decommissioning;
- → two operating spent fuel storage facilities at the Zaporizhzhya and Chornobyl NPPs and two spent fuel storage facilities under construction in the Exclusion Zone;
- → two research reactors;
- → neutron source constructed on the KIPT territory;
- → radioactive waste storage/disposal facilities and radioactive waste management enterprises;
- → Shelter facility and New Safe Confinement at the Chornobyl NPP site;
- → uranium processing plants;

→ radioactive material transport through Ukraine; and

→ use and fabrication of radiation sources and radiation technologies including use of radiation sources in medicine, industry, research, etc.

The current SNRIU organizational structure is shown in Fig. 2.1.

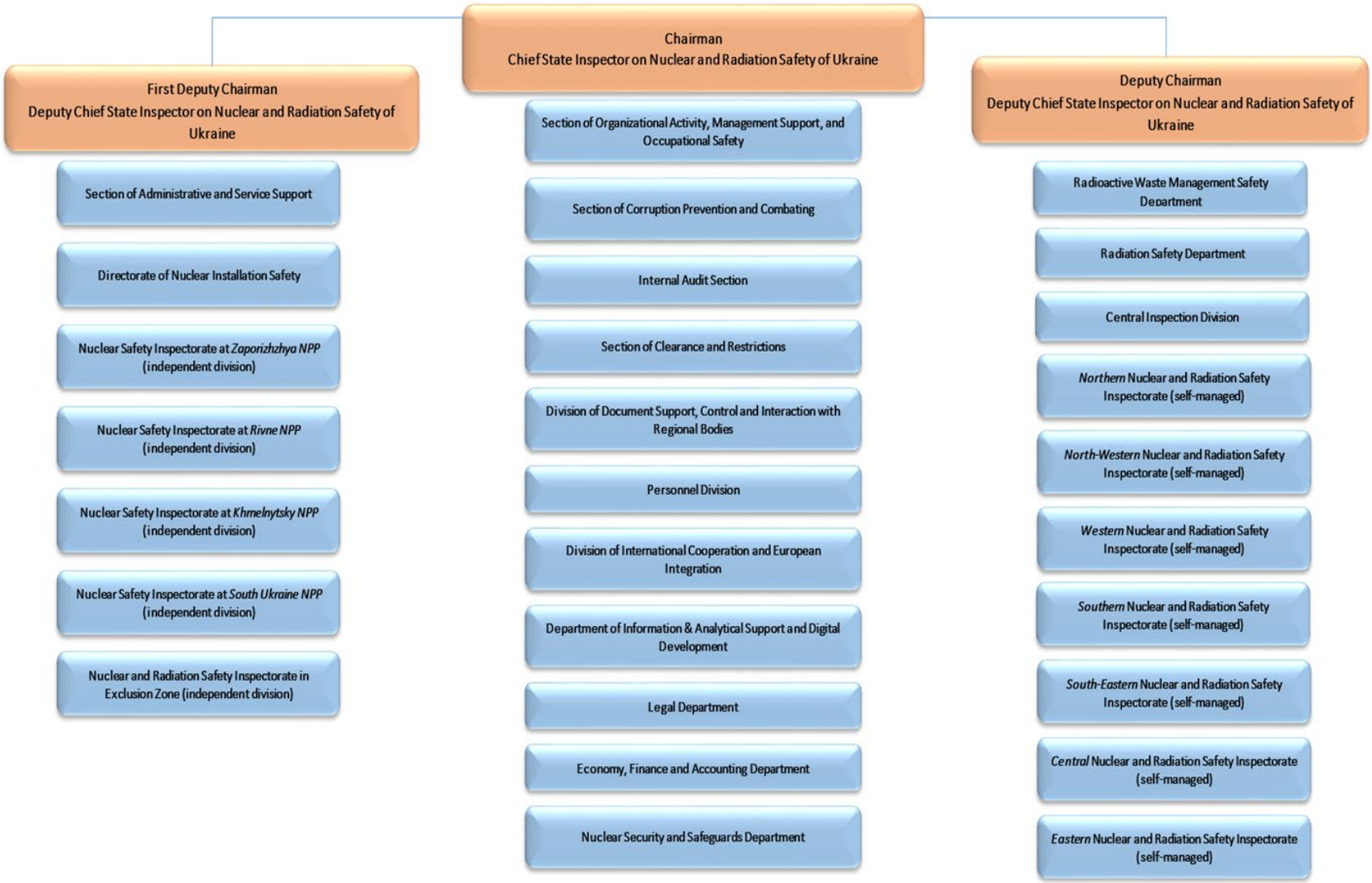
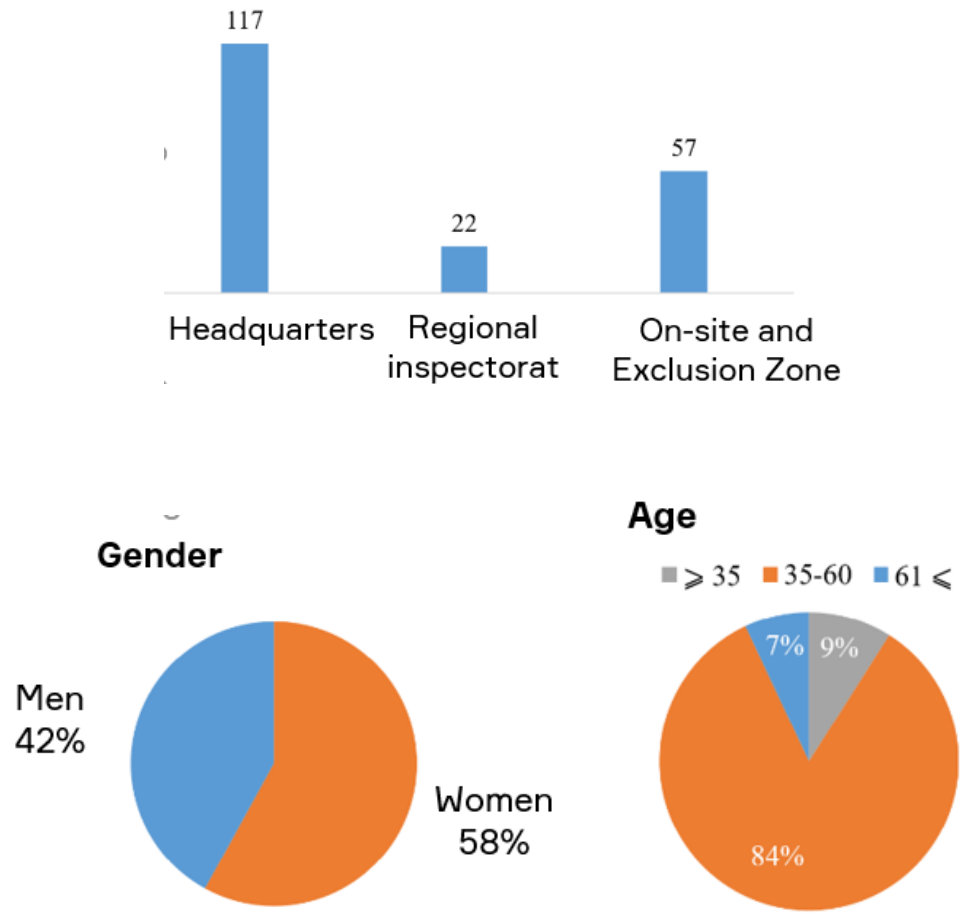


Fig. 2.1 SNRIU organizational structure

The distribution of SNRIU staff by departments, by gender and by age, as of January 2021 is presented in fig. 2.2.



Total staff number – 273
Vacancies – 77

Fig. 2.2 SNRIU staff

The SNRIU has a technical support organization, SSTC NRS, which provides scientific and technical, expert, and analytical support to the SNRIU in compliance with current legislation and the SSTC NRS Statute.

To develop recommendations on significant issues and identify the most essential areas of NRS regulation, the SNRIU Board is working on a permanent basis [19]. The SNRIU Board main tasks are to:

- → review proposals for the formulation and implementation of state policy for the safe use of nuclear energy;
- → define prospects and most important areas in the development of the regulatory framework on state regulation of nuclear energy;
- → analyze results and define policy and priorities of authorizing activities in nuclear energy;
- → analyze results and define policy and priorities of state NRS oversight;
- → consider results of state NRS reviews and inspections of nuclear facilities and radioactive waste disposal facilities in making decisions on issuing licenses to conduct activities at their life stages;

→ extend international cooperation on safe use of nuclear energy;

→ analyze the status of measures on state policy implementation in all areas of SNRIU activities.

The SNRIU Board consists of SNRIU Chairman (Board Head), SNRIU and SSTC NRS management, leading independent experts and representatives of public organizations.

The Public Council was established to ensure that the public is involved in the administration of state affairs, exercise public supervision of SNRIU activities and promote effective interaction of the SNRIU with the public, taking into consideration public opinion in the formulation and implementation of state policy. The main tasks of the Public Council are to:

→ promote conditions for citizens to exercise their constitutional right for participation in administration of state affairs;

→ exercise public supervision of SNRIU activities; and

→ assist the SNRIU in considering public opinion in the formulation and implementation of state policy.

The SNRIU issues annual reports on nuclear and radiation safety in Ukraine. The annual report highlights implementation of the national policy in peaceful use of nuclear energy and compliance with NRS requirements in Ukraine. The annual report is published in Ukrainian and English and posted on the official, recently updated, SNRIU website https://snriu.gov.ua/.

In compliance with ISO 9001:2015 'Quality Management Systems – Requirements', the SNRIU conducts annual internal audits of departments/divisions that deal with quality control system processes and carries out SWOT analysis to identify weaknesses and strengths of activities and performs routine and periodic monitoring of respective parameters and indicators. The results of monitoring and internal audits and recommendations of SWOT analyses are used for continuous improvement of SNRIU activities.

In September 2020, the SNRIU management system passed the next certification audit. Upon the audit, TUV NORD, an independent certification body, issued a certificate of compliance for the SNRIU management system with international standard ISO 9001:2015 'Quality Management Systems – Requirements' for regulatory services in the use of nuclear energy, which was registered on 25 August 2020. Therefore, compliance of the SNRIU management system and approaches to the performance of regulatory functions with up-to-date European level was confirmed once again.

2.2 State Regulation of Nuclear and Radiation Safety in Pandemic Conditions

The coronavirus COVID-19 broke out in late 2019 and has now spread around the world. In order to prevent the spread of COVID-19 in Ukraine, the Law of Ukraine 'On Amendments to Certain Legislative Documents of Ukraine Aimed at Preventing the Occurrence and Spread of Coronavirus Disease (COVID-19)' No. 530-IX of 17 March 2020 introduced a number of restrictive measures. Due to Covid -19 all oversite by supervisory authorities were stopped. Despite the restrictive measures caused by COVID-19, the implementation of the functions by SNRIU on state safety regulation of nuclear energy use, including rulemaking, authorization and state oversight remained at the appropriate level. Under pandemic conditions, licensees continued to implement basic measures for safe operation of facilities in compliance with NRS rules, regulations and limits, conditions and controls established in the authorization. SNRIU continued implementing measures of state NRS regulation of these activities by:

→ issuing permits upon a comprehensive assessment of the documents provided by entities to confirm the ability to perform the declared activities in compliance with the rules and regulations on NRS;

→ state oversight measures after sending a request to the entity to inform SNRIU about safety and epidemiological conditions and restrictions that may prevent implementing a state oversight measure and receiving a relevant response on the absence of objections regarding the stay of state inspectors at a state oversight facility; and

→ official advisory support, clarification and regulatory decision making.

State regulation, despite the challenges faced by Ukraine due to the impact of the pandemic, has been ensured with the unconditional priority of safety culture and through coordinated actions of the state, nuclear regulatory body and nuclear entities.

2.3 SNRIU Independent Status

The commitment of the state to ensure 'effective independence of the competent regulatory body of undue impact on developing and adopting regulatory decisions' is a standard of Council Directive 2014/87/Euratom [20], whose implementation by Ukraine is a condition of the Association Agreement between Ukraine, on the one part, and the European Union (EU) and the European Atomic Energy Community (Euratom), on the other part. To meet this standard, on the legislative initiative of people's deputies in the Verkhovna Rada of Ukraine, the Law of Ukraine 'On Amendments to Certain Laws of Ukraine on Safety of Nuclear Energy Use' was registered on 1 November 2019 and adopted on 19 May 2020. This aim of this law is to avoid weakening state safety regulation of nuclear energy use in accordance with the purpose of such regulation to ensure NRS in the country. Amendments were made to the Laws of Ukraine 'On Basic Principles of State Oversight (Control) in the Sphere of Economic Activities' and 'On Licensing of Economic Activities' and concerned the non-extension of these laws to the oversight of meeting safety requirements of nuclear energy use and licensing activities in nuclear energy use. Thus, significant progress has been made in eliminating the threat identified in Reports [2] and [3] to ensure independent NRS regulatory functions in Ukraine in accordance with international requirements.

In order to strengthen state oversight functions, a draft Law on Amendments to Article 25 of the Law of Ukraine on Nuclear Energy Use and Radiation Safety [21] was submitted to the Verkhovna Rada of Ukraine. The draft law proposes to settle the issue of appointing the Chief State Inspector on Nuclear and Radiation Safety of Ukraine. SNRIU also developed and the Cabinet of Ministers of Ukraine approved Resolution No. 652 of 29 July 2020 on amendment of the Statute of the State Nuclear Regulatory Inspectorate of Ukraine [16]. The purpose of the resolution is to strengthen the effectiveness of state oversight in nuclear energy use and increase the role of the Chief State Inspector on Nuclear and Radiation Safety of Ukraine. In particular, it envisages that the Chief State Inspector on Nuclear and Radiation Safety of Ukraine according to the position is the SNRIU Chairman, and the Deputy Chairmen of SNRIU according to the position performs the functions of the Deputy Chief State Inspectors on Nuclear and Radiation Safety of Ukraine.

2.4 Priority Areas of SNRIU Activities

In order to implement the tasks defined by laws, regulations and instructions of the President and the Government of Ukraine, international obligations aimed at ensuring NRS and security, SNRIU identified the following priority areas for its activities in the coming years:

→ further implementation of the action plan to implement the Association Agreement between Ukraine and the EU;

→ further bringing national standards and rules on NRS into compliance with up-to-date IAEA safety and security standards and their harmonization with WENRA reference levels;

- → fulfillment of Ukraine's obligations under Conventions [14], [15], [17], [18];
- → implementation of existing cooperation projects with regulatory authorities of Sweden, Norway, USA and other partner countries and, in particular, cooperation projects with the European Commission and IAEA;
- → active participation in WENRA activities and interaction with the European Nuclear Safety Regulators Group (ENSREG);
- → implementation of the action plan to form a single state system for control and accounting of individual doses approved by Cabinet Resolution 'Some Issues of Establishing the Unified State System for Accounting and Control of Individual Doses' No. 1141 of 18 November 2020;
- → licensing of activities on uranium ore mining and processing, and development and implementation of radiation safety standards in the area of safety of uranium ore mining and processing including remediation;
- → regulatory engagement and oversight of the following:
    a) implementation of the Comprehensive (Integrated) Safety Improvement Program for Ukrainian NPPs (C(I)SIP) [22];
    b) implementation of the Comprehensive Work Program for Long-Term Operation of Operating NPPs [23];
    c) designs of new nuclear facilities;
    d) diversification of nuclear fuel supply for Ukrainian NPP units;
    e) commissioning of the NSC; and
    f) construction and commissioning of CSFSF;
- → state oversight, comprehensive regulatory analysis and evaluation of activities to bring former uranium production facilities and the site of the Production Association 'Prydniprovsk Chemical Plant' (PChP) into safe condition;
- → regulatory review and assessment and corresponding authorization of radwaste management facilities as part of the Vector site;
- → fulfillment of international obligations in terms of achieving strategic security goals, namely: minimizing the risks of committing acts of nuclear terrorism, theft of nuclear material, radwaste and other radiation sources, as well as strengthening the non-proliferation regime.

The following sections of this Report provide a detailed description of the current SNRIU activities in the above areas, identify new challenges that adversely impact their implementation, and suggest ways to eliminate or minimize these adverse impacts.

3 SAFETY OF NUCLEAR FACILITIES

3.1 General Description

The nuclear facilities in operation in Ukraine as of early 2021 are shown in Fig. 3.1.

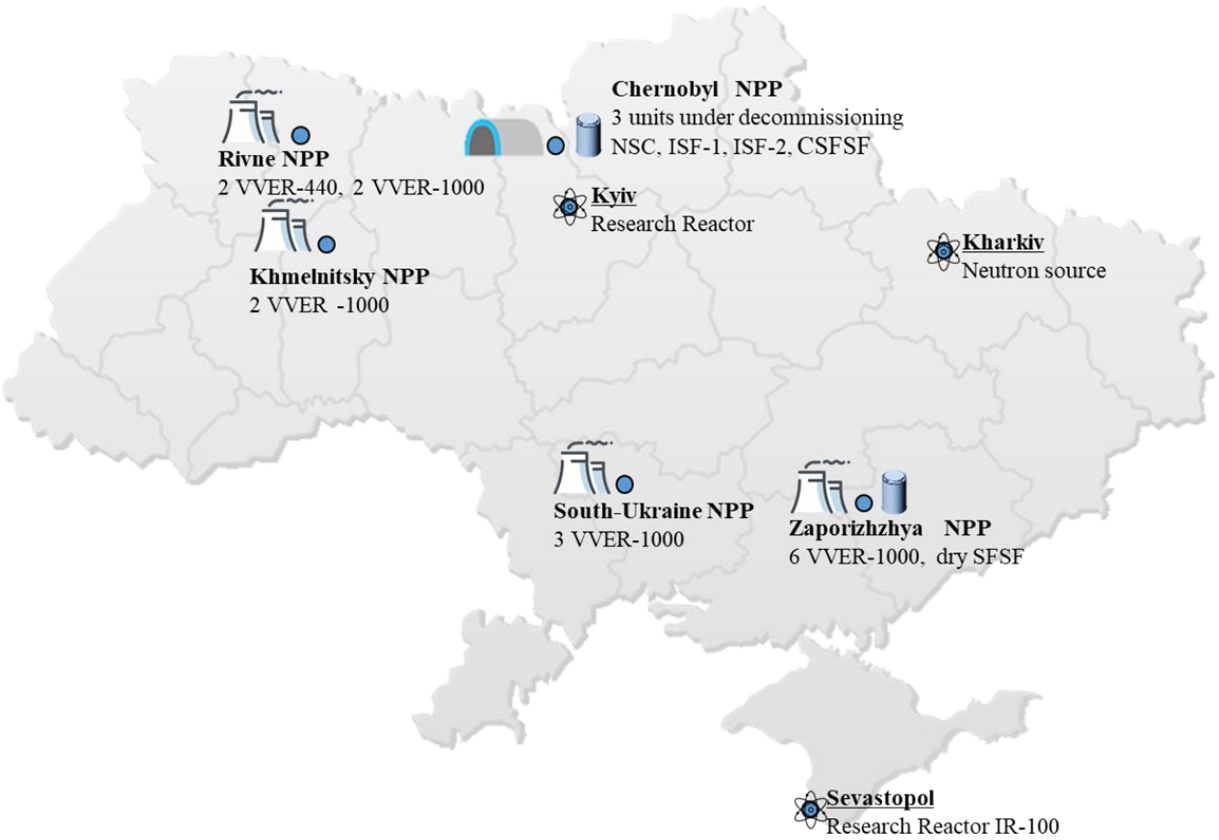


Fig. 3.1 – Nuclear facilities in Ukraine

3.2 Nuclear Power Plants

The importance of nuclear power production for Ukrainian economy is unique ensuring the production of more than 50% of electricity in the country. There are four NPPs operating in Ukraine, which have 15 power units, 13 of them are VVER-1000 units and 2 are VVER-440 units. Ukraine ranks the tenth in the world regarding the number of power units and the seventh regarding the installed capacity [2]. Energoatom is the only operator of all operating NPPs in Ukraine.

According to the current Energy Strategy of Ukraine for the Period until 2035 [24], nuclear energy plays an important role as one of the most cost-effective low-carbon energy sources. Further development of the nuclear energy sector by 2035 provides an increase in electricity production at Ukrainian NPPs. To achieve this goal, an important task, along with long-term operation of NPP units, is analysis with justification for the optimal choice of promising nuclear facilities to replace power units that are being decommissioned.

3.2.1 NPP Safety Improvement

According to the requirements of the Law of Ukraine 'On Nuclear Energy Use and Radiation Safety' [21] and provisions of the Convention on Nuclear Safety [14], the operating organization shall provide sustainable and safe NPP operation. Safety improvement measures for operating NPPs are implemented on a systematic basis in compliance with the requirements of national standards and rules on NRS, IAEA recommendations and considering long-term operating experience and international practice. The World Association of Nuclear Operators (WANO) and IAEA peer reviews confirmed safe operation of Ukrainian NPP units and activities underway at all Ukrainian power units within current programs on safety improvement and long-term operation of NPP units.

During 2015 – 2020, the safety improvement measures envisaged by C(I)SIP [22] to be implemented by the end of 2023 are being performed. After the Fukushima-Daiichi accident, C(I)SIP [22] was supplemented with additional measures identified upon in-depth safety reassessment of Ukrainian NPPs (stress tests) and with additional fire protection measures. The measures under C(I)SIP [22] aimed at safety improvement of power units and equipment modernization are implemented usually during annual refueling outages (see Section 3.2.1 of Report [3] for details). According to the schedules to implement C(I)SIP [22] measures, the main efforts of the operating organization in 2018 – 2020 were focused on the measures for ZNPP Units 4 and 5, KhNPP Unit 1, and SUNPP Unit 3 in preparation for long-term operation, as well as for RNPP Units 1 and 2 within their periodic safety review. The measures were implemented at Ukrainian NPPs to:

- → ensure makeup and cooldown of the spent fuel pool in long-term station blackout;
- → ensure makeup of steam generators in long-term station blackout;
- → ensure operability of group A service water system loads in drainage of spray ponds;
- → ensure post-accident monitoring of systems important to safety;
- → ensure emergency power supply in long-term station blackout;
- → prevent early containment bypass in spread of corium from the reactor beyond the containment;
- → develop and implement measures to reduce hydrogen concentration in the containment for beyond design-basis accidents.

Particularly the implementation of the filtered containment venting system (FCVS) at VVER-1000 (V-320) power units and start of implementing the ex-vessel cooling system for VVER-440 reactor pressure vessels at RNPP Units 1 and 2 should be noted. FCVSs are designed to prevent failures of the containment caused by static pressure increase during severe accidents due to controlled environment discharge from the containment into the atmosphere with its prior high-efficiency cleaning by filters. Westinghouse dry filters are used for FCVS at B-302/338 units. FCVSs at these power units are in commercial operation. V-320 units are expected to use FCVSs with filtering equipment based on the Venturi scrubber manufactured by Skoda JS a.s. (Czech Republic) (Fig. 3.2). FCVSs are actively implemented at all power units of Ukrainian VVER-1000 NPPs in accordance with technical solutions agreed by SNRIU.

Fig. 3.2 – Venturi nozzles used in a scrubber for high-rate filtration of steam-gas mixture

The reactor ex-vessel cooling system is designed to prevent the progression of a severe accident to the ex-vessel phase and, accordingly, to further prevent failure of the containment system due to the impact on the structures and components of the containment system by molten core fragments. Prevention of the ex-vessel phase also prevents a number of phenomena that have a negative impact on the containment systems, in particular, hydrogen generation due to corium and concrete interaction. Destruction of the reactor pressure vessel is prevented by external cooling of the reactor pressure vessel that does not allow:

→ melt-through of the reactor pressure vessel and melt remains inside the reactor pressure vessel or

→ deformations that can cause deterioration of heat removal from the outer surface of the reactor pressure vessel (prevention of local overheating of the reactor pressure vessel wall).

Fig. 3.3 – Equipment for the ex-vessel reactor cooling system (hydraulic seal of the ex-vessel reactor cooling system and floating mechanism to open the hatch of the protective screen of the reactor pressure vessel)

RNPP Units 1, 2 are expected to use the ex-vessel reactor cooling system (Fig. 3.3) manufactured by VUEZ a.s. (Slovak Republic). Ex-vessel reactor cooling systems similar in configuration and design solutions have already been successfully implemented or are currently being implemented at a number of European NPPs with VVER-440 (B-213), in particular, Dukovany NPP (Czech Republic), Mochovce NPP (Slovak Republic), Loviisa NPP (Finland), and Paks NPP (Hungary).

On an ongoing basis, with its own resources and involving SSTC NRS, SNRIU oversees the implementation of relevant safety measures. The full-scale completion of the C(I)SIP [22], including post-Fukushima measures, is one of the challenges for the Ukrainian nuclear industry in the near future. International assistance to strengthen SNRIU capabilities in licensing and oversight over the implementation of safety improvement measures is obtained from a number of sources (see Section 10 of this Report for details).

3.2.2 NPP Long-Term Operation

Eleven of the fifteen power units of Ukrainian NPPs have been in operation for over 30 years. In the Energy Strategy of Ukraine for the Period until 2035 [24], which defined the strategic guidelines to develop the fuel and energy system of Ukraine, nuclear energy is recognized as one of the most cost-effective low-carbon energy sources and further development of the nuclear energy sector by 2035 is foreseen since the share of nuclear generation in total electricity production will remain at the same level. In view of this, the Government of Ukraine has set a course for long-term operation of NPP units in accordance with the Comprehensive Work Program for Long-Term Operation of Operating NPPs [23]. As of 2020, long-term operation was provided according to the established procedure for 12 power units of Ukrainian NPPs. In the period from 2020 to 2030, the design service life of 2 more NPP units will be expired (see Table 3.1), and so will be the period of long-term operation for 7 NPP units.

Table 3.1 – Service life of operating units of Ukrainian NPPs

NPP	Unit	Reactor type	Expiration of service life	
			design-basis	long-term operation
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	05.03.2027
	4	VVER-1000/320	04.04.2018	04.04.2028
	5	VVER-1000/320	27.05.2020	27.05.2030
	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	10.02.2030
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	11.12.2037
	4	VVER-1000/320	07.06.2035	–
KhNPP	1	VVER-1000/320	13.12.2018	13.12.2028
	2	VVER-1000/320	07.09.2035	–

In accordance with current legislation, a decision on authorization of a long-term operation of a power unit is made by the SNRIU based upon conclusions of state NRS review of the periodic safety review report by amending the license for its operation. Authorization for long-term operation may be allowed only if the safety level of the nuclear power unit is not lower than that established by current regulations and rules on NRS. Challenges that occur in the regulation of long-term operation of Ukrainian NPPs are dealt with by the SNRIU and SSTC NRS using their own resources and through assistance of the United States Nuclear Regulatory Commission (USNRC) and European Commission projects (see Section 10 of this Report for details).

3.2.3 Analysis of Operating Experience and Accounting of Operational Events at Ukrainian NPPs

Accounting and analysis of NPP operational events is an integral part of the operating experience feedback system, which in turn is a separate aspect of NPP safe operation. Maintaining the proper level of NPP safe operation requires a continuous comprehensive analysis of operating experience on an ongoing basis to assess the current state of power units, identify lessons and develop corrective measures.

The operating organization according to the requirements of the General Safety Provisions for Nuclear Power Plants [25] specified in the part of investigation and accounting of NPP operational events in the Provisions on the Procedure for Investigation and Accounting of NPP Operational Events [26]:

- → forms a system of records, analysis and use of operating experience;
- → is responsible for completeness and quality of investigation, reliability and timeliness of submitting the results of the investigation of NPP operational events to SNRIU; and
- → carries out activities aimed at prevention of events that affect safety, including equipment failures and human errors, at improving operating procedures, methods and tools to diagnose the condition of equipment, systems and components important to safety.

SNRIU, with involvement of SSTC NRS, oversees compliance with safety standards and rules during investigation and analysis of NPP operational events, as well as providing planning and inspections, taking into account operating experience (see Reports [2] and [3] for details).

In 2020, 19 operational events took place at Ukrainian NPPs: 13 abnormal occurrences and 6 deviations in the operation of NPP units. Figure 3.4 shows the change in the number of occurrences and deviations from 2010 to 2020.

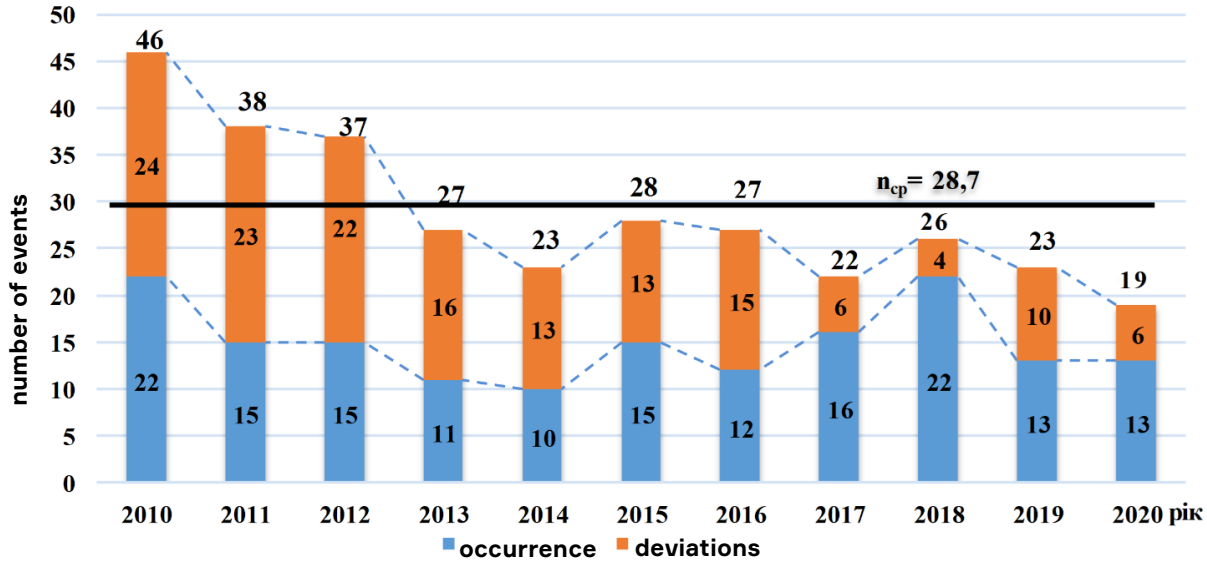


Fig. 3.4 – Number of abnormal occurrences and deviations at Ukrainian NPPs in 2010-2020

One of the challenges identified in Reports [2] and [3] was the need to ensure systematic and comprehensive analysis of operating experience for Ukrainian NPPs on a permanent basis for effective use of lessons learnt and improvement of operational safety. Under DSA and SNRIU cooperation, the EXPERIENCE project was implemented to address this threat. The project provided development of SNRIU guidelines to assess safety culture and human and organizational factors during the operating experience analysis and approved the developed guidelines through a pilot study on the analysis of operational events at Ukrainian NPPs for 2006 – 2017.

The results of the EXPERIENCE project are used within the current analysis of the reports on the investigation of operational events at Ukrainian NPPs, as well as during development of SNRIU recommendations for oversight planning. In addition, the experience gained was also considered during the revision of the Provisions on the Procedure for Investigation and Accounting of NPP Operational Events [26], which is currently underway within the relevant SNRIU international assistance project (see Section 10 of this Report for details).

3.2.4 Diversification of Nuclear Fuel and Technology

The Westinghouse fuel was introduced to avoid dependence on a monopoly supplier. In 2017-2020, diversification of nuclear fuel for Ukrainian NPPs continued (for details on the preconditions and process of diversification, see Reports [2] and [3]). As of the end of 2020, Westinghouse fuel is part of the core of SUNPP Units 2 and 3 and ZNPP Units 1, 3, 4, 5. SUNPP Units 2 and 3 and ZNPP Unit 5 have completely transferred to Westinghouse fuel. Core loading of VVER-1000 NPPs of Ukraine with nuclear fuel manufactured by Westinghouse as of the beginning of 2021 was approximately 41%

Since 2021, Energoatom plans to start trial operation of FA-WR at RNPP Unit 3. Moreover, Energoatom is currently considering the use of an alternative assembly manufactured by Westinghouse for RNPP VVER-440 Units 1 and 2 and, on 30 September 2020, an agreement was signed between Energoatom and Westinghouse on the supply of VVER-440 nuclear fuel for RNPP. Further development of nuclear fuel diversification is one of the most important issues of Ukrainian energy independence and national security. Current regulatory issues that arise during the implementation and distribution of Westinghouse fuel at Ukrainian NPPs are resolved by SNRIU independently and under technical support of SSTC NRS. At the same time, the project [27] supported by the European Commission considers the issue of harmonization of approaches to licensing alternative fuels with European best practices (see Section 10 of this Report for details).

3.2.5 Research Facilities

Ukraine has two research reactors:

→ nuclear research reactor VVR-M of the Nuclear Research Institute in Kyiv (see Fig. 3.5);

→ nuclear research reactor (IR-100) subcritical uranium-water assembly at the Sevastopol National University of Nuclear Energy and Industry (see Fig. 3.6).

Fig. 3.5 – Nuclear research reactor VVR-M at Nuclear Research Institute in Kyiv

Fig. 3.6 – Nuclear research reactor IR-100

In 2014 SNRIU lost regulatory control over research reactor IR-100 and two subcritical assemblies based on low-enriched and natural uranium at the Sevastopol National University of Nuclear Energy and Industry. For this reason, on 16 June 2014, the SNRIU cancelled the license issued to the Sevastopol National University of Nuclear Energy and Industry for operation of the research reactor (IR-100) and subcritical water-uranium assembly.

Nuclear research reactor VVR-M of the Nuclear Research Institute (National Academy of Sciences of Ukraine) was commissioned in February 1960. The design did not establish its lifetime. The safe operation of nuclear research reactor VVR-M was addressed at SNRIU Board meetings in 2005, 2009, 2013 and 2014. Upon a series of measures and inspections, the SNRIU in 2014 extended the service life of reactor VVR-M

until 31 December 2023 (see Reports [2] and [3] for details). In 2020, the Nuclear Research Institute made a decision to continue operation of the nuclear research reactor VVR-M beyond 2023. Report [3] identified a threat caused by the inadequate regulatory framework that governs individual operational aspects of research reactors, including their safety review. One of the components under the Instrument for Nuclear Safety Cooperation (INSC) Project [28] is intended to eliminate this threat through the development and improvement of national requirements for periodic safety review of research reactors and investigation and accounting of operational events that occur at them (see Section 10.3 of this Report for details).

3.3 Construction of New Nuclear Facilities

3.3.1 Construction of KhNPP Units 3 and 4

As of 2020, construction of KhNPP Units 3, 4 (see Fig. 3.7) had been suspended (see Section 3.4.1 of Report [3]).

Fig. 3.7 – Construction status of KhNPP Units 3 and 4

Pursuant to Decree of the President of Ukraine No. 406/2020 of 22 September 2020 'On Urgent Measures for Stabilization of the Energy Sector and Further Development of Nuclear Energy', the operating organization restarted the construction of KhNPP Units 3 and 4 at the end of 2020.

3.3.2 Construction of Neutron Source

This nuclear facility (Fig. 3.8) had been under construction on the KIPT site since 2013. In the period from 2017 to 2020, the operating organization commissioned the facility. Operational and technical documents were developed and approved, systems important to safety were tested, and comprehensive tests of the neutron source in general were performed. On 12 April 2019, SNRIU issued for KIPT a permit for the first nuclear fuel delivery for the neutron source to the KIPT industrial site and on 21 May 2019, neutron source fuel was delivered to the KIPT industrial site. On 1 July 2020, an individual SNRIU permit was issued for the initial startup of the neutron source.

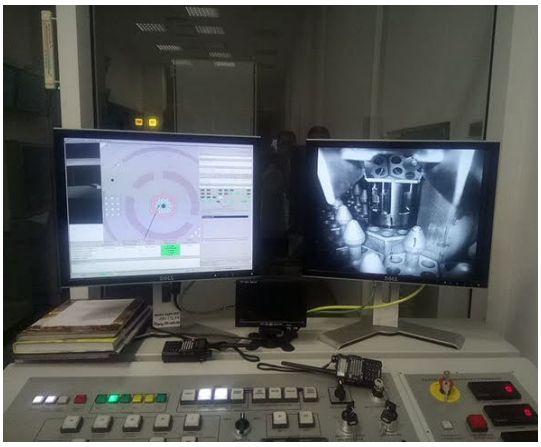


Fig. 3.8 – Neutron source

On 30 July 2020, the first fuel assembly was loaded to the core of the neutron source, and initial startup was initiated and is ongoing now.

The challenges faced by SNRIU in the licensing and regulatory safety review and assessments for the commissioning of new nuclear facilities for Ukraine are being addressed using own resources and under international assistance (see Section 10 of this Report for details).

3.4 Spent Fuel Management

Currently, two facilities for interim storage of spent nuclear fuel are operated in Ukraine: a wet spent fuel storage facility at ChNPP (ISF-1) and a dry spent fuel storage facility at ZNPP (DSFSF) (see Section 3.3 of Report [3] for details). In addition, a dry interim spent fuel storage facility at ChNPP (ISF-2) is in the commissioning stage and a centralized spent fuel storage facility (CSFSF) for spent VVER fuel of national NPPs is in the construction stage.

ISF-2 is designed for acceptance, pre-storage treatment and long-term storage (for 100 years) of all spent fuel by the SSE ChNPP. On 25 August 2020, the SNRIU approved a decision to issue a permit for ISF-2 commissioning to the SSE ChNPP. CSFSF is designed for long-term storage of spent fuel from RNPP, KhNPP and SUNPP.

The activities on the CSFSF construction completion project are carried out in accordance with the license for construction and commissioning of the CSFSF issued by the SNRIU on 29 June 2017. Safety regulation and oversight of the construction and commissioning of this storage facility is conducted by SNRIU through state NRS review and approval of technical specifications and design documents for systems and equipment important to CSFSF safety and projects for the modification of NPP units in their preparation for spent fuel unloading.

All the new facilities and technologies used in the design, construction and operation of spent fuel management facilities are provided by Holtec International (USA).

The current challenges faced by SNRIU in safety regulation and oversight of spent fuel storage facilities located in Ukraine and in commissioning new nuclear facilities for Ukraine are addressed by own resources and under international assistance (see Section 10 of this Report for details).

During the analysis and development of the Section on ‘Safety of Nuclear Facilities’ of this Report, no critical regulatory threats needing immediate intervention were identified. The threats in this area identified in Reports [2] and [3] were addressed in the framework of cooperation with DSA, under projects:

→ Development of Requirements for the Structure and Contents of Emergency Documents (GUIDELINE project) and

→ Development of Guideline for Assessment of Safety Culture and Human and Organizational Factors in Operating Experience Analysis (EXPERIENCE project)

in addition to within other completed or ongoing international cooperation projects (see Section 10 of this Report for details) and through the SNRIU’s own resources.

4 RADIOACTIVE MATERIAL TRANSPORT

4.1 Overview of Ukrainian Legislation on Radioactive Material Transport

Radioactive material transport is a practice in nuclear energy that consists of many stages: preparation, loading, shipment, transport, including transit storage, unloading and acceptance of radioactive material consignments and packages at the final destination point. Radioactive material must remain under continuous regulatory control when it is outside of facilities for the management of fresh and spent nuclear fuel, radwaste, and radiation sources (including disused radiation sources) and it may need to be moved considerable distances.

The regulatory and legal framework has been established to ensure safe transport of radioactive material in Ukraine, which includes the Laws of Ukraine [21], [29] – [31] and other NRS regulations, particularly those for safety in the transfer of hazardous cargoes [9], [32] – [51]. These regulations establish functions and responsibilities of entities dealing with radioactive material transport and state regulatory and control bodies and identify interactions between them.

SNRIU is a competent regulatory body in the area of safe radioactive material transport. SNRIU is responsible for compliance with the Rules [9]. According to [16], SNRIU is responsible for issue official permits (licenses for radioactive material transport, permits for international shipment of radioactive material, approval certificates), conduct of regular reviews and assessments, inspections and enforcement measures, and development and implementation of principles, provisions and guidelines for safe radioactive material transport.

SNRIU:

- → develops and approves regulations, rules and standards on nuclear and radiation safety for radioactive material transport;
- → approves requirements for quality control of radioactive material transport in terms of nuclear and radiation safety;
- → approves requirements and conditions (licensing terms) for radioactive material transport;
- → determines a list of documents submitted to obtain a license for radioactive material transport and requirements for their structure and contents, and procedure for reporting by licensees;
- → licenses activities of radioactive material transport;
- → issues permits for international shipments of radioactive materials;
- → provides conclusions on compliance with requirements of nuclear and radiation safety and physical protection in case of export, import, temporary export, temporary import, re-export and transit of radioactive materials that could be used for production of nuclear weapons;
- → approves the design of packaging for radioactive materials, transport and special conditions;
- → agrees technical specifications for transport packaging;
- → performs oversight and inspection of transport operations; and
- → performs functions of a competent authority responsible for safe radioactive material transport.

Radioactive material transport is carried out only if there is an authorization for its transport (except for the cases described in [9]).

The procedure for issuing different types of authorizations for transport, such as licenses for radioactive material transport, certificates of approval for radioactive material transport, and permits for radioactive material transport (in case of international shipments of radioactive materials), is established in [9], [33], [36], [47].

All entities involved in radioactive material transport and the state nuclear regulatory body shall have a management system, including a program for systematic monitoring and inspecting with the purpose of control compliance with regulatory requirements and ensuring safety in radioactive material transport.

State oversight of compliance with NRS requirements is conducted by SNRIU and its territorial bodies involving, when necessary, representatives of other state oversight (control) bodies in respective safety areas upon their agreement and technical support organizations.

4.2 Analysis of Ukrainian Regulatory Framework on Radioactive Material Transport

Previously, based on the results of regulatory threat assessment performed during development of Reports [2] and [3], the need to review the 'Rules for Nuclear and Radiation Safety in Transport of Radioactive Materials' PBPRM-2006 was identified. This work was performed with the collaboration of DSA experts and DSA financial support which resulted in issuing and enforcing the Rules for the Safe Transport of Radioactive Materials (PBPRM-2020) [9], which follows the provisions of current IAEA standards.

At the same time, Reports [2] and [3] established feasibility and necessity of development of a set of regulations at different levels which shall set the requirements for enforcement the rules of safe radioactive material transport, considering the provisions of IAEA standards on radioactive material transport.

In 2019 SNRIU, with SSTC NRS involvement and DSA expertise and financial support provided in the framework of the COMPLIANCE project (see Section 10 and Annex 1 of this Report for details), revised Ukrainian regulatory framework on safe transport of radioactive material to reveal the gaps and implement further measures on harmonization of the national regulatory framework on safe transport of radioactive material with IAEA standards.

The analysis of gaps in the Ukrainian regulatory framework on safe transport of radioactive material performed within the COMPLIANCE project is informative and briefly described below.

4.2.1 Requirements for Packaging and Other Equipment

SNRIU with DSA assistance developed PBPRM-2020 [9] considering, in particular, IAEA document 'Regulations for the Safe Transport of Radioactive Material' No. SSR-6 (Rev.1) edited in 2018 [52]. Currently, the Rules for the Safe Transport of Radioactive Materials [9] is in force and is the main regulation establishing requirements for packaging and other equipment designed for radioactive material transport (Figs. 4.1 - 4.5).

Fig. 4.1 – Equipment for radioactive material transport

Also, in the framework of the Memorandum of Meeting between USNRC and SNRIU for 2021-2022, it was planned to develop methodological documents to support the assessment of safe management of packaging for radioactive material and radwaste transport, including handling operations, movement, transport and storage of packages with radioactive material and radwaste (see Section 10 of this Report for details).

4.2.2 Regulations on Radioactive Material Transport

During comparative analysis of the provisions of Ukrainian regulatory requirements and IAEA recommendation provisions on the abovementioned issue, noncompliance related to the place of indication in transport documents of the data on additional hazard class was revealed. This noncompliance was addressed by the implementation of Rules [9].

Fig. 4.2 – Railroad radioactive material transport

Fig. 4.3 – Road radioactive material transport

4.2.3 Management System for Radioactive Material Transport

During comparative analysis of provisions of Ukrainian regulatory requirements and IAEA recommendation provisions on the abovementioned issue, the following inconsistencies were revealed:

- → no revision of obsolete concept of the quality assurance program in transport of radioactive material and the need for the implementation of the management system for radioactive material transport;
- → no requirements for management system for radioactive material transport;
- → no requirement to include the identification of auxiliary procedures to the management system manual or quality assurance program;
- → no requirements for management of packaging for radioactive material transport after termination of its lifetime.

Fig. 4.4 – Arrangements for radioactive material transport

The specified inconsistencies can be eliminated through revision of the regulation 'Requirements for Quality Assurance Programs for Transport of Radioactive Materials' [42]. Currently SNRIU, with DSA financial and expert support provided in the framework of the RULES project, performs the development of the regulation with requirements for the management system in the sphere of safe transport of radioactive material (to replace the regulation [42]).

4.2.4 Licensing of Radioactive Material Transport

During comparative analysis of provisions of Ukrainian regulatory requirements and IAEA recommendations on the abovementioned issue, the following inconsistencies were revealed:

- → no separate manual (regulation) which establishes provisions for compliance assurance program;

→ no specification of the scope of information provided in Safety Analysis Report for radioactive material transport attached to the application for a license (only general list of information is set);

→ no requirements for the presence of systems for regular assessment of the safety level of radioactive material transport and provision of information to the population on the safety level of such activities;

→ no requirements for consideration of best practice, current research in the relevant field and other research when conducting regulatory assessment of the applicant's ability to comply with safety requirements for radioactive material transport.

Fig. 4.5 – Vehicles for radioactive material transport

The specified inconsistencies can be eliminated by the following:

→ development of a manual (regulation) considering the provisions of respective IAEA standards;

→ revision of the regulation 'Requirements for Safety Analysis Report for Radioactive Material Transport' [38];

→ revision of the regulation 'Safety Requirements and Conditions (License Terms) for Radioactive Material Transport' [37].

Currently SNRIU, with DSA financial and expert support provided in the framework of the RULES project, performs the following:

→ development of the regulatory framework on the management and compliance assurance system in the field of radioactive material transport and harmonization of the national regulatory framework on the safe transport of radioactive material with IAEA safety standards;

→ review of regulations [37] and [38].

4.2.5 Certification of Packaging, Radioactive Materials (Special Form, Low Dispersible), and Shipments

During comparative analysis of provisions of Ukrainian regulatory requirements and IAEA recommendation provisions on the abovementioned issue (also see Fig. 4.6), the following inconsistencies were revealed:

→ approval and issuance of SNRIU certificate(s) are not required for some types of activities;

→ no requirements for application for authorization of the design of B(U), B(M) and C-type packaging and information on packaging planned for radioactive material transport after storage (safety analysis and analysis of inconsistencies for transport of packaging for radioactive materials after its storage);

→ no requirements for the regulatory body regarding the need for official registration of the grounds for its decision and other specific requirements.

Fig. 4.6 – Packaging for radioactive material transport

The revealed inconsistencies were partially eliminated due to development and enforcement of Rules for the Safe Transport of Radioactive Materials (PBPRM-2020) [9] and total elimination shall take place based on the results of implementation of the COMPLIANCE and RULES projects.

4.2.6 Inspections of Radioactive Material Transport

During comparative analysis of provisions of Ukrainian regulatory requirements and IAEA recommendations on inspections of radioactive material transport, the following inconsistencies were revealed:

→ no requirements for analysis by the regulatory body of the results of inspections (Fig. 4.7) to study the effectiveness of the licensee and its compliance with the requirements of [9];

→ no requirements for investigation by the regulatory body of any reports on violations or noncompliance with the requirements of [9] to determine the causes.

Fig. 4.7 – Inspection of vehicles with radioactive material at state border checkpoint

The abovementioned inconsistencies are currently eliminated in the framework of COMPLIANCE and RULES projects.

Therefore, SNRIU carried and carries out the elimination of regulatory threats in the sphere of radioactive material transport, identified by the IRRS Mission and specified during the development of Reports [2] and [3], in the framework of the following bilateral cooperation projects with DSA (see Section 10 of this Report for details):

→ review of the regulation 'Rules for Nuclear and Radiation Safety in Transport of Radioactive Materials' – TRANSPORT;

→ improvement of regulatory framework on safe transport of radioactive material - COMPLIANCE;

→ system of management and compliance with the requirements for safe transport of radioactive material – RULES.

In addition, the activity related to provision of the support to SNRIU during safety assessment of packages for radioactive material transport is envisaged under the Memorandum of Cooperation between the USNRC and SNRIU for 2021-2022.

No additional threats in this area that would be critical in terms of their elimination in the near future were revealed in the development of this Report.

5 EMERGENCY PREPAREDNESS AND RESPONSE

5.1 Unified State Civil Protection System

In Ukraine, measures to ensure emergency preparedness and response to nuclear and radiation accidents are integrated into the unified state civil protection system (USCPS). Since 2013, the USCPS structure and goals, its tasks, operation modes, requirements for planning protective measures and other aspects are determined by the Civil Protection Code of Ukraine [53] and specified in the provisions on USCPS approved by Cabinet Resolution No. 11 of 9 January 2014 [54]. The USCPS consists of functional and territorial subsystems and their links, whose interaction is coordinated by the State Emergency Service of Ukraine (SESU).

5.2 USCPS Functional Subsystem for Nuclear and Radiation Safety

Under USCPS, SNRIU is defined as the body responsible for establishing and maintaining a functional subsystem that provides oversight and enforces safety of nuclear power facilities. By Cabinet Resolution No. 450 of 6 June 2018, the name of this functional subsystem was changed to the 'functional subsystem of nuclear and radiation safety'. In pursuance of this resolution, SNRIU developed Provisions on the Functional Subsystem of Nuclear and Radiation Safety of the Unified State Civil Protection System [55] approved by Cabinet Resolution No. 11 of 9 January 2014. By supporting the operation of the functional subsystem of nuclear and radiation safety, SNRIU provides, in particular:

- → improvement of the SNRIU emergency preparedness and response system;
- → supervision of emergency preparedness status of nuclear entities by approval of emergency plans, consideration of safety analysis reports, inspections and surveys, observations and regulatory assessment of licensee training;
- → developing and monitoring compliance with regulations, standards and rules on NRS, response procedures and mechanisms for coordination of response actions;
- → timely and reliable notification and informing of interested executive bodies and the public on the threat of occurrence or occurrence of emergencies related to radiation hazards in Ukraine and beyond its territory if transboundary transfer of radioactive substances is possible;
- → sending emergency notification and information in case of a nuclear or radiation accident in Ukraine and receiving emergency notification and information in case of a nuclear or radiation accident in another state and performing other functions in accordance with the Convention on Early Notification of a Nuclear Accident [18], Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency and the Convention on the Physical Protection of Nuclear Material and Nuclear Facilities [17];
- → international exchange of operational information on nuclear events within the International Nuclear Event Scale (INES), Convention [18] and relevant bilateral agreements with other countries;
- → maintaining round-the-clock communication with the IAEA Incident and Emergency Center and competent authorities of other countries under international agreements.

5.3 SNRIU Information and Emergency Center

The executive body of the USCPS NRS functional subsystem is the SNRIU Information and Emergency Center (IEC) established within the assistance and technical support of the USNRC under the Lisbon Initiative and EU under the TACIS projects in 1997-1998.

SNRIU IEC personnel:

- → provide round-the-clock duty and communication with Ukrainian NPPs;
- → develop information reports on the condition of NPP power units, notifications on operational events at Ukrainian NPPs, their posting on the SNRIU website and sending monthly statistical reports to the Cabinet of Ministers of Ukraine;
- → analyze information reports on incidents that have occurred in other countries within international information systems;
- → provide information exchange with the IAEA and competent authorities of other countries in the framework of emergency training and exercises;
- → test communication with competent authorities and/or communication centers of Austria, Belarus, Bulgaria, Latvia, Germany, Norway, Poland, Romania, Slovakia, Turkey, Hungary, Finland and Sweden to implement intergovernmental agreements on prompt notification on nuclear accidents, information exchange and cooperation in the area of nuclear safety and radiation protection;
- → provide the participation of Ukraine in international IAEA ConvEx exercises with activation and without activation of SNRIU IEC; and
- → provide SNRIU participation in headquarter, tactical and special exercises and general training at Ukrainian NPPs conducted jointly with Energoatom Directorate.

SNRIU IEC organizational structure, its functioning modes, staffing principles, hardware and software were presented in detail in Reports [2] and [3].

Under support of the Defense Threat Reduction Agency (U.S. Department of Defense) within the Global Partnership Against the Spread of Weapons and Materials of Mass Destruction Initiative, project 'Upgrade of the SNRIU Information and Emergency Center' was brought into effect in 2017 to implement the system for SNRIU IEC telecommunication and communication with the emergency centers of Ukrainian NPPs, improve the power supply system, and update computer equipment and software for response purposes.

As noted in Report [3], the SNRIU emergency preparedness and response system could be enhanced due to establishing a backup IEC. This would allow experts to continue working in the event of force majeure conditions, which prevent operation of IEC at its current location. Due to financial constraints, this recommendation remains unimplemented.

5.4 Harmonization of the Ukrainian Regulatory and Legal Framework on Emergency Preparedness and Response with EU Directives and IAEA Standards

According to Report [3], Ukraine continues the process of harmonization of the Ukrainian regulatory and legal framework on emergency preparedness with international requirements.

One of the examples of such harmonization is the developed draft on new regulation 'National Response Plan for Nuclear and Radiological Emergencies' (Plan). The development of the draft Plan was completed in February 2020 under DSA support within the PREPAREDNESS project. The Plan was developed to ensure

a coordinated prompt response by governing bodies, forces and means of the USCPS functional and territorial subsystems in the event of a threat or occurrence of a nuclear or radiation accident. The Plan addresses protection of emergency staff, provision of international assistance, mitigation of consequences in case of a nuclear or radiological accident and response measures, mitigation of non-radiological consequences, transfer to existing exposure situations, accident cause analysis, emergency exercises, expert support to regulation, etc. The Plan takes into account the requirements recently introduced by IAEA safety standards, EU legislation and WENRA recommendations, in particular [56] and [57].

5.5 Implementation of HERCA-WENRA Approach in Ukraine

The HERCA-WENRA approach is aimed at achieving coordination by neighboring countries on the protection of the public and the environment in the early phase of an accident, through the use of simplified procedures to assess the situation under uncertain conditions or lack of information. The need to harmonize national and international response procedures was indicated in Report [3]. According to the HERCA-WENRA approach, assessment of radiological consequences by different countries should be harmonized. To achieve this goal, the international community has initiated several projects involving SNRIU (see Section 10 of this Report for details).

5.6 Emergency Exercises

An effective measure to maintain emergency preparedness of all emergency response entities is to conduct emergency exercises. According to Report [3], such exercises should be conducted regularly. In accordance with the requirements of the current regulatory framework, Energoatom annually conducts general plant emergency exercises at one of the NPP sites; two such obligatory exercises are conducted every three years. SNRIU joins the exercises by activating its IEC.

SNRIU takes an active part in IAEA ConvEx exercises, which are held regularly: ConvEx-1a (2017, 2018, 2019); ConvEx-1b (2017, 2018, 2019); ConvEx-1c (2017, 2018, 2019); ConvEx-2a (2017, 2018); ConvEx-2b (2017, 2019); ConvEx-2c (2018); ConvEx-2d (2019); ConvEx-3 (2017). During 2020, SNRIU participated in the following IAEA emergency exercises:

- → ConvEx-1b (10 March 2020) to test the continuous availability of national contact points and ability of national competent authorities to respond promptly to received notifications;
- → ConvEx-2b (23 March – 26 March 2020) to test the mechanisms and procedures for assistance and sending requests for assistance between the IAEA Incident and Emergency Center and national competent authorities of IAEA member states that have registered their countries' capabilities in the IAEA Response and Assistance Network (RANET);
- → ConvEx-2a (12 May 2020) to verify the capabilities and skills in filling in standardized forms by responsible competent authorities, national INES coordinators and those responsible for uploading monitoring data to the International Radiation Monitoring Information System (IRMIS);
- → ConvEx-1a (14 October 2020) to test the continuous availability of national contact points for receiving notifications and their functioning, availability of access to the USIE web portal;
- → ConvEx-2c (09 December 2020) to test the mechanisms in case of a transnational nuclear or radiological emergency.

Under assistance of DSA within the EXERCISE project, SNRIU and SSTC NRS prepared and conducted the emergency exercise under scenario 'Conditional accident at an NPP in a third country with a threat of transboundary impact' on 7 November 2019. The purpose of this emergency exercise was to practice the

procedure for notification and further information exchange between NRS regulatory authorities of Ukraine and Norway and to conduct operational calculations necessary to decide on the measures to protect the public in the event of an accident at a NPP in another country with a threat of transboundary impact on the territory of Ukraine and Norway.

At the DSA headquarters in Osteras near Oslo, radiation impact assessment experts were involved in the exercise (Fig. 5.1) and SNRIU IEC was activated in Kyiv.

Information exchange during the exercise was provided in accordance 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 of 28 September 1994 and draft Protocol on Practical Measures for Early Notification on Nuclear Accidents and Information Exchange on Nuclear Facilities. The Protocol was signed by SNRIU and DSA on 3 December 2020.

Fig. 5.1 – Emergency exercises of SNRIU and DSA on 7 November 2019

Calculations in Norway were performed using the ARGOS decision making support system and in Ukraine using the RODOS system. For the predictive assessment, DSA used source term characteristics received in FASTNET databases and in SNRIU IEC the source term characteristics were taken from the internal RODOS libraries that were calculated with the MELCOR code.

Figure 5.2 presents examples of DSA and SNRIU computations for the assessment of radiological consequences, in particular, the time of radioactive cloud arrival to the territory of Ukraine and Norway.

a) b)

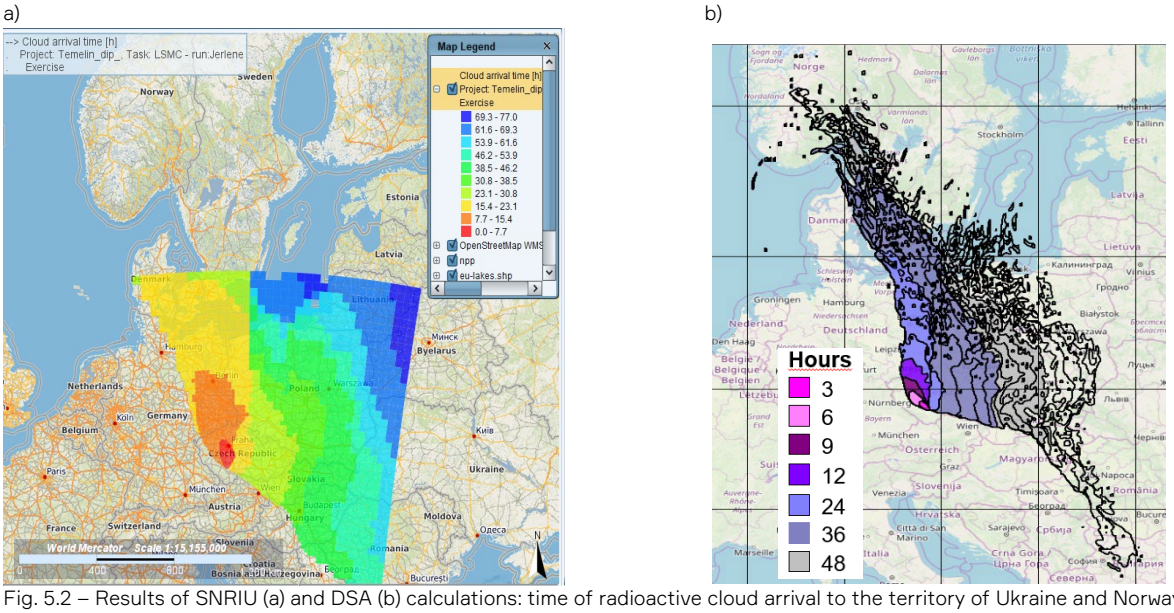


Fig. 5.2 – Results of SNRIU (a) and DSA (b) calculations: time of radioactive cloud arrival to the territory of Ukraine and Norway

The DSA and SNRIU assessment results regarding the time of radioactive cloud arrival to the territory of Norway and Ukraine showed acceptable convergence. Thus, according to the modeling by SSTC NRS experts, it was predicted that a radioactive cloud will reach the western border of Ukraine in 46-47 hours after release started and in about 48 hours according to DSA results.

Within the EXERCISE project, scenarios and programs for two more emergency exercises were developed in order to practice the response to an accident at nuclear facilities on the territory of Ukraine and response to an accident with loss of control over a radiation source on the territory of Ukraine/Norway.

5.7 Application of International Information Systems

SNRIU provides interoperability with IAEA information systems developed for efficient and regular exchange of operational data in the event of a nuclear and radiation accident, radiation monitoring data, and data on emergency preparedness measures in different countries.

The Unified System for Information Exchange in Incidents and Emergencies (USIE) is a secure IAEA website used by the contact points of the member states of the Convention [17] and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, as well as by national coordinators to post the information on event level determined according to the INES. The rights of USIE users in Ukraine are granted to representatives of SNRIU, SSTC NRS, SESU, Energoatom. SNRIU thoroughly monitors the data posted in the USIE by other countries and, if necessary, uses them to prepare informational messages for its own website. USIE is used by SNRIU and SSTC NRS experts both during emergency exercises and to post information about real events in Ukraine. For example:

→ a number of reports were published in October 2017 with measured concentration of artificial isotope ruthenium-106 in the surface air on the territory of Ukraine; and

→ reports on forest fires in the ChNPP Exclusion Zone were published during April-May 2020 (see also Section 5.6 of this Report).

Ukraine joined the activities within INES in 1990 and today NPP events are classified by INES. Nevertheless, in addition to 15 operating power units, Ukraine has on its territory other enterprises

engaged in the production of radiation sources, transportation and storage of radioactive materials, and use of radiation technologies. The formation of legal conditions for application of the provisions of the IAEA Guide for INES users in Ukraine was fully recommended in Report [3] and remains relevant.

The International Radiation Monitoring Information System (IRMIS) supports the implementation of the provisions of the Convention [17] and provides mechanisms to record and visualize large amounts of radiation monitoring data needed to make decisions on public protection. In November 2019, Ukraine in a test mode through the SESU Ukrainian Hydrometeorological Center started sending measurement data of the gamma radiation equivalent dose rate coming from the posts of the unified state automated radiation monitoring system for NPPs and from the network of radiometric observation points of the hydrometeorological services to the IRMIS system. Since December 2019, such data are uploaded daily to the IRMIS system and becomes available to users of the secure IAEA website. In 2020, SNRIU under cooperation with the main providers of monitoring information implements the task of providing measurement results in the IAEA-recommended IRIX format to provide effective international information exchange.

The Emergency Preparedness and Response Information Management System (EPRIMS) allows countries to record the data on available resources used in responding to accidents, perform self-assessments of national measures for compliance with IAEA standards, and fill databases with technical information on nuclear reactors and other information needed for predictive assessment in case of an accident. Under cooperation with Energoatom, SNRIU prepared and published the modules with the information on NPP technical characteristics in the EPRIMS system for the years 2016-2020 and implemented emergency measures in Ukraine.

The European Radiological Data Exchange Platform (EURDEP) is a network to exchange the information of the national radiation monitoring systems of European countries, but other countries can also join it on a voluntary basis. SNRIU had the necessary discussions with Ukrainian stakeholders and took organizational measures at the international level, after which in 2016, Ukraine began to submit daily radiological data to EURDEP through its national provider SESU Ukrainian Hydrometeorological Center.

Ukraine has been a member of the RANET Response and Assistance Network since 2016. RANET records data on national resources that can be provided to other countries as specialized technical, methodological, or expert assistance in the event of a nuclear or radiation accident. RANET is a tool to implement the provisions of the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency.

In order to improve cooperation conditions for Ukraine with international information systems, expand opportunities for responding to radiological risks in Ukraine and improve early warning of European countries, the Cabinet Resolution approved, on 28 September 2020 the conclusion of the agreement on nuclear safety between the Government of Ukraine and the European Commission as a legal basis to implement INSC projects. In particular, a project to support the formation of an integrated automated radiation monitoring system covering the entire territory of Ukraine was implemented. The project beneficiary is the State Agency of Ukraine on Exclusion Zone Management/Ministry of Ecology and Natural Resources of Ukraine. Under the agreement, an automated radiation monitoring system will be established by the integration of existing facility monitoring systems into a unified system, upgrading of obsolete equipment, observation posts and establishment of effective information exchange procedures. This will facilitate the implementation of the recommendation in Section 8.4.4 of Report [3].

5.8 Radiological Monitoring Using RanidSONNI Radiation Reconnaissance Vehicle (Mobile Radiological Laboratory)

According to the current legislation, SNRIU tasks include prompt notification through the media about radiation accidents on the territory of Ukraine, as well as abroad in case of possible transboundary transfer of radioactive substances. To prepare messages on radiation accidents, as well as other events that are accompanied by a threat of radiation impact on the public that could cause public concern, SNRIU uses official information obtained according to the established procedure from licensees, central executive bodies, international organizations. Data from predictive calculations performed by SSTC NRS experts and results of radiation monitoring conducted by SSTC NRS experts using the RanidSONNI radiation reconnaissance vehicle (RanidSONNI mobile radiological laboratory (MRL)) are also used.

Forest fires, which occasionally occur in the radioactively contaminated area of the Chornobyl Exclusion Zone and the zone of unconditional (obligatory) resettlement, are of particular concern to the public both in Ukraine and in neighboring European countries. The RanidSONNI MRL is involved in relevant surveys for timely response to possible radiological consequences of such fires.

Report [3] indicated the lack of conditions for proper maintenance of RanidSONNI MRL. To resolve this issue, SNRIU has taken the necessary administrative and technical measures, including the development of procedures for technical inspection and maintenance of RanidSONNI MRL measuring tools, and regular inspection of equipment operability with confirmation in the form of records in technical examination and maintenance logs.

In October 2019, MRL successfully passed an independent technical audit. Upon audit results, it was recommended to develop a plan for stage-by-stage replacement/upgrade of equipment and software, which is technically and morally obsolete, to prevent inoperability of laboratory functional equipment due to malfunction/failure of individual components. In accordance with audit recommendations, an action plan was developed, whose most part has already been implemented.

There remains a need for a methodological guideline on RanidSONNI MRL operation for emergency response. This guideline would provide recommendations on the measurements to be performed within emergency preparedness and response measures in specific cases of using the mobile laboratory, mobile laboratory use criteria and operational restrictions, radiological survey procedures in each possible case of its use, taking into account available equipment and restrictions, recommendations on radiation safety of the crew of the radiation reconnaissance vehicle, responsibilities of the crew members, recommendations on storage of measurement results, etc. On behalf of SNRIU, SSTC NRS experts will develop such a document in 2021.

5.9 Emergency Preparedness of Nuclear Legacy Sites

One of the threats determined in Reports [2] and [3] is a hazard of public exposure to doses exceeding the established limits, caused by a failure to perform remediation activities for the former PChP. Development and implementation of radiation safety requirements for remediation of abandoned uranium mining and processing plants is a regulatory measure of the highest priority. Important practical steps to prevent the hazardous impact of uranium sites to the public and the environment by monitoring their condition, restricting of access, preserving information about the activities of these facilities, etc. were implemented within the URAN project under DSA and SNRIU cooperation. Upon the results of implementing this project in 2017, the Requirements for Institutional Control of Uranium Sites within Restricted Clearance from Regulatory Control [4] were put in force. In the framework of EC U4.02/16A project [58], it is envisaged to develop new legal documents to ensure radiation protection and safety under existing exposure situations on the territory and around the former uranium facilities. In addition to development of the draft Law of

Ukraine ‘On the Management of Nuclear Legacy Sites and Their Remediation’ and amending the Radiation Safety Standards of Ukraine (NRBU-97) [44] in terms of the measures for remediation and management of residual radioactive material, the need to expand the regulatory and legal framework was determined within this project in order to establish radiation safety requirements for legacy sites regarding: human protection against the impact of residual radioactive materials;

- → preparedness for emergencies at nuclear legacy sites and response to such situations;
- → criteria to complete remediation of sites and perform their radiation monitoring;
- → remediation of facilities at legacy sites.

The threats to regulatory activities in the area of emergency preparedness and response related to uranium legacy sites identified in the Reports [2] and [3] and upon the analysis of results, presented in this section, are eliminated through implementing the following projects of bilateral cooperation with DSA:

- → Enhancement of Emergency Preparedness and Response in Ukraine: PREPAREDNESS
- → Strengthening Emergency Preparedness and Response in Ukraine: EXERCISE.

In addition, the identified threats are subject to consideration within the current and planned cooperation of SNRIU with other partners (USNRC, European Commission), by SNRIU’s own efforts (see Section 10 of this Report for details), as well as within the activities of other central executive bodies (for example, State Agency of Ukraine on Exclusion Zone Management) and other ongoing and planned EC projects (like, for example, project [58]). However, a number of threats (see Section 9 of this Report for details) identified in Reports [2] and [3] and upon the current assessment remain unresolved, such as:

- → strengthen the SNRIU emergency preparedness and response system and establish a backup IEC; and
- → promote legal conditions for full-scope application of the IAEA INES User’s Manual (not only for classification of operational events at NPPs).

6 RADIOACTIVE WASTE MANAGEMENT AND DECOMMISSIONING

6.1 Radioactive Waste Management and Decommissioning Practices in Ukraine

The main radwaste flows in Ukraine include:

- → waste from operating NPPs;
- → legacy and accident-origin waste;
- → disused radiation sources and non-nuclear radwaste;
- → ChNPP radwaste.

Future decommissioning of NPPs currently in operation is not considered in this assessment.

6.1.1 Radioactive Waste Management at Operating NPPs

As of beginning of 2021, the construction and commissioning of solid radwaste treatment plants (SRTP) had been completed at RNPP and ZNPP and permits issued for their operation. The SRTPs are designed to process low- and intermediate-level solid radwaste and combustible liquid radioactive materials (waste oil).

Fig. 6.1 shows the appearance of the SRTPs,

Fig. 6.2 and

Fig. 6.3 provide examples of radwaste processing plants that are part of these plants. It is also planned to construct SRTPs at KhNPP and SUNPP.

Fig. 6.1 – RNPP and ZNPP SRTPs

Fig. 6.2 – SRTP RNPP metal decontamination and cementation facilities

Fig. 6.3 – SRTP ZNPP incineration and fragmentation facilities

There are also problematic flows of liquid radwaste at Ukrainian NPPs, in particular:

- → ion exchange resins in storage tanks at NPPs;
- → salt melt, stored in containers; and
- → dry salt, stored in containers.

Radwaste treatment technologies ensuring production of end products acceptable for further safe storage and disposal of this radwaste are being developed in the framework of the INSC project U4.01/14A [59]. Development of the formulation for immobilization of NPP filter material and sludge and immobilization of the experimental batch of NPP filter material and sludge was started separately. Preparation for immobilization and subsequent disposal of radwaste in the form of bitumen/salt compound is also ongoing. At present, RNPP has performed radiation characterization of the bitumen/salt compound with determination of the nuclide vector, as well as physical and chemical characterization.

6.1.2 Accident-Origin and Legacy Radioactive Waste Management

There are about 2,000,000 m^3 of accident-origin and legacy radwaste in Ukraine, generated mainly as a result of the ChNPP accident. The main disposal/storage facilities of the accident-origin radwaste are:

- → radwaste disposal sites (RWDS) in the Chornobyl Exclusion Zone; and
- → radioactive waste interim confinement sites (RICS, DWDS, VDTS) in and close to the Chornobyl Exclusion Zone.

Other legacy radwaste is stored at the facilities of the Ukrainian State Specialized Enterprise 'Radon Association'. This radwaste was generated in medical and research organizations, industry, as well as a result of military programs and so on. During the acute phase of the accident, the fourth unit of ChNPP was used to collect and localize accident-origin radwaste at the ChNPP industrial site and the territory adjacent to ChNPP.

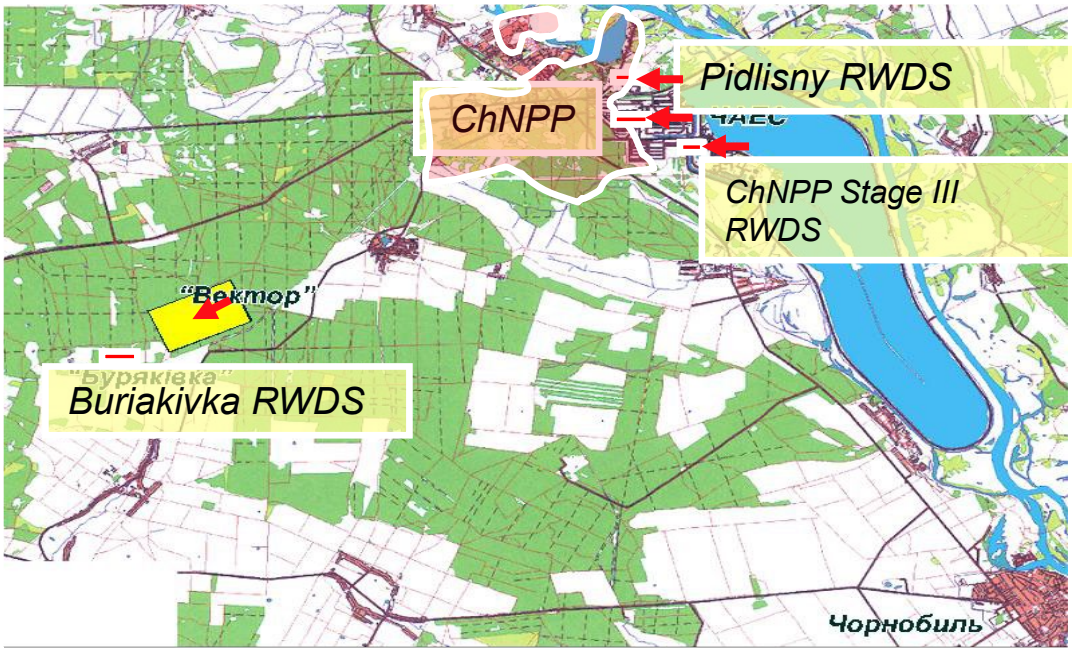


Fig. 6.4 – Location of RWDS in the Chornobyl Exclusion Zone

There are 3 RWDSs in the Exclusion Zone near ChNPP and the total volume of radwaste in RWDS is estimated at 170,000 m^3. The RWDS layout is given in Fig. 6.4 and their appearance in Fig. 6.5.

Fig. 6.5 – RWDS in the Chornobyl Exclusion Zone

The RWDS Buriakivka is a radwaste disposal facility. The Pidlisny RWDS and ChNPP Stage III RWDS provide storage for intermediate-level and high-level radwaste. These storage facilities are regarded as facilities where radwaste will be kept and maintained at an adequate safety level (given the Exclusion Zone) for a long period of time, but later radwaste will be removed, treated and disposed.

Radioactive waste interim confinement sites (RICS) are located in the territory adjacent to the ChNPP, with an area of up to 10 km^2. Low-level radwaste is confined in trenches and pits, the number of which is estimated between 800 and 1000. The industrial party performed RICS safety assessments [60] in the framework of project U4.01/10 C+D+F. To ensure the protection of the public and personnel for most RICS it is sufficient to carry out administrative control for approximately 500 years within a certain Exclusion Zone territory (approximately 10 kilometers).

Fig. 6.6 shows an example of the analysis results of the RICS impact on personnel and the public in the event of a fire on the RICS territory, which was carried out under the project U4.01/10 C+D+F by the industrial party [60].

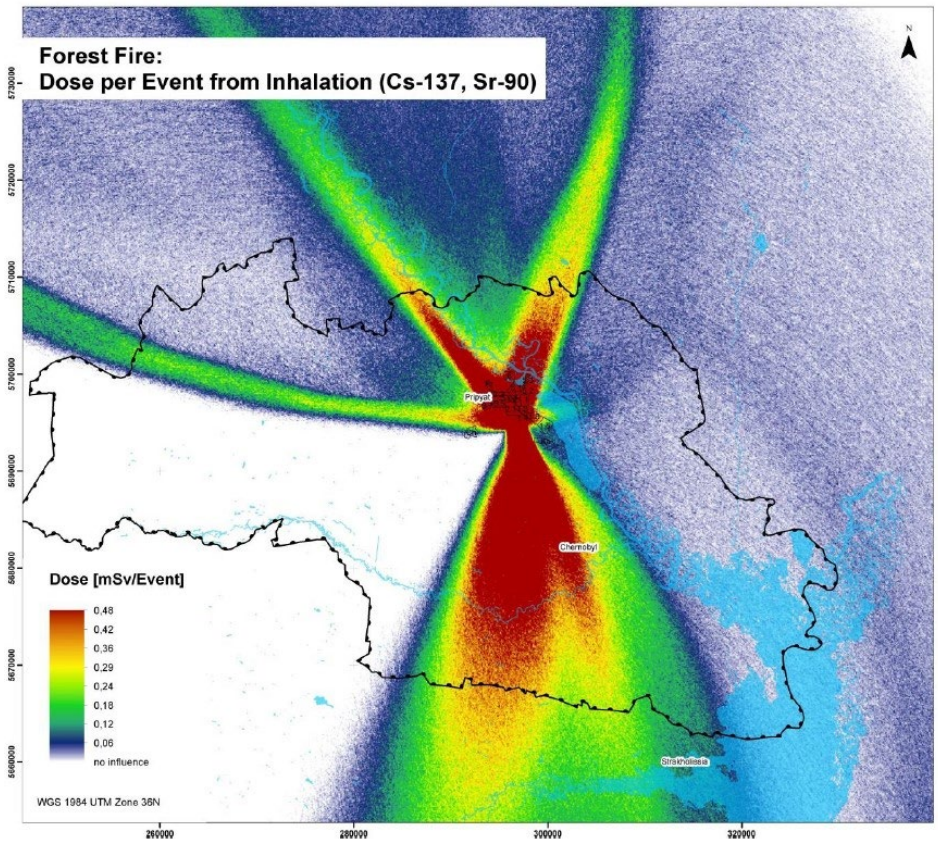


Fig. 6.6 – Analysis of RICS impact on personnel and the public in case of fire on the RICS territory

Decontamination waste disposal sites (DWDS) and vehicle sanitary treatment sites (VDTS) were constructed in the areas adjacent to the Exclusion Zone during mitigation of the ChNPP accident. DWDS/VDTS contain decontamination waste from settlements (topsoil, roofing materials, construction debris, etc.), as well as waste decontamination equipment (trucks, buses, etc.). In total, 53 such sites were constructed around the Chornobyl Exclusion Zone. DWDS/VDTS are usually trenches or abandoned quarries filled with decontamination waste. The dimensions of these sites range from 25×25 m to 200×150 m; thickness of the waste layer is about 1.5-2 m. The surface of DWDS/VDTS is covered with a protective soil shield (with a thickness of 0.1 to 1 m); drainage ditches to collect surface runoff were also arranged.

In the framework of the project INSC U4.01/12 D remediation of radioactive waste storage sites resulting from the Chornobyl nuclear power plant accident and situated outside the exclusion zone, DWDS/VDTS were ranked according to their potential hazard [61]. Screening safety assessment and ranking according to their hazard degree were conducted for 17 RICS located in Kyiv region, for which adequate data on the state of the facilities and activity content were available.

The following scenarios of radiation impact on the population are considered:

- → regular presence of a person at RICS;
- → excavation of RICS;
- → residence on RICS (in the near future).

Orane RICS, Rudnya Shpylivska RICS, Sidorovychi RICS and Pisky-1 RICS were identified as priority sites for remediation. Eight RICSs located outside the Chornobyl Exclusion Zone are candidates for clearance from control due to low activity (compared to background overall contamination in the area) and estimated low exposure on humans (doses << 1 mSv/year). Other RICS require a more detailed assessment to support decision-making on radwaste retrieval and remediation. At present, radwaste has been retrieved

from the Pisky-1 pilot site and the territory has been remediated [62], [63]. Radwaste retrieval was performed layer-by-layer, with the thickness of each layer being about 25 cm. A survey was performed following completion of the remediation activities, which confirmed that specific activities were lower than those set in the end state criteria for remediation.

Several military facilities of the former Soviet Union are located in Ukraine and are associated with legacy radwaste. These facilities should be decommissioned and remediated, and so should be the territory where they are located. A pilot remediation project was implemented at the Vakulenchuk site with NATO support. A repository was constructed at the site in the late 1970s and consisted of reinforced concrete rings with an outer diameter of 1.6 m and a depth of 5.5 m. Disused radioactive sources (DRS) (alpha, beta, gamma and neutron emitters) had been buried in the facility, but data on the radwaste characteristics were practically absent. Another remediation project was implemented at the Tsybuleve site, where three concrete cylindric tanks (wells) had been constructed, each with an inner steel sleeve. The wells contained DRS. Placement of DRS in wells started in 1966-1967, but DRS accounting (with very limited data) was carried out only from 1976 to 1987. In the process of remediating the Vakulenchuk and Tsybuleve burials, a step-by-step approach was applied, which consisted of site examination, site preparation for remediation, radwaste retrieval (or entire wells), radwaste placement in containers and their transportation, and then final remediation of the site. Dismantling of the Vakulenchuk burial well was performed portion-wise with layer-by-layer radwaste retrieval, whereas Tsybuleve wells were dismantled without their fragmentation and without retrieving radwaste from the wells (see Fig. 6.7).

Fig. 6.7 – Well with DRS retrieved from the Tsybuleve disposal site

A final site survey was performed, including measurements of gamma dose rate, neutron flux density, and surface contamination to confirm that radiological risks had been eliminated. After that, the final remediation measures were taken, including leveling the site, adding fertile soil and planting trees.

6.1.3 Management of DRS and Non-Nuclear Radioactive Waste

After expiry of the operational period of radiation sources, the following options for their management are envisaged in Ukraine:

- → reuse the DRS (after life-time extension of a radiation source according to the established procedure);
- → return the DRS to the supplier in accordance with the contractual agreement; or

→ declare the DRS as radwaste and transfer it to a specialized radwaste management company for storage and/or disposal.

Ukraine has accumulated more than 660,000 DRS declared as radwaste, with a total activity of $2.23 \cdot 10^{16}$ Bq.

The majority of DRS declared as radwaste was transferred to the State Specialized Enterprise 'Radon Association' and placed in storage facilities on the sites of this enterprise. These DRS can be divided into the following main types:

→ DRS with well-known characteristics stored separately from other radwaste;

→ 'legacy' DRS with unknown characteristics stored separately from other radwaste;

→ 'legacy' DRS stored in a mixture with other radwaste (some facilities are cemented);

→ 'legacy' DRS placed in well-type storage facilities (some facilities are cemented).

The Centralized Long-Term Storage Facility for DRS (CSDRS) is a key facility of the system for safe DRS management in Ukraine. CSDRS should ensure centralized placement of the main radwaste volume in the form of DRS of various types and designs, which are currently accumulated on the sites of the State Specialized Enterprise 'Radon Association', as well as radioactive sources used in medicine and industry, after their transfer into the radwaste category. The DRS management process includes their acceptance, identification, sorting, conditioning and long-term storage (50 years). In recent years, the State Specialized Enterprise 'Central Radioactive Waste Management Enterprise' has been conducting comprehensive 'hot' tests of the CSDRS. During these tests, the State Specialized Enterprise 'Central Radioactive Waste Management Enterprise' must confirm shielding properties of the facility structures, master the technological processes of DRS processing, process procedures, interaction with suppliers of radwaste declared as DRS, and functioning of the accounting and control system for such radwaste during the entire process of their processing from acceptance from suppliers to placement of prepared packages for long-term storage, as well as secondary radwaste management.

Non-nuclear radwaste is supplied by various producers (medical, scientific, industrial organizations) to the State Specialized Enterprise 'Radon Association'. This specialized enterprise has 5 industrial sites (Kyiv, Lviv, Odessa, Kharkiv, Dnipro). Non-nuclear radwaste is temporarily stored in specialized storage facilities at these industrial sites. It is planned to construct a plant for management this radwaste on the 'Vector' site.

6.1.4 ChNPP Decommissioning and Radioactive Waste Management

The SSE ChNPP conducts ChNPP decommissioning activities by successive implementation of the following decommissioning stages: termination of operation, final closure and shutdown, safe storage and decommissioning and dismantling.

In 2015 the SSE ChNPP completed the operation termination stage during which nuclear fuel was removed from ChNPP units and obtained an SNRIU permit to implement the following decommissioning stage: final closure and shutdown. During the final closure and temporary shutdown stage, it is envisaged, in particular, to:

→ dismount and management the fuel channels and control channels of ChNPP units;

→ perform shutdown of the reactors and confine shutdown areas; and

→ reconstruct covers of the central halls and dismount the lifting mechanisms.

The SSE ChNPP operates the liquid radwaste treatment plant and management of the evaporation bottoms. The solid radwaste treatment plant is at the stage of hot tests.

There are 15 NPPs units in operation in Ukraine. There are NPP units whose design service life is expiring and there are NPP units whose life has been extended. Decommissioning of some NPP units is expected to begin in the coming decades, and the corresponding generation of waste is expected as well. Processing plants for solid radioactive waste have been commissioned at the Zaporizhzhya and Rivne NPPs.

6.1.5 Radioactive Waste Disposal

An engineered near-surface disposal facility for solid radwaste (ENSDF) was constructed and is in operation at the Vektor site in the Exclusion Zone. The design capacity of the facility is 50,210 m^3 of radwaste packages. The ENSDF consists of two parallel sections, each of which has 11 reinforced concrete compartments (modules) arranged with the central drainage gallery, two mobile frame structures with bridge cranes for filling modules, and a radiation control and environmental monitoring system. The SNRIU license allows filling of the two symmetric ENSDF modules (A1 and D1).

Two near-surface storage facilities for solid radwaste disposal with a total capacity of 19,200 m^3 are at the final stage of construction (acceptance tests of systems and equipment are scheduled) at the Vektor site complex:

- → SRW-1 - storage for disposal of short-lived low- and intermediate-level radwaste in reinforced concrete containers.
- → SRW-2 - storage for disposal of short-lived low- and intermediate-level unpacked large-size radwaste.

Construction of a radwaste disposal in deep geological formations is at an early stage in Ukraine. The first steps in the development of conceptual disposal options, radwaste acceptability criteria for the proposed disposal concepts, and a roadmap on radwaste geological disposal were taken under the industrial projects INSC U4.01/09B ‘Concept of Radioactive Waste Disposal in Ukraine’ [64] and U4.01/14B ‘Development of a National Plan for Geological Disposal of Radioactive Waste in Ukraine and Its Implementation Schedule’ [65]. In recent years, topical studies have been conducted to assess the feasibility of placing a geological repository in the granitoid formations of the Ukrainian Crystal Shield. In accordance with the amendments to the legislation to place disposal facilities at medium depths for radwaste disposal, common disposal of intermediate level radwaste (ILW) and high-level radwaste (HLW) in a geological disposal facility or construction of separate disposal facilities for ILW disposal at medium depths and a geological disposal facility for HLW disposal in deep geological formations are considered.

6.2 Development of Regulatory Framework on Radioactive Waste Management and Decommissioning

Reports [2] and [3] analyzed issues for the safe radwaste management and decommissioning of nuclear facilities in Ukraine. The summarized analysis covered all activities of the industrial party and the process of regulation of this activity as a whole.

The analysis identified general threats to safety regulation in the radwaste management and decommissioning areas. To eliminate the identified threats, the need to develop a regulatory system was identified, which would include:

1) First level (high-level) regulations including:

- → General Safety Provisions for Predisposal Management of Radioactive Waste; and
- → General Safety Provisions for Disposal of Radioactive Waste;
- → General Safety Provisions for Decommissioning of Nuclear Facilities.

2) Regulations and recommendation documents (Guidelines) of the second level, which detail the high-level regulatory requirements regarding:

- → radwaste classification for different purposes;
- → individual of radwaste management stages and individual types of radwaste management facilities;
- → decommissioning of different types of nuclear facilities;
- → safety assessments, development of license documents;
- → etc.

Report [2] addressed the issues of safety regulation of radwaste management and decommissioning in a general way. Individual specific issues were not considered.

Report [3] addressed the following important specific aspects:

- → management of accident-origin and legacy radwaste;
- → management of DRS declared as radwaste; and
- → release of radioactive materials from regulatory control.

Threats on these specific issues and possible ways to eliminate them have been identified.

The situation regarding the regulatory framework of Ukraine in the field of radwaste management as of early 2021 is described in the following sections.

6.2.1 Ukrainian Laws and High-Level Regulations on Radioactive Waste Management

The Law of Ukraine 'On Amending Some Laws of Ukraine on Improving Legislation on Radioactive Waste Management' [66] introduced amendments to the Law of Ukraine 'On Radioactive Waste Management' concerning the radwaste disposal in one of four types of storage facilities (surface, near-surface, at medium depths, geological repository) depending on the potential hazard level of radwaste. The definition of each type of storage facility is given and the distribution of radwaste into the following classes is introduced:

- → very low-level waste (VLLW);
- → low-level waste (LLW);
- → intermediate-level waste (ILW); and
- → high-level waste (HLW).

The Law of Ukraine [66] states that assignment of radwaste to the appropriate type shall be carried out in accordance with the NRS rules and standards. At the same time, there are no definitions of each radwaste type, and to date, there are no the criteria for assigning radwaste to each class.

The following was carried out with DSA expert and financial support in the framework of the WASTE Project:

- → the regulation ‘General Safety Provisions for Predisposal Management of Radioactive Waste’ was developed and put in force (NP 306.4.213-2017) [6]. This document sets forth objective, criteria, principles and general requirements for ensuring NRS for all stages of radwaste management prior to their disposal;
- → the regulation ‘General Safety Provisions for Disposal of Radioactive Waste’ (NP 306.4.219-2018) was developed and put in force [8]. This document defines the purpose, criteria, principles and general requirements for ensuring NRS during radwaste disposal.

Therefore, the above two regulations form the top-level regulatory framework in the radwaste management field.

6.2.2 Requirements for the Structure and Contents of Safety Analysis Reports on Radioactive Waste Management Facilities

With the support of the European Commission, requirements for the structure and contents of safety analysis reports of radwaste management facilities, their long-term storage and disposal are being developed and revised as follows:

- → the regulations ‘Requirements for the Structure and Content of the Safety Analysis Report for Shallow and Near-Surface Radwaste Disposal Facilities’ (NP 306.4.223-2020) [68] and ‘Requirements for the Structure and Content of the Safety Analysis Report for Radwaste Treatment Facilities’ (NP 306.4.225-2020) [69] were developed and put in force in the framework of INSC project U3.01/12 (UK/TS/48) [67];
- → development of the regulation ‘Requirements for Structure and Contents of the Safety Analysis Report for Radioactive Waste Storage Facilities’ is ongoing in the framework of project INSC U3.01/14&U3.01/15 (UK/TS/58) [27].

Together, these three regulations will provide a systematic set of requirements for the structure and contents of safety analysis reports at different stages of radwaste management, with the exception of disposal in medium-depth and geological disposal facilities.

In accordance with current regulatory requirements [8], under designing medium-depth and geological disposal facilities for ILW and HLW disposal at each stage of their life cycle, it will be required to carry out safety assessments and justifications to support decisions, in particular in choosing the type of disposal facilities and defining the safety concept for radwaste disposal, siting, etc.

At the same time, requirements for the structure and contents of the safety analysis report of such disposal facilities are missing and will need to be established. This is relevant given the current activities on creating such storage facilities in Ukraine, and, development of a roadmap under project INSC U4.01/14B [65] with the support of the European Commission. The first step, which is planned to be implemented in the coming years, is to select the facility type for ILW and HLW disposal and to define the concept of safety assurance for ILW and HLW disposal in these facilities. A possible way to eliminate this threat is to develop a specific regulation.

6.2.3 Safety Requirements for Radioactive Waste Disposal

Guidelines for detailing general provisions of NP 306.4.213-2017 [6] and NP 306.4.219-2018 [8] on application of an integrated approach to radwaste management and an approach to radwaste classification for different purposes are being developed with the support of the European Commission:

- → in the framework of INSC Project U3.01/14&U3.01/15 (UK/TS/56) [70] development of the 'Guideline for Integrated Radwaste Management Prior to Disposal and Classification of Radwaste' is in progress. The Guideline objective is to detail general provisions on application of an integrated approach at all radwaste management stages prior to its disposal defined in the NP 306.4.213-2017 [6];
- → development of the 'Guideline for Applying an Integrated Approach to the Disposal of Radwaste and Their Classification for the Purposes of Disposal' is in progress in the framework of the INSC project U3.01/14&U3.01/15 (UK/TS/56) [70]. The Guideline objective is to detail approaches to application of general provisions of the NP 306.4.219-2018 [8] on identification of standard barriers and main safety functions, as well as application of the defense-in-depth strategy using a barrier system based on a graded approach for safety assurance of radwaste disposal in surface and near-surface storage facilities. Approaches to establishing of permissible specific activities of radionuclides for disposal in different types of storage facilities are being defined.

The Law of Ukraine [66] requires specific criteria to be established for dividing radwaste into types for the purpose of their disposal in four types of storage facilities (see Section 6.2.1 above). However, the current rules and standards do not set numerical criteria for classifying radwaste as VLLW, LLW, ILW and HLW for disposal in one of four disposal facility types. These Guidelines will only define recommendation approaches to establishing criteria. Therefore, there is a need to further revise the establishment of numerical values for specific activities of radionuclides for assigning the waste to VLLW and LLW categories. Regulatory requirements for waste classification for disposal purposes and classification criteria need to be established. The IAEA document GSG-1 'Classification of Radioactive Waste' [71] states that 'In accordance with national programs and requirements, more detailed quantitative criteria may be developed, which include a wider range of parameters.' The Law of Ukraine [66] sets requirements for development of such criteria. The way to eliminate this threat is to develop a specific regulation.

As stated above, the legislation of Ukraine has recently defined the types of facilities for radwaste disposal at medium depths and in geological disposal facilities (previously there was a single disposal facility type: geological). To date, no specific safety requirements for designing medium-depth storage facilities and geological disposal facilities have been identified, including defense-in-depth applicability and definition of radwaste classification criteria for ILW and HLW disposal depending on the disposal facilities depth and consideration of hydrogeological site conditions and physical and chemical waste properties. Such specific requirements should be used at the stage of choosing a storage type and definition of safety assurance concept of radwaste disposal, as well as at the stage of siting. The way to eliminate this threat is to develop a specific regulation.

6.2.4 Safety Requirements for Legacy and Accident-Origin Radioactive Waste Management

The Guidelines for safety assessment of radwaste facilities located in the Chornobyl Exclusion Zone were developed with the support of the European Commission under project INSC U3.01/08 (UK/TS/39) [72], namely:

- → Guideline for Assessing the Common Impact of the Vektor Site with Multiple Facilities for Radioactive Waste Processing, Storage, and Disposal [73] and
- → Guideline for Safety Assessment of Accident-Origin Radioactive Waste Interim Confinement Sites in the Chornobyl Exclusion Zone [74].

Using the Guideline for Safety Assessment of Accident-Origin Radioactive Waste Interim Confinement Sites in the Chornobyl Exclusion Zone [74], the industrial party performed in the framework of the INSC project U4.01/10C+D+F [75] a safety assessment of RICS in the Chornobyl Exclusion Zone. Based on the assessment, individual RICS were ranked according to the hazard degree and recommendations on

maintaining the RICS safety level, and radwaste retrieval from individual RICS were defined. In addition, in the framework of the project INSC U4.01/10C+D+F [75] the industrial party performed a comprehensive safety assessment of radwaste storage/disposal in the Chornobyl Exclusion Zone using the Guideline for Assessing the Common Impact of the Vektor Site with Multiple Facilities for Radioactive Waste Processing, Storage, and Disposal [73]. Therefore, safety assessments of radwaste facilities located in the Chornobyl Exclusion Zone are regulated by these specific Guidelines. The Guideline for safety assessment of facilities with legacy radwaste, namely: Guideline for Safety Reassessment of the Existing Storage/Disposal Facilities and Decision-Making Criteria Concerning Subsequent Measures at These Facilities [76] was developed with the support of the European Commission in the framework of the INSC project U3.01/08 (UK/TS/39) [72], which is used under safety assessment of RWDS *Radon* with legacy radwaste under the project INSC U4.01/14C [77] and radwaste burials at military sites of the former Soviet Union.

IAEA GSR Part 3 states that" The government and the regulatory body or other relevant authority shall ensure that remedial actions and protective actions are justified and that protection and safety is optimized". The regulatory documents of Ukraine do not establish or define the requirements and criteria for remediation of facilities with accident-origin and legacy radwaste and corresponding territories. In decision-making on radwaste retrieval from the Pisky-1 site with the confined radwaste of Chornobyl origin located outside the Exclusion Zone and Vakulenchuk and Tsybuleve military sites of the former Soviet Union, separate regulatory decisions on remediation criteria were made. However, requirements for the procedure for defining these criteria and the criteria themselves are not set in the regulations. Such requirements and criteria need to be established and should be based on application of a graded approach and experience in conducting safety assessments and ranking of relevant radiation-hazardous facilities.

6.2.5 Safety Requirements for Shelter Radioactive Waste Management

In 1997, the Ukrainian nuclear regulatory authority as well as the other regulatory bodies encountered the challenge of ensuring proper safety regulation in the Shelter Implementation Plan (SIP) for the destroyed 4th ChNPP unit, since there was no corresponding experience in the world. The regulatory framework was developed for the SIP implementation period. To date, the SIP project has been completed. The measures to increase Shelter safety level were implemented and the NSC was constructed (see

Fig. 6.8). NSC trial operation is in progress. The regulatory framework is being updated for the subsequent period of the NSC safe operation (including Shelter transformation).

Fig. 6.8 – New Safe Confinement

After completion of the NSC trial operation, SNRIU intends to issue a license for the NSC operation, regarding the NSC (inclusively with Shelter) as a facility for accident-origin radwaste management. The regulatory document [6] developed with DSA support will cover this facility. Given the uniqueness of the NSC (including Shelter), it is necessary to develop a regulatory document based on the regulation [6], which would set special requirements and safety rules for the NSC (including Shelter) and activities at this facility. A draft of such a document has already been developed with the support of the European Bank for Reconstruction and Development under the Chernobyl Shelter Fund. Thus, the activity on elimination of the threat identified in Report [3] concerning regulatory control gaps in the part of lack of requirements on maintaining safe state of the Shelter is about to be completed.

6.2.6 Safety Requirements for Management of Disused Radiation Sources

Regulatory control of DRS management safety relies only on regulations establishing safety requirements for 'ordinary' radwaste management. There are no special requirements for safe DRS management. The CSDRS licensing experience has demonstrated the need to establish special requirements.

The high-level regulation 'General Safety Provisions for Predisposal Management of Radioactive Waste' [6] developed with the DSA support covers also DRS management activities declared as radwaste. Development of a regulation establishing requirements and rules for management of DRS declared as radwaste, based on the provisions of regulation [6], started in the framework of the ACCEPTANCE project with the support of the DSA.

Thus, activities are underway to eliminate the gap identified in [3] in the regulatory control area related to safe management of DRS declared as radwaste.

6.2.7 Requirements for Clearance of Radioactive Materials from Regulatory Control

In Ukraine, clearance of radioactive materials from regulatory control (radioactive material clearance) was regulated by document NP 306.4.159-2010 'Procedure for Clearance of Radioactive Materials from Regulatory Control within Practices' [79]. The experience in using NP 306.4.159-2010 [79] showed that this regulation:

- → had certain drawbacks;
- → had insufficiently detailed requirements; and
- → did not cover individual issues important to safety.

In the framework of the CLEARANCE project with DSA support, the development of a new document to replace NP 306.4.159-2010 [79] and establish detailed requirements for criteria and procedures for clearance of radioactive materials from regulatory control has begun.

6.2.8 Safety Requirements for Decommissioning

The following regulations were developed with the DSA support in the framework of the DECOMMISSIONING Project:

- → General Safety Provisions for Decommissioning of Nuclear Facilities [10] and
- → Requirements for the Structure and Contents of the Operator's Documents for Licensing Application for Decommissioning of Nuclear Facilities.

Regulation [10] was put in force at the end of 2020. The draft regulation 'Requirements for the Structure and Contents of the Operator's Documents for Licensing Application for Decommissioning of Nuclear Facilities' has been harmonized with regulation [10], and is currently under review by interested organizations.

The regulation 'General Safety Provisions for Decommissioning of Nuclear Facilities' [10] provides the high-level regulatory framework for decommissioning. One of the key provisions of this regulation defines the application of a graded approach during decommissioning, as required, in particular, by the IAEA documents [80] and [81], and the WENRA reference levels for decommissioning [82]. At present, specific requirements for application of the 'graded approach' in decommissioning are missing and they need to be defined.

Summarizing the information set out in this Section, it should be noted that the threats and challenges identified in the Reports [2] and [3] have been either eliminated or are being addressed in the framework of the following SNRIU-DSA bilateral cooperation projects:

- → Development of General Safety Provisions for Radioactive Waste Management in Ukraine: WASTE;
- → Development of High-Level Regulatory Documents for Decommissioning Safety of Nuclear Facilities: DECOMMISSIONING;
- → Development of Regulatory Document on Requirements and Rules for Safe Management of Disused Sealed Radiation Sources (DSRS) Declared as Radioactive Waste: ACCEPTANCE; and
- → Development of Regulatory Document on Clearance of Radioactive Materials from Regulatory Control: CLEARANCE.

In addition, the threats to regulatory activities in the field of radwaste management and decommissioning identified in Reports [2] and [3] are being eliminated with the support of the European Bank for

Reconstruction and Development and are being considered in the framework of joint SNRIU-European Commission projects (see section 10 of this Report for details).

At the same time, the analysis performed during development of this Report identified a number of new challenges, elimination of which will allow further improvement of the regulatory framework for radwaste management and decommissioning activities (see section 9 of this Report for details).

7 RADIATION PROTECTION

Safety regulation principles for use radiation sources in industry, medicine, research and training are described in Reports [2] and [3]. One of the SNRIU priority tasks in the rule-making activity is the implementation of the Directive 2013/59/Euratom [12] establishing basic safety standards for protection against the hazard caused by radiation, which are partly already introduced in the national legislation. Implementation of the Directive (and respective ICRP and IAEA recommendations as well) by adopting new safety standards and improving the state regulation system will provide an up-to-date level of radiation safety in Ukraine meeting the standards established in the EU countries.

Further in this Section, attention is focused on the analysis of modifications in legislation and in the state regulation system of radiation safety in recent years, analysis of radiation safety state at Ukrainian NPPs and a more detailed description of remaining threats that are relevant and need to be addressed.

7.1 Safety Regulation of Radiation Sources

In Ukraine, the use of radiation sources in industry, agriculture, medicine, education and research is subject to state regulation in nuclear energy use (Article 27 of the Law of Ukraine 'On Nuclear Energy Use and Radiation Safety') [21]. The application of the established safety requirements is based on a graded approach depending on the potential nuclear and radiation hazard and risks for a given activity with specific facilities (radiation sources).

The graded approach principle is also applied in authorizing activities: a system and procedures for licensing, state registration of radiation sources [29], oversight and enforcement are implemented. Criteria and procedures for release of radiation sources from regulatory control or licensing are approved [83].

One of the SNRIU priority tasks is the implementation of the Directive [12] for ensuring the up-to-date radiation safety level in Ukraine according to international best practices. To implement it, the corresponding Action Plan [86] was developed.

Given the significant work scope being done to improve the state regulation system of radiation safety, it should be noted that early in 2020, the Parliament amended Article 17 of the Law of Ukraine 'On Human Protection against Ionizing Radiation' [85] to improve activities with medical radiation sources and reduce exposure levels of patients and personnel. In particular, in accordance with the provisions of the above Article, it is prohibited to import to Ukraine, manufacturing and commissioning of:

- → X-ray machines designed for radioscopy, without X-ray image amplifier;
- → new X-ray machines without a device for automated exposure and dose rate control;
- → devices for remote radiation therapy with a nominal value of beam energy (accelerating voltage) over 1 MeV without a device for checking the basic exposure parameters;
- → devices for interventional radiology without a device or function of informing the doctor and persons performing medical exposure about the dose received by the patient;
- → devices for interventional radiology and computer tomographs, in particular equipment for planning and performing a medical examination, without a device or function of informing the doctor and persons performing medical exposure on the parameter values of the equipment at the end of the medical examination required for assessment of the patient's dose; and
- → new non-radionuclide installations and devices generating ionizing radiation, without a device for informing the doctor about the parameters required for assessment of a patient's dose.

In pursuance of the provisions of the Action Plan [86], a draft Law 'On Amending the Law of Ukraine on Nuclear Energy Use and Radiation Safety Concerning a Radiation Protection Expert' [87] was developed. After entry into force of this Law, the Cabinet Resolution will put into effect the Procedure for recognition of radiation protection experts. The first version of the Procedure was developed in the framework of the PROVISION project implemented under SNRIU and DSA cooperation.

The improvement of the accounting system for radiation sources continues, so Cabinet Resolution 'Some Issues of Establishing the Unified State System for Accounting and Control of Individual Doses' No. 1141 of 18 November 2020 has been recently adopted [88]. In accordance with this Resolution, the State Register of Radiation Sources and Individual Doses (State Register) is being created based on a common platform, as previously planned. The same Resolution cancels a number of Cabinet resolutions, which regulated the activity of the State Register of Radiation Sources. This approach allows for improving the radiation source accounting system itself by upgrading software and hardware and reducing the number of regulations in the field of radiation safety regulation, which is in line with the recommendations of international experts provided in the analysis of Ukrainian regulations for compliance with Council Directive 2013/59/Euratom [12]. (One of the conclusions of international experts in the framework of the project [92] was the follows: in Ukraine there are too many regulatory documents in the field of radiation protection in general, which complicates the situation for licensees and for the regulatory review and assessment of the applications).

One of the main challenges in the field of the state NRS regulation, as it was defined based on the previous threat assessments [2] and [3], were and actually still remain the outdated basic documents in the radiation protection and safety field: Radiation Safety Standards of Ukraine (NRBU-97) [44] and Basic Health and Radiation Safety Rules of Ukraine (OSPU-2005) [46]. As it was stated in the Reports [2] and [3], the international radiation protection system has been modified (improved) several times as of the effective date of the above documents. Ministry of Health of Ukraine is responsible for development and revision of NRBU-97 [44] and OSPU-2005 [46].

Recommendations for the priority revision of above documents documents were provided by both DSA in the framework of SNRIU-DSA cooperation and by other international experts [92]. In particular, the following comments and recommendations were among the main ones:

- → basic provisions of the Council Directive 2013/59/Euratom 12] on exposure situations (planned, existing and emergency) are missing in the regulatory framework of Ukraine;
- → first of all it is necessary to revise the basic documents in the field of radiation safety of Ukraine NRBU-97 [44] and OSPU-2005 [46] and bring them in line with the provisions of the Council Directive 2013/59/Euratom and IAEA GSR Part 3 Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards [93]; and
- → since NRBU-97 [44] and OSPU-2005 [46] cannot be revised in the first place, it is necessary to expand the draft regulation 'Basic Radiation Safety Rules of Ionizing Radiation Sources' developed within the SOURCE project and supplement it with appropriate requirements for exposure situations, i.e. to develop a single basic document establishing basic radiation protection principles.

SNRIU in the scope of their responsibilities decided to solve the issue in limited manner and supplemented and expanded the draft regulation 'General Radiation Safety Rules for Radiation Sources', including provisions and requirements for situations of planned, existing and emergency exposure, changing the regulation title to 'General Requirements for Radiation Protection and Safety'. The document is being finalized.

In pursuance of the Association Agreement, an Action Plan to Reduce Public Exposure to Radon and Products of its Decay, Minimize Long-Term Risks of Radon Spread in Residential and Non-Residential Buildings, in Workplaces for 2020 - 2024 was developed. The Action Plan defines the main activities and establishes the main measures to reduce the exposure level of the population to radon and its decay products and provides for further activities to develop respective procedures and methods. Mentioned procedures and methods are for monitoring of radon in Ukraine, creating an interagency group, improving legislation in the field of human protection against radon impact, forming a database on radon levels in the air of houses, etc.

In 2019, the Law of Ukraine No. 107-IX 'On Amendments to Certain Laws of Ukraine on Safety of Nuclear Energy Use' came into force [89]. To implement the provisions of this Law and to improve the documents on regulation of uranium ore mining and milling, a draft SNRIU Order 'On Amending Some Regulations on Uranium Ore Mining and Milling Operations' was developed. The problem that resulted from the extension of state regulation in the field of nuclear energy to uranium ore mining activities in accordance with the Law of Ukraine [89], was solved by amending the regulation 'Safety Requirements and Conditions (License Terms) for Uranium Ore Processing' [90] and the regulation 'Requirements for the Annual Radiation Safety Report on Uranium Ore Processing' [91]. Since the uranium ore mining and milling operations belong to a single technological cycle and mentioned operations, in fact, have always been carried out in accordance with the SNRIU license for uranium ore milling. Also, after entry into force of the Law of Ukraine [89], the preconditions for implementation of the regulation 'General Radiation Safety Provisions for Uranium Ore Mining and Milling' [11], which was developed in the framework of the SNRIU and DSA cooperation under the URAN project were created. Therefore, the document [11] came into force in early 2021.

During the current period, activities on improving the regulatory framework in the field of radiation source safety continued. The regulation 'Safety Requirements and Conditions (License Terms) for the Use of Radiation Sources' [94] is currently being finalized. Medical radiation technologies are constantly being developed and extended as well as the area of their application. Respectively, the regulatory framework for regulating their safety is being improved. Therefore, to eliminate the threat mentioned in Report [3], SNRIU has developed a draft regulation on safety of linear accelerators for medical purposes using its own resources. As of the beginning of 2021, the draft was submitted for review to the interested central executive power bodies.

The field of radiation source use in Ukraine continues to develop actively. However, there are still challenges that have either not been fully addressed by national regulations or are not currently regulated at all. This concerns the limitation of radiation exposure by medical sources.

As part of the MEDICINE project implemented in the framework of SNRIU and DSA cooperation, General Safety Rules for Medical Radiation Sources [5] and Radiation Safety Rules for Using Radiation Sources in Brachytherapy [7] were developed and implemented. Currently, a regulation on safety of medical accelerators (as mentioned above) is being drafted to further develop this area. However, the high growth rate of radiation technologies used in medicine creates new challenges: for example, as a result of the introduction of X-ray diagnostic procedures, including interventional procedures. It is commonly known that high doses are received by medical personnel in interventional radiology. The lack of safety rules in this area established in regulations endangers both staff performing such procedures and the patients receiving them.

One of the serious challenges in the field of patient safety assurance is using worn out and obsolete X-ray machines. As of the beginning of 2021, according to the State Register of Radiation Sources, there are 17,198 X-ray diagnostic units in permanent operation in Ukraine, at least half of which are devices manufactured in the 1970s and 1980s. Dose loads on patients when using such devices are much higher (approximately 5-7 times) than in the up-to-date X-ray machines during such examinations, and the quality of diagnostic information is much worse. At the same time, there is no regulatory leverage to encourage

medical institutions to replace obsolete X-ray machines with modern ones. For example, while the regulation 'General Safety Rules for Medical Radiation Sources' establishes requirements for quality control of X-ray diagnostic equipment, there is no regulation establishing assessment criteria of image quality and technical condition of X-ray machines. Therefore, SNRIU, in cooperation with other stakeholders, is making considerable efforts to remedy this situation. Thus, the Grigoriev Institute of Medical Radiology of the National Academy of Medical Sciences of Ukraine developed a draft document 'Program for Quality Control of X-ray Diagnostic Equipment in the X-ray Projection Diagnostics. Methodological Guide' and submitted it for review to the relevant authorities and experts in the field of medical radiation technologies. However, this is only the first step in solving this problem. In general, elimination of such threat should be addressed through the introduction of a procedure for assessing the compliance of equipment with the criteria of its acceptability and, based on this, testing for acceptability (during commissioning of X-ray equipment) and consistency of characteristics (during its subsequent use) should be implemented. In turn, this requires considerable efforts on the part of all interested parties, and the first step to be made by SNRIU in this context should be developing a 'Procedure and Criteria for Acceptability Assessment, Stability Control and Withdrawal of X-Ray Diagnostic Medical Equipment'. The document should comply with the IAEA recommendations and be based on European Commission document [84].

The individual doses of patients during diagnostic and therapeutic medical procedures are accounted for and controlled in accordance with the requirements of Article 17 of the Law of Ukraine 'On Human Protection against Ionizing Radiation' [85]. Currently, the number of radiodiagnostic procedures caused by the Covid-19 pandemic, both medically justified and uncontrolled ones, without a respective doctor's prescription, has increased significantly, thus increasing the unjustified dose load on the population. This situation creates new challenges that need to be solved, in the first place by establishing a system for accounting radiation doses of patients (i.e., a dose register of patients). In this context, it is considered appropriate to develop a training course on radiation safety for personnel involved in radiodiagnostic procedures, including interventional radiology, using up-to-date multimedia tools, given the accumulated knowledge as well as international and domestic experience in this field.

Today, these aspects are of increased interest, since they go beyond the usual regulatory area and relate not only to 'practical activity' with already established rules and requirements, but also to the area of activity that affects everyone, such as medical exposure.

Other challenges concerning lack of regulatory requirements remain, such as safety of activities relating to the management of materials containing natural radionuclides (e.g., waste coming from industrial enterprises and technologies). Such enterprises do not carry out individual dosimetric control or control of premises, and do not assess dose loads or optimize exposure levels of both workers or the population.

One of the basic documents on safety in the use of radiation sources, both medical and industrial (see Fig. 7.1), requires revision: Technical Specifications for Sealed Radiation Sources [95], given that the regulatory framework it refers to has been amended.

Fig. 7.1 – Industrial radiation sources

The introduction of new approaches to the radiation protection system requires not only formal implementation of the definitions of radiation situations (planned, existing and emergency) in national regulations for three types of exposures, such as occupational exposure, public exposure and medical exposure, but also establishment of appropriate requirements and definitions with respect to assessing an exposure situation, choosing a protection strategy, and agreeing on the acceptability of this system with the SNRIU.

These particular challenges are the basis for elaborating plans for the SNRIU rule-making activities and determining the priorities for state regulatory control in this area. Therefore, the main areas of the SNRIU rule-making activities for 2021 - 2022 are:

- → continue activities on bringing national rules and standards on radiation safety in line with the up-to-date international safety standards and EU legislation;
- → increase the radiation protection level of personnel and the public through the introduction of basic safety requirements for radiation sources management, based on current IAEA standards and EU legislation;
- → continue activities on development of a unified state accounting and control system of individual doses of occupational exposure;
- → launch activities on development of a unified state accounting and control system of individual doses of medical exposure;
- → continue activities on introduction of criteria and a system for recognition of radiation protection experts;
- → develop radiation safety requirements and rules for interventional radiology;
- → improve the system of DRS safe management before their transfer to specialized management enterprises;
- → implement radiation protection programs for workers of industrial enterprises dealing with materials with natural content of radionuclides (iron ore mines, coal mines, etc.) and aircraft crews;
- → develop measures to implement the Action Plan on reducing public exposure level with radon and its decay products, minimizing long-term risks of radon spread in residential and non-residential buildings, workplaces, from any source of radon penetration from soil, building materials or water;
- → develop radiation safety rules and requirements for radiation sources used for human imaging not in medical purposes (Radiation Sources Used for Inspection Purposes and for Non-Medical Imaging); and
- → develop radiation safety rules and requirements contaminated scrap metal management.

The activity of regional inspections (7 regional state inspections) continues to improve and be optimized in accordance with the provisions of the Code of Conduct on the Safety and Security of Radioactive Sources (IAEA, 2003) [96], which has a significant impact on improving radiation safety and physical protection. Regional inspections, undertaken jointly with the State Agency of Ukraine for Exclusion Zone Management, are implementing measures to raise public awareness on illicit trafficking of radiation sources taking into account the decriminalization Article 265 of the Criminal Code of Ukraine [97] under the Orphan Radiation Sources Amnesty Program, which exempts citizens from administrative and criminal liability in case of voluntary surrender of such materials. Such measures facilitate to increase the radiation safety level by restoring control over the radiation sources out of the regulatory control.

7.2 Radiation Protection of Personnel and Dosimetry Services

In Ukraine, the Law of Ukraine 'On Human Protection against Ionizing Radiation' [85] establishes the basic principles of radiation protection: justification, limitation and optimization that fully complies with the international practice and the provisions of the Council Directive 2013/59/Euratom [12]. Meeting these principles is ensured by controlling the effective dose level, which in its turn requires developing special methodologies, using complex and expensive instrumentation, and ensuring reliability and quality of measurements.

As it was stated above, Cabinet Resolution 'Some Issues of Establishing the Unified State System for Accounting and Control of Individual Doses' [88] No. 1141 of 18 November 2020 was developed and entered into force. The Resolution implements the Action Plan for implementation of the Association Agreement between Ukraine and the EU [86], requirements of Article 18 of the Law of Ukraine 'On Nuclear Energy Use and Radiation Safety' [21], and Article 18 of the Law of Ukraine 'On Human Protection against Ionizing Radiation' [85]. The Resolution was developed to increase the radiation safety level in the field of nuclear energy use and management of other radiation sources, to establish state control overdose load levels in all exposure situations, to predict the exposure consequences in planned and emergency exposure conditions and ways to reduce possible radiation risks. The Resolution provides for the creation of a unified state information system for accumulation and storage of data on radiation sources used in Ukraine, and results of individual measurements of occupational and emergency radiation exposure merged into the State Register of Radiation Sources by expanding its functions. Resolution [88] establishes the procedure for creating such a unified state accounting and control system of individual doses. The procedure determines organizational principles for creating and ensuring functioning of the unified state accounting and control system of individual doses, for implementing common approaches to determining individual doses by measurement or calculation, and for ensuring their reliability, assessment, accounting, storage and access to the results of individual dosimetry controls.

In accordance with the Resolution [88], the State register shall ensure:

- → systematization, electronic accounting, updating and storage of information on received occupational doses per year;
- → submission of an annual report to the SNRIU;
- → coordination of activities on maintaining and updating data in the State Register information database; and
- → accumulation and storage of data on individual occupational doses during the entire period of employment and after completion of the employment period at least until the date a person turns 75, but not less than 30 years after employment termination.

One of the important priorities of SNRIU activities is to ensure that the unified state system for accounting and control of individual doses is fully functional by creating real conditions ensuring

implementation of the Action Plan defined by the Resolution [88]. The following measures should be prioritized for implementation:

- → development of qualification requirements for personnel of economic entities in the field of nuclear energy, which determine individual occupational doses;
- → establishing requirements for quality control of determination (measurements and calculations) of individual doses;
- → definition of criteria and requirements for technical and organizational aspects of occupational exposure control, and an integrated approach to external and internal occupational exposure control, in particular, for exposure to materials with natural radionuclide content, taking into account the IAEA GSG-7 publication [100].

7.3 Regulation of Radiation Safety at NPPs in Normal Operation

The SNRIU priority tasks with respect to occupational and public exposure in planned exposure situations in accordance with provisions of paras. 3.69-3.73 and 3.117-3.144 of GSR Part 3 [93] are to:

- → establish and ensure compliance with the requirements for optimization of the radiation protection as well as personnel and the public safety;
- → ensure compliance with the established occupational dose limits and public dose limits;
- → establish and ensure compliance with the requirements for monitoring, accounting and control of occupational exposure;
- → ensure regulatory control over releases and discharges from nuclear facilities; and
- → establish regulatory requirements for environmental monitoring.
- → Threat assessment in the field of NPP radiation safety regulation in planned exposure situations was carried out in two areas:
- → radiation safety of NPP personnel as occupational exposure in planned exposure situations;
- → radiation safety of the public and the environment, as public exposure in planned exposure situations.

7.3.1 Regulation of Radiation Safety for NPP Personnel

As stated above, one of the main challenges in the field of the state NRS regulation, as was defined based on the previous threat assessments [2] and [3], are outdated basic documents in radiation protection and safety field: Radiation Safety Standards of Ukraine (NRBU-97) [44] and Basic Health and Radiation Safety Rules of Ukraine (OSPU-2005) [46]. The regulation 'Radiation Safety Rules for NPPs' (PRB AS-89) [98] remains in force in the field of radiation safety regulation under professional exposure in planned exposure situations at NPPs. This document regulates radiation-hygienic and organizational and technical requirements of radiation safety assurance for personnel and the public and environmental protection during NPP commissioning and during operation and decommissioning of individual NPP units and is aimed at fulfilling basic radiation safety principles. It should be noted that document PRB AS-89 [98] was developed in the Soviet period taking into account NPP operating experience at the time of development. A significant risk for the regulation of NPP radiation safety is that the use of these documents does not allow the SNRIU to fully perform its tasks in accordance with the recommendations and requirements of IAEA GSR Part 3 [93], GSG-7 [100] and Council Directive 2013/59/Euratom [12] on control of occupational exposure in planned exposure situations. To assess the implementation feasibility of the provisions of

Council Directive 2013/59/Euratom and IAEA documents [93], [100] on radiation safety aspects for personnel of nuclear facilities in SNRIU regulatory supervision, the radiation safety of personnel at nuclear facilities needs to be analyzed.

7.3.2 Radiation Safety of Personnel at Ukrainian NPPs

In Ukraine, Energoatom operates fifteen nuclear power units with the installed capacity of 13,835 MW, including thirteen power units with VVER-1000 type reactors and two power units with VVER-440 type reactors. Below is an analysis of the radiation safety indicators of NPP personnel. In accordance with the requirements of the Law of Ukraine 'On Nuclear Energy Use and Radiation Safety' [21] and provisions of the Convention on Nuclear Safety [14], the operating organization shall ensure stable and safe operation of nuclear power plants. One of the main radiation safety indicators of facilities such as nuclear power plants is the collective dose of personnel. According to Energoatom, in recent years there has been stable dynamics of the annual collective doses for NPP personnel referred to one power unit. On average for Energoatom, the indicator is fixed at levels (see Fig. 7.2) for the last five years.

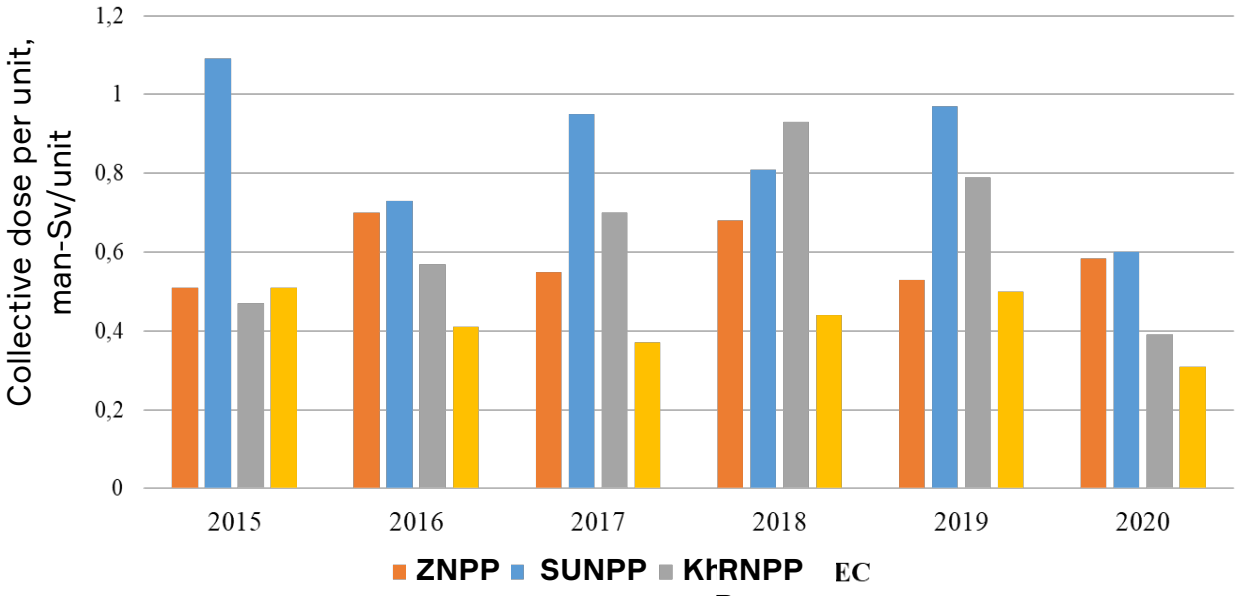


Fig. 7.2 – Annual collective doses of NPP personnel (with personnel of external organizations) per power unit for 2015–2020

As shown in Fig. 7.2, the indicator value corresponds to the values of the indicators for the same type power units operated in the world. Fluctuations of the indicator for different Ukrainian NPPs depended on the design features of power units and on the volume of radiation-hazardous activities performed in the framework of respective reconstruction and upgrading measures. The design exposure indicator of NPP personnel (categories A and B) is the dose limit set in terms of the annual individual effective dose of external and internal exposure of personnel in NRBU-97 [44] and constitutes DLE = 20 mSv. According to the data reported by the operating organization, the individual external doses of personnel are in the range of less than 1 mSv for most of the controlled personnel. There has been no exceedance of the annual individual effective dose limit for personnel of Ukrainian NPPs in the last 10 years. This indicates that the radiation safety principle of dose limitation for personnel at Ukrainian NPPs is observed. At the same time, the relative increase in the collective dose depending on the scope of radiation-hazardous activities indicates that the optimization measures implemented by the operating organization are not always effective. The need, criteria and mechanisms for application of optimization procedures, and organizational and technical radiation protection measures at NPPs are implemented in accordance with

the requirements of PRB AS-88 [98]. The requirements of this document, as mentioned above, do not fully meet up-to-date approaches for planning radiation protection measures of personnel, for establishing criteria for planning and conducting radiation-hazardous activities, or for control and management of personnel doses.

Certain components of optimization procedures are already being implemented by the operating organization. For example, groups (cohorts) of personnel are distinguished, whose individual doses are above 6 mSv and above 15 mSv per year. For these two groups (cohorts), the collective effective doses of personnel are subject of limitation (reference levels). However, lack of regulatory requirements for the process of establishing reference levels does not allow consistency to be achieved in the area of radiation safety assurance in accordance with current approaches, as recommended by the provisions of Council Directive 2013/59/Euratom [12] and IAEA documents [93], [100], by optimization of radiation protection and safety of personnel at nuclear facilities in relation to occupational exposure in planned exposure situations.

7.3.3 Radiation Safety of the Public and Environment in Planned Exposure Situations

To assess the feasibility of implementing the provisions of Council Directive 2013/59/Euratom [12] and IAEA publication [93] on radiation safety aspects of nuclear facilities (as a source of potential exposure) in SNRIU regulatory activities, the current level of radiation safety of the public and NPP environment is analyzed.

The public exposure (NRBU-97 [44]) is limited by regulation and control of:

- → airborne releases and liquid discharges during NPP operation and
- → content of radionuclides in individual environments.
- → NRBU-97 [44] sets numerical values for the public dose limit, based on which permissible releases and discharges are set for each NPP. Indicators of the radiation safety state of the public and the environment in relation to the source, i.e. NPP, are as follows:
- → indicators of NPP releases and discharges compared to the established values of permissible releases and discharges and
- → indicators of the radiation state of environmental compartments.

Each Energoatom NPP has duly developed and approved limits for airborne releases, as well as reference levels for releases and discharges of radioactive substances into the environment.

In 2019, the values of airborne releases and liquid discharges of Energoatom NPPs were registered at a level much lower than the limits set for each NPP. Total indicators (the ratio of the actual parameter value to its limit set by regulations) of releases and liquid discharges of radioactive substances in 2019 are given below. The measurements results of environmental compartment are given as well.

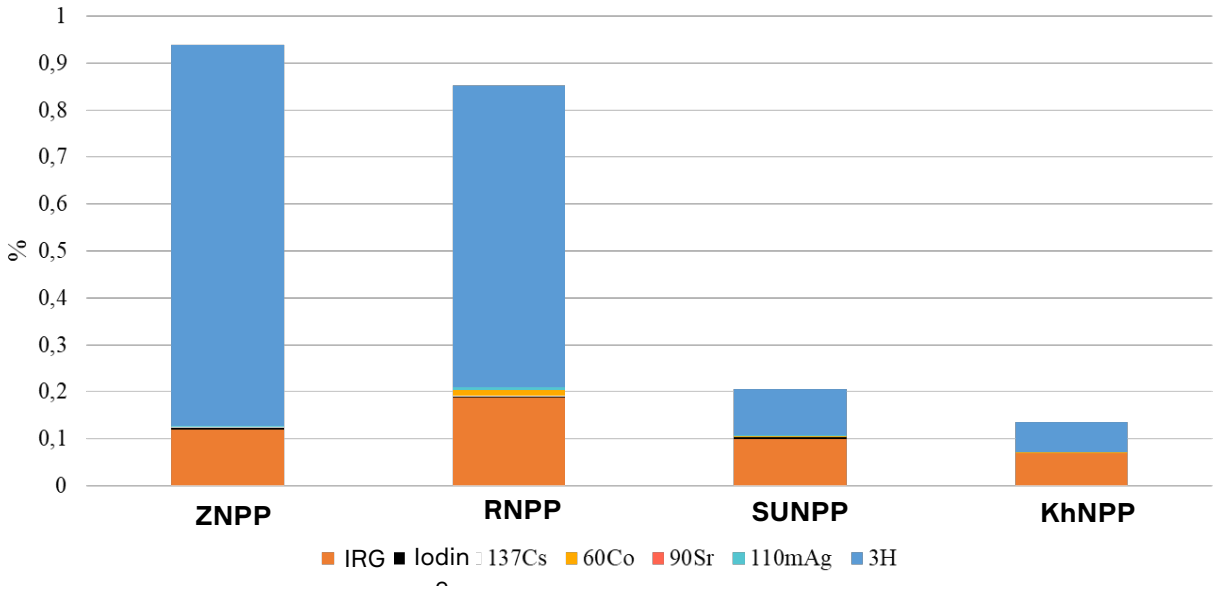


Fig. 7.3 – Total indicators of radioactive airborne releases to the environment from NPPs for 2020 with individual contributions

As can be seen from the figure, NPP airborne releases amounted to 1% of the permissible levels. The main contributors (Fig. 7.3) to the releases were tritium and inert radioactive gases (IRG). Long-lived radionuclides such as ^{60}Co (RNPP) and ^{110m}Ag, associated with the structural materials or piping and primary side equipment, were present in releases from individual NPPs.

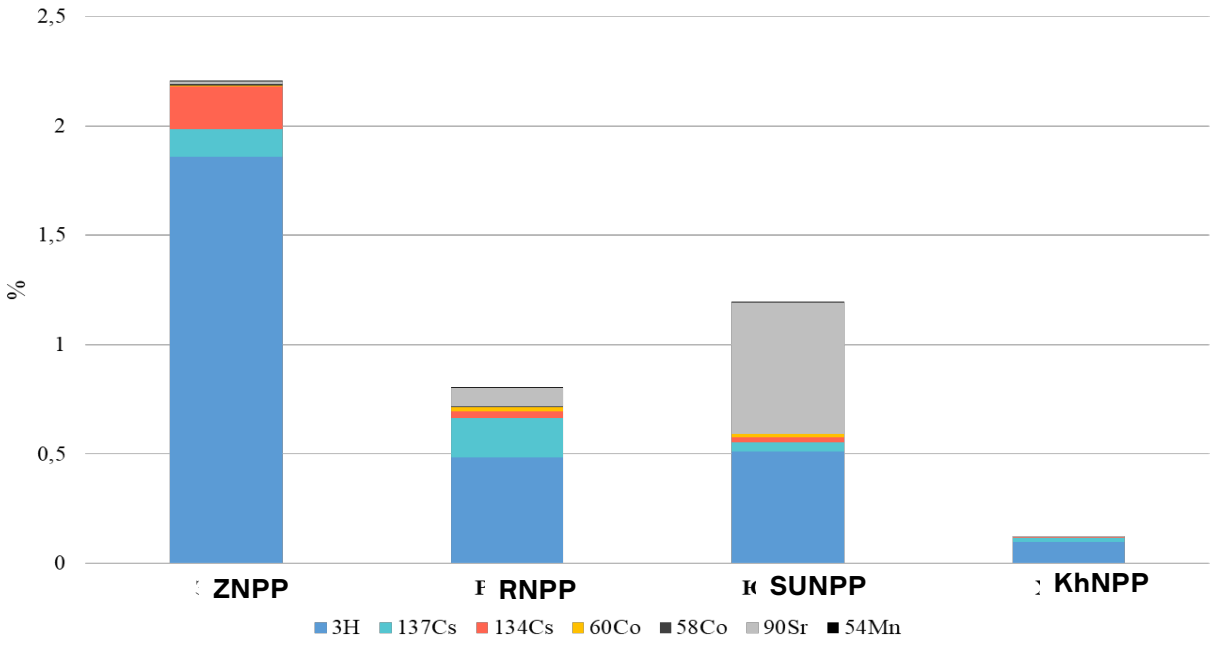


Fig. 7.4 – Total indicators of radioactive water discharges from NPPs for 2020 with individual contributions

As can be seen from the figure, liquid discharges (Fig. 7.4) from NPPs amounted to up to 2% of the permissible limits. The main contributors to the discharges are tritium and long-lived radionuclides that are associated with corrosion and fission-fragment activity of the NPP primary circuit coolant.

For all NPPs, monitoring is undertaken to analyze the content of radioactive substances in environmental compartments around the NPP: in surface water reservoirs, in the atmospheric air and soil of the neighboring settlements.

The monitoring scope and methods are defined by the Radiation Monitoring Procedures in force at Energoatom NPPs. Comparison of the numerical values obtained during monitoring of environmental compartments are compared with the 'zero' (natural) background values in the area of NPP location.

The monitoring data should indicate an acceptable radiation safety level of the public and the environment at Ukrainian NPPs as well as absence of significant radiation risks for the public under normal NPP operation.

However, parameters such as reference levels, lists of reference radionuclides and radiation monitoring scope are not established by Ukrainian regulations. Conclusions on radiation safety level are therefore made solely by comparing against the 'zero background' of long-lived radionuclides.

It should be noted that the regulatory requirements for environmental monitoring of NPPs were established by document SP AS-88 'Health and Safety and Technical Requirements for Design and Operation of Heat Removal Systems from Nuclear Power Plants', which currently lost validity in Ukraine. The lack of regulatory requirements for control of releases and discharges, monitoring of the environment and public exposure complicates execution of the regulatory function by the SNRIU to fulfill the requirements of Sections 6.8.4 and 6.8.5 of the General Safety Provisions for Nuclear Power Plants [25], and does not comply with the provisions of the EU/Euratom Directives and IAEA documents.

7.4 Summary

The results of the analysis identified a number of threats and challenges (see Section 9 of this Report for details), whose elimination will improve radiation protection in accordance with the current international standards and strengthening of relevant SNRIU capabilities in this area. Most of the radiation protection threats identified in Reports [2] and [3] have been eliminated or are being addressed in the framework of the following SNRIU-DSA bilateral cooperation projects:

- → Support to the SNRIU in Amendment of Ukrainian Regulatory Documents on Radiation Protection in Medicine in Accordance with IAEA Safety Standards and Council Directive 2013/59/EURATOM: MEDICINE;
- → Development of Ukrainian Regulation on Radiation Protection in Use of Radiation Sources: SOURCE; and
- → Development of Proposals/Recommendations on Procedure and Criteria for the Recognition of the Radiation Protection Expert According to Council Directive 2013/59/Euratom and IAEA Standards: PROVISION.

In addition, the threats identified in Reports [2] and [3] are being further eliminated both by the SNRIU using its own resources and in the framework of cooperation projects with the European Commission (see Section 10 of this Report for details).

8 NUCLEAR SECURITY

8.1 Analysis of Legislative Bases for Nuclear Security in Ukraine and Their Implementation into Regulatory Activities

The IAEA's nuclear security measures [101] and Ukraine's participation in the IAEA three-year Nuclear Security Plans since 2006 have provided a significant impetus to the establishment of the legislative basis for nuclear security in Ukraine. Ukraine's ratification of the Amendment to the Convention on the Physical Protection of Nuclear Material and Nuclear Facilities by a special Law [102] in 2008 necessitated revision and considerable amendment of the basic law on physical protection [103].

With the support of the IAEA and the Swedish nuclear regulator (SKI), SNRIU implemented the project 'Improvement of Regulations in the Field of Physical Protection in Ukraine' in 2007-2008. This enabled not only the development of a system for regulatory support measures for the physical protection regime to implement the above Amendment but also appropriate clarifications and amendments were made to some NRS laws [103], [21], [29]. The responsibility of licensees for physical protection was introduced in the Basic Law [21], the types of physical protection activities to be licensed were established, as well as the need to confirm physical protection measures in the Law on Authorizing Activities in Nuclear Energy [29] in licensing other activities associated with nuclear energy use was identified. In revision of the Law on Physical Protection [103], the requirements of the basic physical protection principles established by the Law [102] were introduced, in particular, regarding the physical protection regime in the country, the state physical protection system (SPPS), and development and support of the design basis threat. In addition, a number of concepts and basic requirements for nuclear security were elaborated and approved.

Thus, implementation of the 'nuclear security' concept in Ukraine started in 2010 with the introduction of the definition of this term in the Law on Physical Protection [103]. In addition, the Law made it mandatory to identify legal entities that ensure security of nuclear facilities, nuclear materials, radwaste, and other radiation sources. It was determined that the SPPS objective is to ensure security of nuclear facilities, nuclear materials, radwaste, and other radiation sources, taking into account the design basis threat.

These amendments to nuclear legislation have created a legal basis for further development of security of nuclear facilities, nuclear materials, radwaste, and other radiation sources in Ukraine for security regulation. The Statute of SNRIU [16] specified and expanded the regulatory authority's powers in certain areas of nuclear security: physical protection, combatting illicit trafficking of radioactive materials, security culture and international activity. Accordingly, the SNRIU Physical Protection Department was transformed into the Nuclear Security Department (now the Nuclear Security and Safeguards Department) and was entrusted with the authority for regulatory control, state supervision and authorizing activity in this area.

8.2 Need for Regulation of Nuclear Security in Ukraine

During the previous threat assessments presented in Reports [2] and [3], the regulatory activity of SNRIU in terms of security of nuclear facilities, nuclear materials, radwaste and other radiation sources was analyzed by the SPPS competent authority. Areas such as physical protection assurance in licensing; development of physical protection rules and standards; state supervision over compliance with physical protection requirements were reviewed. The analysis performed in Report [2] established that the physical protection regime in Ukraine was introduced and maintained at the state level, in accordance with the Amendment to the Convention ratified by Law [102]. This is the main function of the SPPS, which includes executive bodies executing state management and regulation in the field of nuclear energy use, law enforcement, as well as the operating organization and other licensees. This analysis was extended in

performing the subsequent threat assessment [3]. The SPPS structure and functions, as well as the tasks and powers of the SNRIU, were addressed in detail. The study outlined the main activities of the regulatory authority in the framework of the SPPS and analyzed the regulatory framework as the basis for this activity.

It was established in the assessment that several regulations concerning physical protection have been developed and adopted in recent years in Ukraine. All documents are developed in accordance with the provisions of directives and other EU documents, international agreements, and conventions in the nuclear field, and comply with requirements of other NRS regulations. In addition, they consider the IAEA recommendations on security and physical protection.

Report [3] states that the basis for establishing and maintaining the nuclear security regime is implementation of the regulatory framework and the application of a systematic approach to the study of the Euratom regulatory requirements for nuclear safety and security, as well as the IAEA recommendations. Therefore, a minimum list of EU documents and IAEA publications for in-depth study and comparative analysis of the existing regulatory framework of Ukraine was outlined. It was concluded that there was the need to develop a list of national regulations on specific issues of physical protection and nuclear security requiring development or revision, as well as justification of the priority of certain actions in this area. This task was given the highest priority and involved strengthening the national legal and regulatory framework by implementing the main nuclear security components and identifying areas for further activity in Ukraine, which became the objective of the FRAMEWORK project (launched in 2018) implemented in the framework of the DSA and SNRIU bilateral cooperation.

8.3 Analysis of Regulatory Activities on Nuclear Security. Identification of Threats

To assess the ongoing threats to regulatory activity on nuclear security, the following areas were analyzed:

Oversight activity. State and regular inspections. As part of the oversight activity, 5 inspections of physical protection systems of Energoatom nuclear facilities, CSFSF and 4 operating NPPs, were carried out in 2017. Examinations were conducted and 20 institutions resumed their operation after modernization of engineered features of physical protection systems.

In 2018, 7 scheduled comprehensive inspections and 1 unscheduled inspection of nuclear, uranium and radwaste management facilities were carried out. State physical protection inspectors participated as observers in tactical exercises to verify the effectiveness of facility-level interaction plans in the framework of the Comprehensive Exercises and Training Project to Ensure Preparedness of Response Forces at ZNPP and RNPP.

In 2019, 11 inspections were carried out: 6 scheduled comprehensive inspections, 4 unscheduled inspections, and 1 inspection survey. State inspectors took part in the verification of preparedness to respond to crisis situations by the forces and means included in the facility interaction plan in case of sabotage at ZNPP and SUNPP.

In 2020, 8 inspections were conducted: 3 scheduled comprehensive inspections, 4 unscheduled target inspections and 1 inspection survey. State inspectors took part in special tactical exercises to test interaction procedures at the Nuclear Research Institute.

Regulatory control. As part of rule-making activities, the first revision of the draft Cabinet Resolution on Amending Cabinet Resolutions No. 1471 of 25 December 1997 and No. 625 of 26 April 2003 was developed in 2017. Coordination of the draft Resolution review by interested central authorities was performed in

2018, and Cabinet Resolution No. 273, which introduced amendments to the above regulations, was adopted in 2019.

Authorizing activity. To meet the requirements of Article 45 of the Law of Ukraine [21], 1 permit for the use of land and water reservoirs located in the control area of nuclear, radwaste management, and uranium facilities was issued, and amendments to 2 permits were introduced in 2017.

In 2018, to define and maintain the physical protection level of nuclear facilities, nuclear materials, radwaste and other radiation sources, in particular during their transportation, licensees provided 40 acts on determination of the physical protection level, 11 of which were returned for updating. Two permits for using land and water reservoirs located in the control area of nuclear, radwaste management, and uranium facilities were issued, and 1 permit was amended.

In 2019, state physical protection inspectors reviewed the assurance of the physical protection requirements in licensing packages submitted to the SNRIU Licensing Commission. Four permits for the use of land and water reservoirs located in the control area of nuclear, radwaste management, and uranium facilities were issued, amendments were made to 1 permit. 47 acts on determination of the physical protection level of nuclear facilities, nuclear materials, radwaste, and other radiation sources were reviewed and 1 license for the right to conduct training and re-training of physical protection experts in the National Technical University of Ukraine 'Igor Sikorsky Kyiv Polytechnic Institute' was issued.

In 2020, state physical protection inspectors participated in review of licensing applications for nuclear activities, and 5 permits were issued for the use of land and water reservoirs located in the control area of nuclear facilities and radwaste management facilities. An inspection of KIPT was carried out in the framework of the licensing process.

State physical protection review. In pursuance of Article 15 of the Law of Ukraine [103], state physical protection review of 10 detailed designs for creation or upgrading of physical protection systems of nuclear facilities, radwaste management facilities and other radiation sources as well as of radioactive materials transport was conducted.

Combatting illicit trafficking of radioactive materials. To ensure information exchange on incidents involving illicit trafficking of nuclear and other radioactive materials, 37 information notices on cases detected in Ukraine in 2017 were sent to the IAEA. A group of Ukrainian citizens transporting a depleted uranium gamma flaw detector in their car was detained in Kyiv. There are many cases where Ukraine citizens have posted abroad various items, such as watches, altimeters, etc., containing Ra-226 salts with equivalent dose rates significantly exceeding established limits.

a) b) c)

Fig. 8.1 – Cases of illegal transfer of radioactive materials across the border: a) a rock sample placed into a hole cut in Children's Bible; b) an aviation watch with Ra-226-coated numbers; c) marine sextant; articles being popular among collectors

With the assistance of the IAEA, practical training on NRS assurance during major public events was carried out, including preparation for the 2017 Eurovision Song Contest. SNRIU participated in two training exercises organized by Interpol Headquarters to combat the illegal transfer of radioactive materials across Ukrainian state border. SNRIU representatives took part in Operation Navigator-2 to combat the illicit trafficking of weapons, chemical, biological and radioactive materials across the Ukrainian-Moldovan border and in training conducted in Cagul and the port of Giurgiulești (Republic of Moldova) on strengthening the combatting of illegal transfer of radioactive materials across the border.

In 2018, in the framework of information exchange with the IAEA Incident and Trafficking Database (ITDB), 26 incident notifications were submitted to ITDB. To improve anti-trafficking opportunities, SNRIU employees participated in:

- → preparing and conducting the Orion operation against the illicit trafficking of radioactive and nuclear materials on the Ukrainian-Moldovan border;
- → Ukrainian-Polish exercises on mastering scenarios for detecting nuclear smuggling in the framework of the joint project with the U.S. Department of Defense near the Rava-Ruska checkpoint, Lviv region; and
- → joint cross-border exercises on prevention of illicit trafficking attempts of radioactive materials outside checkpoints and a seminar on improving the information exchange, response methods to radioactive materials beyond regulatory control conducted in Odessa. The event took place within the Export Control and Related Border Security Program of the U.S. Embassy.

During 2019, 35 incident notifications on cases that occurred in Ukraine were submitted to ITDB. There were cases involving detection of orphan radiation sources at bankrupt enterprises or enterprises that have terminated their activities. Thus, in May 2019 in Toretsk, Donetsk region, 4 BGI-75 type containers with Cs-137 radiation sources were detected on the territory of the liquidated Pivnichna mine. SNRIU recorded 12 cases of radioactive materials being out of regulatory control. The majority of these cases involved watches of various types, including aircraft watches with radionuclides of natural origin Ra-226, scrap metal, and elements of radioisotope equipment.

In 2019, the SNRIU jointly with the IAEA Nuclear Security Division conducted a preparatory meeting on implementation of the nuclear security response program for Georgia, the Republic of Moldova and Ukraine in combating the illicit trafficking of radioactive materials and agreed a number of measures for 2020-2021. The joint operation, codenamed Orion, supported by the EU Border Assistance Mission to Ukraine and the Republic of Moldova (EUBAM) was conducted with the participation of Slovakia, Romania and Poland and was aimed at combating the illegal transfer of weapons, explosives, chemical, biological, nuclear and radioactive materials across the Ukrainian-Moldovan border.

In 2020, the final third stage of the Program for Search and Securing Orphan Radioactive Sources was conducted. This involved physical examination of radiation-hazardous facilities to detect and return orphan radioactive source under regulatory control. This was carried out in JSC SUMYKHIMPROM, certain territories in Rubizhne, Luhansk region, and in the former Prydniprovsk Chemical Plant, Kamyanske, Dnipropetrovsk region. In the course of the year, 19 cases of illicit trafficking were identified and reported to the ITDB: 11 cases concerned RS, including 2 smuggling attempts across the border, and 8 cases of contaminated scrap metal. Furthermore, 56 radioisotope smoke detectors of the RID type containing the radioactive isotope Pu-239 were seized from illicit circulation and 1 person was detained for theft and attempt to sell 17 RIDs.

Fig. 8.2 Smoke detectors RID-1 seized under the illicit sale attempt.

In autumn 2020, with the support of EUBAM, SNRIU representatives took part in practical exercises to combat the illicit trafficking of radioactive materials at the checkpoint across the state border of Ukraine with the Republic of Moldova *Mamaliga - Kriva*.

To get a general picture of the SNRIU's activity in 2017-2020 in the nuclear security field, the measures addressed above have been summarized in

Table 8.1 according to the regulatory functions and areas of activity.

Table 8.1 – Regulatory activities on nuclear security distributed by regulatory functions and areas

No.	**Regulatory functions and areas**	**Number of measures**			
		2017	2018	2019	2020
1	Inspections at the licensees' enterprises	21	8	27	8
2	State inspections of the physical protection system and interaction plans	4	2	2	1
3	Regulatory control	1	1	1	1
4	Issue and extension of licenses and permits	3	3	5	5
5	Admission to special activities	139	130	152	213
6	Acts on determination of physical protection level	85	40	47	54
7	Improvement of SPPS effectiveness	15	6	4	4
8	Notifications on illicit trafficking incidents	37	26	35	19
9	Combatting illicit trafficking	4	3	3	3
10	Physical protection training	6	2	4	3
11	Training on combatting illicit trafficking	3	4	4	1

This table is indicative and is not intended for efficiency assessment of the regulatory body. It was used only for illustration purposes in the analysis of functions and areas in the nuclear security field covered by the state regulation, and for identification of gaps and threats in this area.

As can be seen from the above description, all regulatory measures (Nos. 1-6 in

Table 8.1) concerned physical protection only. This is because the legislation contains regulatory requirements only for physical protection. This type of activity in the field of nuclear energy use is sufficiently detailed and has clear rules, standards and criteria. Therefore, it is possible to implement state supervision of licensees, carry out inspections/surveys of their activities and require them to self-assess the quality assurance of their activities only within the physical protection regime. In addition, no new

regulations have been developed in recent years that consider current international requirements and IAEA recommendations.

In accordance with IAEA recommendations [104], the above functions and areas of activity belong to the components of the nuclear security regime. According to the Law of Ukraine [103], nuclear security shall be assessed by the compliance of the physical protection level with the legislation requirements. Thus, regulation of physical protection requirements is at the same time regulation of the relevant nuclear security requirements.

In addition to physical protection measures, Table. 8.1 has a number of measures to combat the illicit trafficking of radioactive materials. This activity, which is an important component of the nuclear security regime in accordance with IAEA recommendations [104], is regulated by the document [105], which is included in the nuclear legislation of Ukraine. The description of SNRIU activity also contains a number of measures that are not regulatory functions of physical protection, but relate to nuclear security support: coordination and communication between regulators and other competent authorities; threat assessment; protection of restricted information and non-proliferation safeguards; preparedness and training checks; transportation security of nuclear and other radioactive materials; law enforcement measures, export-import and border control of nuclear and other radioactive materials; and nuclear security culture. A significant number of these measures were carried out in the framework of international support projects.

Therefore, it can be concluded that since the regulatory threat assessments [2] and [3], SNRIU activity in the nuclear security field involves a significant number of important and diverse measures. At the same time, these activity areas are not currently subject to state regulation due to the lack of relevant regulations in the Ukrainian legislation, which would contain necessary requirements, rules and standards. International documents containing such requirements (for example, EU regulations or IAEA recommendations) should be implemented into national legislation by accounting for them in national regulations. Thus, there is a threat to the implementation of the nuclear security regulation in Ukraine in full scope and at the appropriate level. This can be solved by implementing and maintaining a nuclear security regime at the state level.

8.4 Analysis of Regulatory Requirements for Nuclear Security and Development of Regulatory Framework

As already pointed out, the basis for establishing and maintaining the nuclear security regime is the implementation of nuclear security requirements and the creation of a comprehensive regulatory framework. As a method to achieve this goal, Report [3] recommended a systematic approach to study Euratom's regulatory requirements for nuclear safety and security, as well as the IAEA recommendations. Therefore, in accordance with the Roadmap for Cooperation between the DSA and SNRIU for 2018-2020, the FRAMEWORK project was developed and implemented in 2019-2020. The main task of the Project was to identify regulatory framework areas for nuclear security that need to be expanded and improved.

In the course of the project implementation, the experience of physical protection regulation in Ukraine was analyzed. The practice of nuclear security regulation and the national experience of implementing the nuclear security regime in countries with developed nuclear energy such as the USA, Great Britain and the Czech Republic were reviewed. An in-depth analysis of the requirements for physical protection and nuclear security in EU documents and IAEA recommendations concerning the legal and regulatory framework and structure of the main components of the nuclear security regime was carried out. In general, based on the analysis results the ways to transform the physical protection regime into a nuclear security regime were identified, and the results, important for creating regulatory framework and implementing state nuclear security regulation in Ukraine in full scope and in accordance with international requirements and recommendations were obtained. These are:

- → provisional structure of the nuclear security regime;
- → a list of nuclear security issues requiring state regulation;
- → provisional structure of the nuclear security regulatory framework;
- → a list of nuclear security regulatory requirements to be implemented in Ukraine;
- → recommendations on the structure and content of regulations to be developed to create the nuclear security regulatory framework;
- → recommendations on the structure and content of current regulations to be amended or revised; and
- → a list of measures to create the nuclear security regulatory framework.

The latter list contains 16 step-by-step measures needed to create the basis for a nuclear security regulatory framework. These activities are prioritized. The development or revision of the regulations listed, considering the recommendations on their structure and content, will provide a legal basis for introduction of a nuclear security regime in Ukraine both at the state and at the operator/licensee level as well as for state oversight and for providing licensing requirements on ensuring nuclear security.

Thus, the FRAMEWORK project, implemented following the conclusions of Reports [2] and [3], is the basis for further development of SNRIU regulatory activities in the nuclear security field. The priority tasks identified because of this project involve development of a number of top-level regulations establishing general and specific requirements for implementation of the nuclear security regime in Ukraine (see Section 9 of this Report for details).

9 MAIN THREATS IDENTIFIED AND PROPOSALS FOR THEIR ELIMINATION

This Section provides information on the elimination or minimization of threats identified in the previous Report [3] and on new threats compared to those described in the previous Reports [2] and [3]. Each threat that has not been resolved as of the beginning of 2021 is prioritized considering the extent of its negative impact on SNRIU activities in relevant areas, and ways for its elimination are proposed.

9.1 Organization and General Principles for Activities of the Regulatory Authority

The following threats were identified in the assessment [3] in this area:

- → need to ensure SNRIU independent status;
- → need to improve the regulatory framework for nuclear security; and
- → need to further support harmonization of national regulatory requirements of nuclear and radiation safety with WENRA reference levels.

The issue of SNRIU independent status has been solved through persistent SNRIU actions over the last years, comprehensive international assistance, and appropriate decisions of governmental authorities (see Section 2.3 of this Report for details). Nevertheless, this issue is to be paid continuous attention to ensure that the SNRIU status is further supported.

Implementation of the FRAMEWORK project within the bilateral cooperation between DSA and SNRIU was the first step towards improvement of the national regulatory framework on nuclear security. The next steps intended to eliminate this threat are described in Section 9.7 of this Report.

The harmonization of national regulatory requirements on NRS with WENRA reference levels is a priority area of SNRIU activities (see Section 2.4 of this Report). This challenge is dealt with through direct interaction with ENSREG (Ukraine became an observer in the ENSREG forum in 2020), active participation of SNRIU representatives in WENRA working groups, and ongoing and planned SNRIU rule-making activities. The main source of international support for SNRIU in the coming years in this area is participation of DSA in ongoing INSC projects [106] and [107] that are planned to be continued in the future (see Section 10 of this Report for details).

The assessment described in this Report did not find any new threats relating to compliance with the general principles for activities of the nuclear regulatory body.

9.2 Safety of Nuclear Facilities

The following threats were identified in the assessment [3] in this area:

- → need to further support the licensing process and safety assessment of C(I)SIP measures [22];
- → need to further support the oversight function using NPP operating experience;
- → need to establish general regulatory requirements for NPP emergency documents;
- → need to improve the existing regulatory framework that governs operation of research reactors; and

→ need to support SNRIU in licensing and safety assessment of construction and commissioning of new nuclear facilities.

All the above threats were eliminated or are being eliminated within the GUIDELINE and EXPERIENCE projects in the bilateral cooperation between DSA and SNRIU, other completed or ongoing international cooperation projects (see Section 10 of this Report for details), and through SNRIU's own efforts. The current assessment did not find any new threats relating to safety of nuclear facilities.

9.3 Radioactive Material Transport

The following threats were identified in the assessment [3] in this area:

→ need to improve legislation on radioactive material transport;

→ need to improve the regulatory framework on compliance with regulations on radioactive material transport; and

→ need to improve the regulatory framework on management systems for radioactive material transport.

The main and most important stage in eliminating the above threats was the revision of the general rules for nuclear and radiation safety in transport of radioactive materials, to bring them into compliance with current IAEA standards. This task was performed in the framework of the TRANSPORT project of cooperation between DSA and SNRIU, which resulted in implementation of high-level regulatory requirements [9]. Current activities intended to eliminate the above threats and further develop the regulatory framework on safe radioactive material transport are performed with DSA support within the COMPLIANCE and RULES projects. The Memorandum of Meeting between the USNRC and SNRIU for 2021-2022 provides for joint activities to improve approaches to safety assessment of transport packages for radioactive materials (see Section 10 of this Report for details).

Taking into account the above information, the current assessment did not find any new threats relating to radioactive material transport that would be required to be eliminated.

9.4 Emergency Preparedness and Response

The following threats were identified in the assessment [3] in this area:

→ need to improve the emergency preparedness and response system and harmonize it with IAEA standards, WENRA reference levels, new EU/Euratom directives, and HERCA initiatives regarding consistency of national procedures for response to transboundary nuclear or radiological events;

→ need to revise and improve standard provisions on the USCPS functional and territorial subsystems and procedure for notification of a threat or emergency and communication in the area of civil protection;

→ need to consider recommendations of the NATO Advisory Support Team to define the role of the RODOS decision support system in the state emergency response system;

→ need to implement interagency procedures to ensure interaction between SPPS and USCPS;

→ need to enhance SNRIU emergency preparedness and response through the arrangement and conduct of regular emergency exercises at national and international levels;

→ need to promote proper conditions for use of the RanidSONNI MRL as a tool for independent radiological assessment of the environment;

- → need to strengthen SNRIU emergency preparedness by establishing a backup IEC; and
- → need to promote legal conditions for full scope application of the IAEA INES User's Manual in Ukraine (but not only for classification of plant operational events).

All the above threats, except for the two last ones, are being eliminated or are planned to be eliminated within:

- → PREPAREDNESS and EXERCISE projects of cooperation between DSA and SNRIU;
- → ongoing and planned projects of cooperation between SNRIU and USNRC; and
- → ongoing and planned projects of EC INSC, in which SNRIU and other central executive bodies are beneficiaries.

The last two threats remain currently relevant. In addition, the current assessment found one new threat in the area of emergency preparedness and response. Information on this threat is provided below.

9.4.1 Need for Strengthening the SNRIU Emergency Preparedness System by Establishing a Backup IEC

The NATO Advisory Support Team mission in 2014 recommended that the SNRIU emergency response system be strengthened through establishment of a backup IEC.

The proposals on establishing a backup IEC on SSTC NRS premises were provided as part of the technical proposal package for the project 'Inclusion of the Ukrainian Nuclear Security System into the Global Nuclear Security', which was implemented in Ukraine by the Defense Threat Reduction Agency of the US Department of Defense from 2015 to 2019 under the Global Nuclear Security Program. After preliminary discussions, the proposals on a backup IEC were postponed for an indefinite period. A backup IEC would allow the SNRIU emergency staff to continue their efforts in force majeure conditions that would make the operation at the current IEC location impossible (see Section 5.3 of this Report). This threat was identified in Report [3], remains relevant, and is of **high** priority.

9.4.2 Promoting Legal Conditions for Full-Scope Application of the IAEA INES User's Manual in Ukraine

Ukraine became a member of INES activities immediately after creating conditions for INES functioning in 1990. Operational events at Ukrainian NPPs are currently classified using INES. Although INES was originally applied to classify only NPP events, now the scale covers any events associated with transport, storage, and use of radioactive materials and radiation sources. This issue (see Section 5 of this Report for details) is solved by developing a regulatory framework for application of INES in Ukraine to classify all events defined in the INES User's Manual 2008 Edition [108]. The development of a special regulation(s) or revision of current documents to introduce provisions on obligations and mechanisms for full-scope INES application may be initiated following expert and public consultations and considering international experience. This threat was identified in Report [3], remains relevant, and is of **high** priority.

9.5 Radioactive Waste Management and Decommissioning

The threats and challenges identified in Report [3] have been eliminated or are being eliminated within projects of cooperation between SNRIU and DSA and project funded by the European Bank for Reconstruction and Development and are addressed within ongoing and planned projects of SNRIU with

the European Commission. The assessment carried out in the development of this Report identified a number of new challenges, which are described below.

9.5.1 Need for Identifying Criteria for Radwaste Classification by Activity for Disposal Purposes

According to the Law of Ukraine [66], specific criteria for the classification of radwaste for its disposal in one of the four types of disposal facilities (shallow, near-surface, and medium-depth disposal facilities, and geological disposal facilities) shall be established in NRS regulations and rules. Specific requirements for classification and generic classification criteria will allow a potential disposal option to be determined during predisposal radwaste management. There are currently no numerical criteria to classify radwaste according to its activity for disposal in facilities of the above-listed types (see Sections 6.2.1 and 6.2.3 of this Report for details). The development of a regulatory document that would establish appropriate requirements is of **highest** priority.

9.5.2 Lack of Specific Safety Requirements for Medium-Depth Disposal Facilities and Geological Repositories

The high-level regulatory requirements [8] identify the types of facilities for radwaste disposal at medium depths and in geological formations (medium-depth disposal facilities and geological disposal facilities, while previously there was only one type, geological disposal facility). However, there are no specific requirements for medium-depth and geological disposal facilities, particularly specific requirements for use of the defense-in-depth concept in the design of such facilities, other requirements for design, etc. (see Sections 6.2.1 and 6.2.3 of this Report for details). To optimize the disposal of ILW and HLW, specific safety requirements and generic classification criteria shall be established for medium-depth disposal facilities and geological disposal facilities for ILW and HLW, respectively, depending on the disposal depth and considering the site geological characteristics and waste physical and chemical properties. The elimination of this threat is of **highest** priority.

9.5.3 Lack of Requirements for the Structure and Content of Safety Analysis Reports on Medium-Depth Disposal Facilities and Geological Repositories

There are no requirements for the structure and content of safety analysis reports on medium-depth and geological disposal facilities to be submitted to SNRIU in the licensing process for the design and life stages of such facilities (see Section 6.2.2 of this Report for details). The development of requirements for safety analysis reports on disposal facilities for ILW and HLW is relevant because activities have been started [65] in Ukraine to design disposal facilities for ILW and HLW. The elimination of this threat is of **high** priority.

9.5.4 Lack of Regulatory Requirements and Criteria for Remediation of Accident-Origin and Legacy Radioactive Waste Sites and Territories

Individual regulatory decisions on remediation criteria are currently made on retrieval of radwaste from pilot facilities with Chornobyl-original waste outside the Exclusion Zone and pilot facilities on former military sites of the Soviet era. There are no regulatory requirements on the procedure for determining these criteria, and there are no such criteria established in regulations (see Section 6.2.4 of this Report for details). These requirements and criteria shall be established and shall be based on a graded approach and

experience in safety assessments and ranking of radiologically hazardous facilities. The elimination of this threat is of **highest** priority.

9.5.5 Lack of Specific Requirements for Application of Graded Approach in Decommissioning

There are no specific requirements for application of a graded approach to decommissioning operations at nuclear facilities, which is required by high-level regulations in the area of decommissioning [10] (see Section 6.2.8 of this Report for details). There is a lack of methodological and criterial requirements for:

- → scope of comprehensive engineering and radiological surveys;
- → scope and content of measures to maintain nuclear facilities in safe deferred dismantling states and ensure dismantling safety;
- → scope and content of radiological and process monitoring measures;
- → definition of decommissioning stages;
- → criteria for determining the end state of nuclear facilities upon completion of all decommissioning stages.

The elimination of this threat is of **high** priority.

9.6 Radiation Protection

Most threats in the area of radiation protection identified in Report [3] have been eliminated or are being eliminated within the MEDICINE, SOURCE, and PROVISION projects of cooperation between DSA and SNRIU. In addition, the threats identified in Report [3] are eliminated through SNRIU's own efforts and under European Commission cooperation projects (see Section 10 of this Report for details). At the same time, there is a number of threats identified in Report [3] that remain relevant. The assessment set forth in this Report also identified a number of new threats. All threats that remained unresolved as of the beginning of 2021 or new threats in the area of radiation protection are described below.

9.6.1 Lack of a Regulation to Establish General Up-to-Date Safety Requirements for Management of Radiation Sources in Accordance with Basic Safety Requirements in New EU/Euratom Directives and IAEA Publications

In the framework of the SOURCE project of cooperation between DSA and SNRIU, the development of regulation 'General Requirements for Radiation Protection and Safety' was started to implement the main provisions of the IAEA Standard [93] and EU Directive [12] into regulatory activities. The successful completion and implementation of this high-level regulation (see Section 7.1 of this Report for details) will eliminate the associated threat [3] that remains currently relevant.

9.6.2 Lack of a Comprehensive Approach to Radiation Protection in Medical Exposure and Harmonization with the Directive 2013/59/Euratom dated 5 December 2013

The regulation 'General Safety Rules for Medical Radiation Sources' [5] was developed and implemented in the framework of the MEDICINE project of cooperation between DSA and SNRIU. The development of this high-level regulation is the first step towards the elimination of the threat identified in Report [3]. The next step is to eliminate the deficits of regulatory control in medical applications of radiation source, particularly using the latest nuclear technologies associated with the production and use of

radiopharmaceuticals for therapy and diagnostics (see Section 7.1 of this Report for details). Using regulation [5] and experience in its application, the following regulations shall be developed (or revised):

1 Radiation Safety Rules for Diagnostical Intervention Radiology (new development);

2 Radiation Safety Rules for Use of Radiation Sources in Nuclear Medicine (new development);

3 Safety Requirements and Conditions (Licensing Terms) for Use of Radiation Sources in Radiotherapy (revision); and

4 Requirements for Quality Control System for Diagnostic and Therapeutic Procedures Using Radiation Sources (revision).

The elimination of this threat is of **highest** priority.

9.6.3 Need for Developing Procedural Requirements and Identifying Criteria to Evaluate the Condition of X-Ray Diagnostic Units

The use of aged and obsolete X-ray diagnostic units leads to an unjustified increase in the patient's doses during X-ray diagnostic procedures and causes poor quality of diagnostic data (see Section 7.1 of this Report for details). To decommission such X-ray diagnostic units and ensure their compliance with up-to-date requirements and standards, an SNRIU guidance document 'Procedures and Criteria for Assessment Criteria, Stability Monitoring, and Removal of X-Ray Diagnostic Units' shall be developed. The document shall comply with IAEA recommendations and be based on the European Commission document [84].

The elimination of this threat is of **highest** priority.

9.6.4 Need for Defining Requirements and Criteria to Establish a National System for Accounting and Control of Personnel Doses

The first, important step towards establishing a unified national system for accounting and control of individual doses has been taken: implementation of the Cabinet Resolution [88]. However, the performance of such a system cannot be ensured without implementation of the action plan envisaged by this Cabinet Resolution (see Section 7.1 of this Report for details). For this purpose, the following documents shall be primarily developed:

→ qualification requirements for personnel of organizations in the area of nuclear energy that determine individual occupational doses;

→ requirements for quality control of determination (measurement and calculation) of individual doses; and

→ criteria and requirements for technical and administrative aspects of professional exposure monitoring, integrated approach to monitoring of internal and external professional exposure, particularly exposure from materials with naturally occurring radionuclides considering the IAEA Standard [100].

The elimination of this threat is of **highest** priority.

9.6.5 Need for Establishing Safety Standards for Radiation Sources Used for Non-Medical Human Imaging

Ukraine recently made substantial efforts to improve legislation on NRS regulation in compliance with new IAEA standards and EU/Euratom Directives. However, an important issue that remains to be resolved (see Section 7.1 of this Report for details) is regulation of radiation safety in the use of radiation sources for non-medical human imaging (Radiation Sources Used for Inspection Purposes and for Non-Medical Imaging). To resolve this issue, a regulation 'Radiation Sources Used for Inspection Purposes and for Non-Medical Imaging' shall be developed.

The elimination of this threat is of **high** priority.

9.6.6 Need for Revising and Updating Regulatory Requirements for Radiation Protection Optimization in Personnel Occupational Exposure at Nuclear Facilities

Regulatory requirements that comply with Council Directive 2013/59/Euratom [12] and IAEA documents [93] and [100] shall be developed to determine procedure for radiation safety of personnel, radiation monitoring, planning of radiation protection in radiological hazardous activities, and implementation of measures to optimize occupational exposure of personnel at nuclear facilities (see Section 7.3.2 of this Report for details). The issue shall be solved by the development of a regulation 'Radiation Safety Rules for Personnel of Nuclear Facilities'.

The elimination of this threat is of **highest** priority.

9.6.7 Lack of Regulatory Requirements for Environmental Monitoring and Monitoring of Public Exposure for Nuclear Facilities

Regulatory requirements for environmental monitoring for NPPs were established in document SP AS-88 'Health & Safety and Technical Requirements for the Design and Operation of Heat Supply Systems at Nuclear Power Plants', which is no longer valid in Ukraine. The lack of up-to-date regulatory requirements for monitoring of releases and discharges and monitoring of the environment and public exposure for NPPs complicates the SNRIU regulatory functions and contradicts the EU/Euratom Directives and IAEA publications. Such regulatory requirements shall cover the scope, types, arrangement, and procedures for radiation monitoring of the environment around nuclear facilities, including requirements for management, storage, use, and transfer of measurement results in normal operation of nuclear facilities (see Section 7.3.3 of this Report for details).

The elimination of this threat is of **highest** priority.

9.7 Nuclear Security

The FRAMEWORK project implemented to incorporate findings of Reports [2] and [3] is the basis for further development of SNRIU regulatory activities in the area of nuclear security. The primary tasks determined upon completion of this project are intended to develop a number of high-level regulations that establish general requirements for implementation of nuclear security regime in Ukraine.

9.7.1 Need for Developing the Regulatory Framework on Nuclear Security

In accordance with the FRAMEWORK project and ongoing SNRIU tasks (see Section 8.3 of this Report for details), the following four regulations shall be primarily developed:

- → General Security Provisions for Nuclear Facilities, Nuclear Materials, Radioactive Waste, and Other Radiation Sources. This will be a fundamental regulation in the national regulatory framework on nuclear security and will promote the implementation of a nuclear security regime at the national level and support state regulation of nuclear security;
- → General Requirements for Nuclear Security Regime for Nuclear Facilities, Radioactive Waste Management Facilities, and Other Radiation Sources. This will be a basic regulation for activities related to the implementation of a nuclear security regime at nuclear and other facilities and will include a series of regulatory requirements for operating organizations and other licensees;
- → Requirements for Development of Facility-Level Design-Basis Threat. This regulation will establish procedure for threat assessment and development of facility-level design-basis threat and requirements for the facility-level design-basis threat; and
- → Physical Protection Rules for Radioactive Waste and Other Radiation Sources.

10 OVERVIEW AND STATUS OF INTERNATIONAL PROJECTS AND EFFORTS TO RESOLVE IDENTIFIED THREATS

This Section provides an overview of the projects that are ongoing or planned to be implemented as of early 2021 and that are aimed at eliminating or minimizing the impact of the threats and challenges identified in previous Sections of this Report.

10.1 Cooperation between SNRIU and DSA

In 2014, DSA and SNRIU signed an Agreement [1] with the objective to initiate bilateral cooperation through periodic assessments of threats and challenges that affect SNRIU's performance of its functions. The Regulatory Threat Assessment Reports [2] and [3] as well as this Report are the results of these assessments over certain time periods. Based on these documents, a priority list of actions (projects) implemented in the framework of cooperation and aimed at eliminating or minimizing the consequences of identified threats is defined. Review of the implementation status of these projects, solution of current issues, as well as planning of future activities takes place during working (coordination) meetings between DSA and SNRIU, which are periodically organized and held in Kyiv, Oslo, or in virtual format.

The implementation chronology of these projects from the start of the cooperation is provided in Fig. 10.1. Brief information on the technical nature of the 12 completed (as of early 2021) and 7 ongoing projects is provided below.

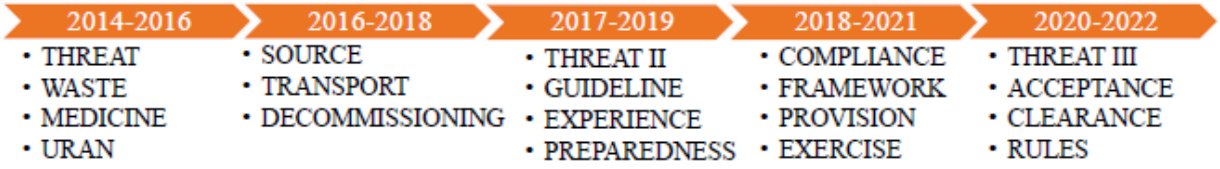


Fig. 10.1 – Projects of cooperation between DSA and SNRIU

10.1.1 THREAT, THREAT II, THREAT III Projects

The objective of these projects is to assess threats and challenges affecting implementation by SNRIU of central executive body functions in the field of state NRS regulation. The following tasks are performed under these projects:

→ analysis of the situation, at the time of project implementation, in the field of NRS regulation within the competence of SNRIU to identify the most significant threats and challenges that require response;

→ assessment of progress in regulatory activities of SNRIU since the previous threat assessment (for the THREAT II and THREAT III projects); and

→ identification of areas and tasks for joint efforts of SNRIU and DSA in response to identified threats.

The outcomes of these projects are used in the development of the threat assessment report and the roadmap for cooperation between DSA and SNRIU in the period after the assessment.

10.1.2 URAN, WASTE, MEDICINE Projects

The URAN project (Support of the SNRIU in Amendment of Ukrainian Regulatory Documents on Radiation Protection in Uranium Industry in Accordance with IAEA Safety Standards and Council Directive

2013/59/EURATOM) was aimed at improving the regulatory framework for nuclear and radiation safety in the uranium industry. Two high-level regulations were developed and implemented in the project:

→ Requirements for Institutional Control of Uranium Sites within Restricted Clearance from Regulatory Control [4], which established procedures for planning, conducting, revising and terminating administrative control of uranium sites, which after termination of their operations by liquidation of conversion are under restricted clearance from regulatory control; and

→ General Radiation Safety Provisions for Uranium Ore Mining and Milling [11], which established safety standards for uranium ore mining and milling and for termination of these operations by designing, siting, construction, upgrading, operation, decommissioning and temporary shutdown of uranium mining and milling facilities.

The WASTE project (Development of General Safety Provisions for Radioactive Waste Management in Ukraine) was aimed at improving the regulatory framework on nuclear and radiation safety under radwaste management. Two high-level regulations were developed and implemented in the project:

→ General Safety Provisions for Predisposal Management of Radioactive Waste [6], which established safety criteria, as well as the main NRS safety requirements for all stages prior to radwaste disposal.

→ General Safety Provisions for Disposal of Radioactive Waste [8], which established the main requirements for NRS assurance under radwaste disposal and are aimed at personnel, population and environment protection against possible radiation impacts during the operational period of the facility as well as for the long-term period after its closure.

The MEDICINE project (Support of the SNRIU in the Amendment of Ukrainian Regulatory Documents on the Radiation Protection in Medicine in Accordance with the IAEA's International Safety Standards and Council Directive 2013/59/EURATOM) was aimed at improving the regulatory framework on radiation safety assurance in medicine. Two high-level regulations were developed and implemented in the project:

→ General Safety Rules for Medical Radiation Sources [5], which established safety criteria and requirements for all health care institutions that use radiation sources for medical purposes; and

→ Radiation Safety Rules of Using Radiation Sources in Brachytherapy [7], which defined safety principles and protection criteria of personnel and patients against radiation risks in brachytherapy.

10.1.3 SOURCE, TRANSPORT, DECOMMISSIONING Projects

The SOURCE project (Development of a National Regulation on Radiation Protection in the Use of Radiation Sources) was aimed at improving the national regulatory framework in the radiation protection area by development of a high-level regulation establishing systematized radiation safety requirements for the safe use of radiation sources. During the implementation period, the draft regulation 'Basic Requirements for Assurance of Radiation Protection and Safety' was developed. The regulation establishes systematized radiation safety requirements for the safe use of radiation sources. The measures to implement this document in regulatory practice were carried out in 2019-2020 (receiving comments from interested organizations, appropriate revision of the document taking into account recommendations of international experts to expand the scope of the document and consider the provisions of Council Directive 2013/59/Euratom [12]),(see Section 7.1 of this Report for details). After registration of the document in the Ministry of Justice of Ukraine (scheduled submission of the

registration documents - December 2021) and its entry into force, the final version of the regulation will be provided to the DSA.

The TRANSPORT project (Revision of the Regulatory Document 'Rules for Nuclear and Radiation Safety in Transport of Radioactive Materials') was aimed at assuring the up-to-date basis for safety regulation in radioactive material transport at all stages of the process (preparation, loading, transfer, transport, transit storage, unloading and final acceptance of radioactive materials and packages). The high-level regulation 'Rules for the Safe Transport of Radioactive Material' [9] was developed and implemented in the project.

The DECOMMISSIONING project (Development of High-Level Regulatory Documents for Decommissioning Safety of Nuclear Facilities) was aimed at strengthening the regulatory activities in the area of decommissioning of nuclear facilities. Two high-level regulations were developed and implemented in the project:

→ General Safety Provisions for Decommissioning of Nuclear Facilities [10] establishing safety criteria and NRS requirements at all stages of decommissioning of facilities; and

→ Requirements for the Structure and Contents of the Operator's Documents for Licensing Application for Decommissioning of Nuclear Facilities.

The document [10] has been put in force. Approval of the second document is scheduled for autumn 2021. After its entry into force, the final version of the regulation will be provided to the DSA.

10.1.4 GUIDELINE, EXPERIENCE, PREPAREDNESS Projects

The GUIDELINE project (Development of General Regulatory Requirements for the Structure and Contents of NPP Emergency Documentation) was aimed at developing a regulatory document establishing requirements for development, use, review and maintenance, including regulatory one, sets of emergency documentation for Ukrainian NPP units of. During the project implementation period, the draft regulation 'Requirements for the Structure and Contents of Emergency Documentation for NPPs' was developed in 2017–2019. The final revision of the document is being finalized. After the registration of the document in the Ministry of Justice of Ukraine (June 2021 is scheduled submission of documents for the registration) the final revision of the regulation will be submitted to the DSA.

The EXPERIENCE project (Development of Guideline for Assessment of Safety Culture and Human and Organizational Factors in Operating Experience Analysis) was aimed at increasing operational safety of Ukrainian NPPs by prevention of operational events caused by human and organizational factors and more effective application of operating experience. Based on the project outcomes, the SNRIU Guideline for assessment of safety culture and human and organizational factors during the operating experience analysis of Ukrainian NPPs was developed. This document is currently used in defining inspection areas, their planning and implementation of the general regulatory oversight.

The PREPAREDNESS project (Enhancing Emergency Preparedness and Response in Ukraine) is aimed at ensuring the harmonization of the national regulatory framework in the field of emergency preparedness and response with up-to-date requirements of the IAEA and Euratom Directives. During the project implementation period, the National Radiation Emergency Response Plan, which is the main regulation defining emergency preparedness and response measures in Ukraine, was revised. The document is scheduled to be submitted for registration to the Ministry of Justice of Ukraine in September 2021. After its entry into force, the final version of the regulation will be provided to the DSA.

10.1.5 COMPLIANCE, FRAMEWORK, EXERCISE Projects

The COMPLIANCE project (Improvement of Regulatory Framework on Safe Transport of Radioactive Materials) is aimed at identification of needs in improvement of the regulatory framework of Ukraine in the area of radioactive material transport. The Tasks to be performed in the framework of the project are:

→ establishment of requirements for the procedure of issuing the certificates on the safe transport of radioactive material;

→ establishment of requirements for the structure and contents of safety analysis reports that are included into the package of documents for obtaining certificates;

→ revision of the regulation 'Safety Requirements and Conditions (Licensing Conditions) for Carrying out Activities on Transport of Radioactive Materials' (NP 306.6.095-2004); and

→ revision of the regulation 'Requirements for the Safety Analysis Report for Carrying out Activities on Transport of Radioactive Materials' (NP 306.6.096-2004).

It is scheduled to finalize the project in 2021 in full scope.

The FRAMEWORK project (Definition of Areas to Improve Regulatory Framework for Nuclear Security) is aimed at improvement and development of the national regulatory framework in the specified area. The project will result in definition of the areas and priority measures for further rule-making activities of SNRIU in this field.

The PROVISION project (Development of Proposals/Recommendations on Procedure and Criteria for the Recognition of the Radiation Protection Expert According to Council Directive 2013/59/Euratom and IAEA Standards) is aimed at implementation of the specified measures, some of which have been carried out as of early 2021:

→ analysis of international practices on recognition of radiation protection experts and their involvement into the provision of safety services in the sphere of professional exposure and public protection;

→ gap analysis of the Ukrainian regulatory framework on expert consultations on radiation protection and analysis of practices of expert recognition in other spheres;

→ developed of recognition procedure to confirm qualification of experts in radiation protection;

→ development of a database of experts (database structure, software) to be transferred to SNRIU.

The project tasks are to be completed in full scope in 2021.

The EXERCISE project (Strengthening Emergency Preparedness and Response in Ukraine) is aimed at strengthening the SNRIU capacity in terms of emergency preparedness and response. The project was scheduled to be implemented in 2019 – 2021:

→ the emergency exercise according to the developed Scenario No. 1 'Conventional accident at an NPP on the territory of a third country with the transboundary impact threat' was conducted;

→ scenarios No. 2 'Conventional accident at a nuclear facility on the territory of Ukraine' and No. 3 'Conventional accident with the loss of control over a radiation source on the territory of Ukraine/Norway' were developed and agreed in the established order as well as corresponding exercise programs.

Emergency exercises No. 2 and 3 and completion of the entire project were planned for spring 2021.

10.1.6 ACCEPTANCE, CLEARANCE, RULES Projects

The ACCEPTANCE project (Development of Regulatory Document on Requirements and Rules for Safe Management of Disused Sealed Radiation Sources (DSRS) Declared as Radioactive Waste) is at the initial implementation stage.

The CLEARANCE project (Development of Regulatory Document on Clearance of Radioactive Materials from Regulatory Control) is aimed at revising the regulatory document in force NP 306.4.159-2010 'Procedure for Clearance of Radioactive Materials from Regulatory Control within Practices' [79]. The project is at the initial implementation stage.

The RULES project (Management and Compliance Assurance System for the Safe Transport of Radioactive Materials) is also at the initial implementation stage. Two regulations have to be developed in the framework of the project to establish:

→ requirements for the management system for the safe transport of radioactive material; and

→ procedures for compliance assurance with requirements and rules for the safe transport of radioactive materials.

Since its initial phase, the cooperation between SNRIU and DSA has been carried out not only in the framework of the projects mentioned above, but also covers a number of other important activities, several recent bright examples are given below.

In autumn 2019, at the invitation and assistance of the DSA, a representative of SSTC NRS participated in the international conference Regulatory Supervision of Legacy Sites, Decommissioning, and Wastes - from Recognition to Resolution: Building Optimization into the Process, organized by DSA and NEA-OECD, in cooperation with the IAEA and ICRP.

Fig. 10.2 – Participants of the International Conference: Regulatory Framework of Decommissioning, Legacy Sites and Wastes from Recognition to Resolution: Building Optimization into the Process, 28 October - 3 November 2019, Tromsø, Norway

The report 'Applying a Graded Approach to Ensuring the Safety of Emergency and Legacy Radwaste in Ukraine' was made at this representative international forum. This issue is currently on the cooperation agenda between SNRIU and DSA (see Section 6.2.4 of this Report for details).

In December 2020, an online meeting of SNRIU and DSA management was held with the participation of representatives of the Ministry of Foreign Affairs of the Kingdom of Norway and the Embassy of the Kingdom of Norway in Kyiv, during which a Protocol on practical implementation of early notification

procedures on nuclear accidents and information exchange on nuclear facilities was signed between SNRIU and DSA.

Fig. 10.3 – Signing the Protocol on implementation of early notification procedures on nuclear accidents and information exchange on nuclear facilities between SNRIU and DSA

The importance of the above Protocol includes the need to ensure:

- → implementation of procedures for early notification on nuclear accidents and information exchange on nuclear facilities in the framework of the Agreement between Ukraine and the Government of Norway on Early Notification of a Nuclear Accident and Information Exchange on Nuclear Facilities of 28 September 1994;
- → preparedness for incidents and emergencies, given the changing global challenges and introduction of new technologies (see Section 5.6 of this Report for details);
- → further cooperation to minimize consequences of transboundary transfer of radioactive substances; and
- → improved preparedness and response to nuclear and radiological emergencies and incidents at both the regional and international levels, including emergencies that do not pose a high radiological hazard but however lead to increased public interest/concern.

These examples illustrate the variety of cooperation types between the SNRIU and DSA, which definitely has a positive impact on quality and content of completed and ongoing bilateral projects.

10.2 Cooperation between SNRIU and USNRC

The cooperation between the parties has been developing since 2000. Cooperation areas for a certain time period are agreed during meetings of the USNRC and SNRIU representatives and are reflected in the relevant Memoranda of Meetings (hereinafter - the Memorandum), which contain a detailed list of tasks planned for implementation by the partners: USNRC, SNRIU and SSTC NRS.

In determining the cooperation areas and goals, the parties take into account the current regulatory situation in Ukraine and the challenges faced by the SNRIU, as well as the results of activities in previous periods, available experience and professional potential of Ukrainian specialists.

Since 2015, cooperation between the regulatory authorities of Ukraine and the U.S. has been carried out in the framework of Memoranda [109] and [110]. The parties identified areas and content for further cooperation in the coming years during the review meeting, which took place in December 2020.

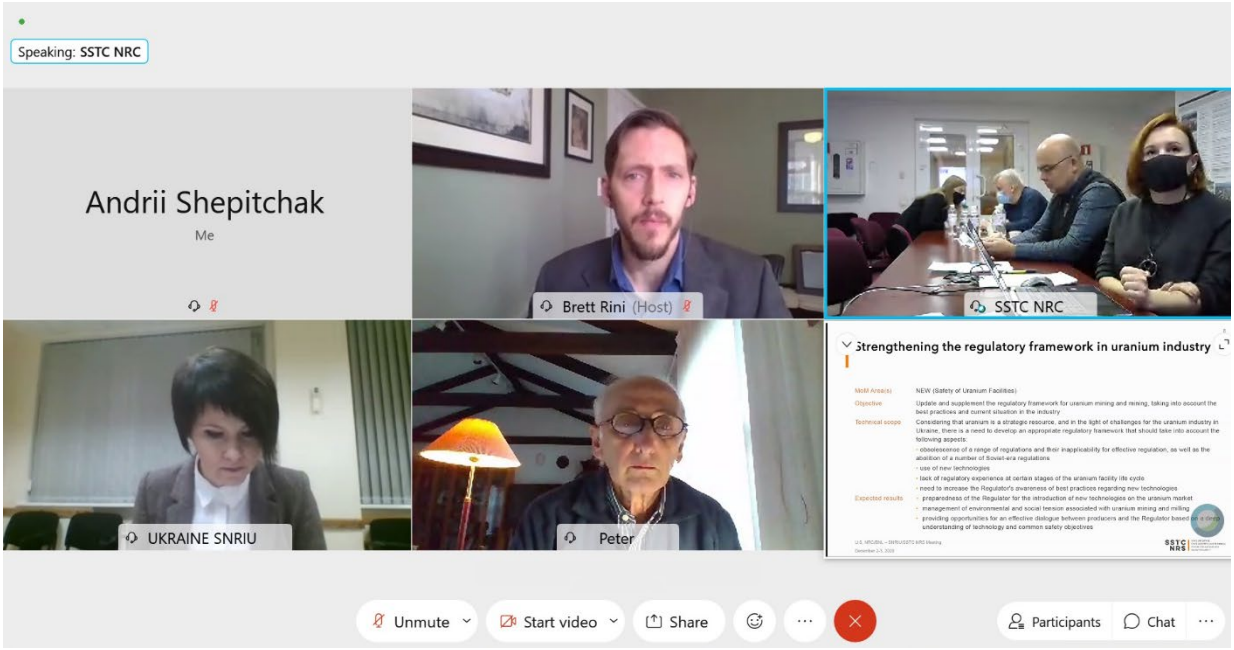


Fig. 10.4 – Review meeting between USNRC, SNRIU, and SSTC NRS, December 2020

At present, the draft Memorandum for 2021-2022 developed by the SNRIU, envisages cooperation in the following areas:

→ oversight and licensing activity;

→ risk-informed regulatory activity;

→ transport and interim storage of spent fuel;

→ VVER reactor pressure vessel embrittlement;

→ new fuel management;

→ radioactive materials and waste management;

→ emergency response and related capabilities;

→ safety of uranium facilities;

→ regulatory oversight of radioactive sources;

→ nuclear security; and

→ strengthening of the SNRIU infrastructure.

Tasks carried out with the support of the USNRC under the Memoranda [109] and [110], and planned for implementation under the draft Memorandum for 2021-2022, are aimed at eliminating a number of threats and at responding to the challenges referred to in Sections 3-5 of this Report.

10.3 Ongoing and Planned INSC Projects for Strengthening SNRIU Capabilities

The EU continues providing technical assistance to the SNRIU on a systematic basis under the Instrument for Nuclear Safety Cooperation (INSC) through the funding of national Annual Action Programs. Currently, these activities are carried out under Annual Action Programs for 2014-2015 and 2018, in the framework of INSC projects [106], [107], which are being implemented with the DSA involvement. Brief information on

the implementation of the INSC projects [106], [107] as of early 2021, is provided below. The deadline for completion of both projects is May 2022.

UK/TS/51 Strengthening of SNRIU Capabilities in Licensing of New Nuclear Installations (Except NPPs) – Component A [107]. The tasks under this Component are aimed at improving the national regulatory framework and approaches to licensing of corresponding nuclear facilities (nuclear fuel fabrication plant; spent fuel storage facility; subcritical research facilities; research reactors) licensing of neutron source facility; spent fuel management and storage, and safety assessments of research reactors (e.g. neutron source facility). So far, a number of recommendations have been prepared for establishing regulatory requirements and the relevant range of aspects, and a review of existing calculation tools used in licensing has been performed. The tasks performed under this Component are aimed at eliminating the threats referred to in Section 3 of this Report.

UK/TS/52 Assistance to SNRIU in Enhancing and Ensuring Robustness of Models for Severe Accident Analysis based on EU up-to-date Experience and Fukushima Daiichi Lessons – Component B [107]. The following tasks have been already performed in the framework of this Component: modeling of phenomena related to severe accidents (potential cooling of the overheated and partially displaced reactor core; melt spreading and its retention inside the reactor vessel; melt interaction with the concrete; hydrogen generation and its behavior in the containment, etc.). Modelling of the safety improvement measures under severe accidents management at Ukrainian NPPs (VVER-1000) with special focus on severe accident progression in the spent fuel pool has also been carried out. The tasks performed under this Component are aimed at eliminating the threats referred to in Section 3 of this Report.

UK/TS/53 Strengthening and Alignment of Ukrainian Nuclear Safety Regulations in Line with the EU Experience, Best Practice and EURATOM Acquis – Component C [107]. The objective of the Component Tasks is to: contribute to enhancing the Ukrainian regulatory framework in implementing EU Directives and WENRA reference levels. The experts have already performed the overview and self-assessment of the national regulatory framework for compliance with a number of key EU Nuclear Directives. The work resulted in specific proposals on bringing the national NRS regulatory framework in line with the provisions of EU Council Directives and WENRA reference levels. The Tasks performed under this component are aimed at eliminating the threats addressed in Sections 3-7 of this Report.

UK/TS/54 Strengthening of Ukrainian Nuclear Safety Regulatory Capabilities in The External Hazard Assessment Area – Component D [107]. In accordance with the project objectives, the SNRIU receive expert support in performing assessments of the external hazards (natural and man-made) under review of corresponding safety justifications. The project resulted in the development of two Regulatory Guidelines were developed for performing review of safety justifications, taking into account natural and man-made external hazards. The tasks performed under this component are aimed at eliminating the threats referred to in Section 3 of this Report.

UK/TS/55 Enhancement of the National Regulatory Framework and Relevant Regulatory Capabilities in the Frames of Operational Experience Feedback System – Component E [107]. The SNRIU is supported in improving the regulatory requirements for accounting and investigation of operational events at Ukrainian NPPs, as well as in strengthening and expanding the regulatory oversight capabilities taking into account the lessons learned from operating experience feedback. The Tasks performed under this Component are aimed at eliminating the threats referred to in Section 3 of this Report.

UK/TS/56 Support of the Regulatory Activity under Implementation of the Modern Safe Technologies of Radioactive Waste Management and Remediation – Component F [107]. The Component objective is to ensure efficient regulation of radwaste management on the most important safety issues. The project Tasks cover the various components of the radwaste management process: waste management prior to disposal, safe disposal of radwaste and clearance from regulatory control. Drafts of two documents are

developed in the framework of individual tasks: a) Guideline for comprehensive approach for disposal of radwaste of different origin, b) Guideline on radwaste classification for disposal in different types of storage facilities. The Tasks performed under this Component are aimed at eliminating the threats referred to in Section 6 of this Report.

UK/TS/57 Assessment of Licensing and other Operator Activities – Component G [107]. The objective of this Component is enhancement of SNRIU capabilities in assessment of measures implemented by the Operator for safety upgrading of Ukrainian NPP power units with the consideration of implementation experience from similar activities in EU countries. During joint on-site inspections at Ukrainian NPPs with involvement of the EU experts corresponding groups of measures are reviewed; the results of such missions are included into expert reports with recommendations and action plans for SNRIU. The tasks performed under this Component are aimed at eliminating the threats referred to in Section 3 of this Report.

The objective of the project *INSC UK/TS/58 Support to Ukrainian Regulatory Authority* [106] is to strengthen the capabilities of SNRIU and its TSO in strategic planning, emergency preparedness and response, safe management of radioactive waste and licensing of new nuclear fuel. The following individual tasks are included in the project:

→ Task 1. Development of a strategy on completing regulatory framework, capacity building and resource planning. Task 1 is aimed at eliminating the threats referred to in Sections 2-8 of this Report;

→ Task 2. Implementing the HERCA-WENRA approach to improve interstate coordination of protective actions during nuclear accidents. Task 2 is aimed at eliminating the threats referred to in Section 5 of this Report;

→ Task 3. Support of the regulatory activity for radioactive waste management, decommissioning and remediation. Task 3 is aimed at eliminating the threats referred to in Section 6 of this Report;

→ Task 4. Support in licensing of diversified nuclear fuel supplies for Ukrainian NPPs. Task 4 is aimed at eliminating the threats referred to in Section 3 of this Report.

The SNRIU proposals to the Annual Action Program for nuclear safety cooperation for 2021, which have recently been submitted to the European Commission for review, cover the tasks as presented below.

Task 1: Support to the SNRIU in activities implemented in the framework of the ENSREG Topical Peer Reviews on Ageing Management and Fire Protection. This task is intended to enhance SNRIU capabilities required in implementation of the expected scope of regulatory activities within the ENSREG Topical Peer Review (TPR) process. The task includes the following two parts:

→ implement measures to improve SNRIU ageing management practices upon the first topical peer review performed in support of the ENSREG ageing management initiative; and

→ support SNRIU in respective activities implemented under the second TPR, which is focused on the fire protection of nuclear installations situated in Ukraine.

Task 1 is aimed at eliminating the threats referred to in Section 3 of this Report.

Task 2. Introduction of graded and integrated approaches in regulating safety of radioactive waste and radioactive material management. This task is intended to support the SNRIU in implementation of graded and integrated approaches in regulating the safe management of radioactive waste and materials, including the following regulatory areas:

→ regulation of safety in integrated management of radioactive waste of various origins using a graded approach;

→ regulation of remediation safety with application of the graded approach; and

→ regulation of safety in clearance of radioactive materials with application of the graded approach.

Task 2 is aimed at eliminating the threats referred to in Section 6 of this Report.

Task 3: Providing methodological unity in radiation monitoring through development of guidance on radiation monitoring in planned, emergency and existing exposure situations. This task is intended to ensure development of the programs for source monitoring and environmental monitoring and that the results from the monitoring are recorded and made available. To unify monitoring programs, it is planned to develop methodological guidance for licensees on radiation monitoring in planned, emergency and existing exposure situations and for different stages of emergency response, including the period of transition to stabilization and resumption of normal activities. Task 3 is aimed at eliminating the threats referred to in Section 5 of this Report.

Task 4: Strengthening of SNRIU regulatory capabilities in licensing of 'load following modes' for NPP units. This task is intended to support SNRIU in licensing of respective measures implemented by the operating organization aimed at introducing the daily power control mode of NPP units for power control per day within a range of 100-75-100% power level. In order to support the licensing process, it is necessary to enhance the national regulatory framework by means of establishing the procedure for regulatory review and independent technical assessments of the safety justifications for implementing the load following modes at Ukrainian NPPs. Task 4 is aimed at eliminating the threats referred to in Section 3 of this Report.

Task 5: Implementation of the Strategy on completing regulatory capacity building and resource planning developed under INSC U3.01/18 (UK/TS/58) for harmonizing Ukrainian nuclear and radiation safety regulations and standards with European Union legislation and WENRA Reference Levels. The proposed task is intended to support the SNRIU in implementation of the strategy provisions, which will be developed based on the outcomes of Task 1 [106] with respect to further harmonization of Ukrainian nuclear and radiation safety standards and rules with legislation of the European Union and WENRA Reference Levels. Task 5 is aimed at eliminating the threats referred to in Section 2-8 of this Report.

Task 6: Strengthening regulatory capabilities in review of safety improvement measures for severe accident management. This task is aimed at ensuring the SNRIU support under regulatory review of Operator's justifications of the safety measures in accordance with the C(I)SIP [22] and mitigation of severe accident consequences. The task will also involve in-depth study of selected severe accident phenomena. Special attention will be focused on investigation of implementing in-vessel melt retention for Ukrainian NPPs (VVER-440 and VVER-1000). Task 6 is aimed at eliminating the threats referred to in Section 3 of this Report.

10.4 Cooperation of SNRIU with the International Atomic Energy Agency

In compliance with Cabinet Resolution [111], SNRIU is responsible for cooperation with IAEA. During the last years, several national projects for Ukraine were ongoing under the IAEA Technical Cooperation Program:

→ Strengthening the Capabilities of the State Nuclear Regulatory Inspectorate of Ukraine Considering Current IAEA Standards Revised after the Fukushima NPP Accident as well as Best International Practices;

→ Supporting Decommissioning of Nuclear Power Plant Units and Radioactive Waste Management at the Chernobyl Site and in the Exclusion Zone;

→ Strengthening the Capabilities for Diagnostics and Treatment of Cancer;

→ Strengthening Capabilities of Ukraine for Production of Radiopharmaceuticals for Healthcare;

→ Supporting Ukrainian Organizations in Decommissioning, Radioactive Waste, and Spent Nuclear Fuel Management, including Radio-Environmental Monitoring.

Currently, IAEA adheres to the principal position of continuing to apply the IAEA safeguards to nuclear facilities and materials in Ukraine in accordance with international law and the Agency's Statute, based on the fact that the Autonomous Republic of Crimea is an integral part of Ukraine.

In June 2019, an IAEA expert mission focusing on approaches to independent neutronic calculations within technical evaluations of mixed core safety justifications was conducted at SNRIU and SSTC NRS. Upon the IAEA expert mission, a report with conclusions on the status and quality of independent neutronic calculations used in technical evaluations of safety justifications for mixed cores in the introduction of alternative vendor's fuel at Ukrainian NPPs was prepared and recommendations on improvement were provided.

In November–December 2019, SNRIU received three groups from the Kyrgyz Republic with scientific visits (internships). The internships were supported by IAEA to disseminate Ukraine's national experience in establishing and operating a state nuclear regulatory authority in accordance with the Agency's standards.

SNRIU and SSTC NRS experts take an active part in the improvement of IAEA safety standards through their efforts for the Nuclear Safety Standards Committee (NUSSC), Radiation Safety Standards Committee (RASSC), Waste Safety Standards Committee (WASSC), Nuclear Security Guidelines Development Committee (NSGC), and Emergency Preparedness and Response Standards Committee (EPReSC).

10.5 Other Areas of SNRIU International Cooperation

In addition to the SNRIU international cooperation areas presented in the previous Sections, the Ukrainian nuclear regulator actively cooperated in recent years with other international organizations, also in the framework of relevant bilateral agreements. These activities are ongoing and aimed at eliminating threats and challenges addressed in this Report. For example, SNRIU's cooperation with the European Bank for Reconstruction and Development is carried out under the following Agreements:

→ Grant Agreement No. 002 (Chornobyl Shelter Fund: Licensing Consultant) [112];

→ Grant Agreement No. 007 (Chornobyl Nuclear Safety Project) [113]

and is aimed at eliminating the threats addressed in Section 6 of this Report.

Joint ongoing projects implemented in cooperation between SNRIU and the Federal Ministry of the Environment, Nature Conservation and Reactor Safety of the Federal Republic of Germany, are aimed at experience exchange on topical NRS issues, as well as supporting SNRIU in DRS management (in the framework of a respective project, the DRS are withdrawn from enterprises that have stopped operations or are in a difficult economic situation. The withdrawn DRS are then packaged and transferred for long-tern shielded storage. During the project implementation period, around 23 thousand DRS were withdrawn from enterprises across all regions of Ukraine and were packaged and transferred for long-term storage

In the framework of cooperation with the U.S. Department of State, the projects 'Cybersecurity Improvement at the State Nuclear Regulatory Inspectorate of Ukraine' and 'Combating Illegal Use and

Illicit Trafficking of Radioactive Material in the Eastern Region of Ukraine. Task 1. Extraordinary inventory of Radioactive materials' (INVENTORY) are in the active phase of implementation. These projects are aimed at eliminating the threats addressed to in Sections 7 and 8 of this Report.

Pursuant to the Executive Agreement between the SNRIU and the U.S. Department of Energy on Cooperation to Improve the Safety of Radiation Sources Used in Ukraine, the implementation of the project 'Improvement of Security of Radiation Sources Used in Ukraine' continues. The objective of this project is to enhance capabilities in Ukraine to prevent unauthorized use of radiation sources, which could pose a threat to the public in case of their use for malicious purposes.

The following SNRIU and Swedish Radiation Safety Authority (SSM) cooperation projects are in the active phase of implementation:

→ Information Support to the State Nuclear Regulatory Inspectorate of Ukraine;

→ Technical Support to the SNRIU in Keeping the Database on Nuclear Material Accounting (STAR);

→ Transfer of the LR's RiskSpectrum Software to the State Enterprise 'State Scientific and Technical Center for Nuclear and Radiation Safety';

→ Information Support of SNRIU Authorizing and Oversight Activities; and

→ Support of the State Register of Radiation Sources.

In addition, the Swedish Radiation Safety Authority supports systematic participation of SNRIU specialists in trainings and training courses on implementation of Safeguards on nonproliferation, control and accounting of nuclear material, physical protection, etc.

The information presented in Sections 10.1-10.5 of this Report builds a general picture of the status, main areas and components of international support aimed at eliminating threats and challenges affecting the SNRIU activities in the relevant areas. A list of such existing threats identified as a result of the current assessment and for elimination or mitigation of which no remedial action has been identified in the framework of international cooperation or planned activities using SNRIU's own resources is provided in Section 9 of this Report.

11 CONCLUSIONS

At the beginning of 2021, SNRIU and DSA performed a common analysis of the current situation and assessed the existing threats in NRS regulation in Ukraine. The results of these activities are described in this Report, serving as a basis for further planning, replenishing, and coordinating the cooperation between the two parties in accordance with the Agreement [1] in the coming years. Regulatory Threat Assessment Reports [2] and [3] can be indicated as examples of such activities ongoing since 2014. In the development of this Report, current NRS regulatory activities were reviewed with an emphasis on the progress of overcoming the threats identified in Reports [2] and [3] and actions taken to eliminate or mitigate them through efforts at the national and international level. Generic overview and summary of the threats identified in [2] and [3] together with the status is given in Appendix 1 to this report. At the same time, new, in comparison with [2] and [3], threats and challenges that can affect SNRIU activities and require appropriate actions to overcome or minimize them involving international assistance, have been identified.

Based on the review, in general, a significant progress can be noted in overcoming the threats in NRS regulation in Ukraine identified in the previous assessments [2] and [3], which undoubtedly led to improvement in the area of legislative and regulatory support of state nuclear regulation safety regulation. At the legislative level, the independent status of SNRIU as a central executive body in state regulation in accordance with Ukraine's international obligations was confirmed. A number of new high-level regulatory documents were put into effect to establish the legal framework for nuclear regulation safety. A significant number of these regulatory documents were developed with comprehensive DSA support within bilateral cooperation program. These bilateral program is aimed to support Ukraine to implement the best international standards in nuclear and radiation safety regulations, harmonizing the Ukrainian regulatory framework with EU Directives and IAEA standards, and ensuring its compliance with WENRA reference levels.

There is a need to underline that the revision of NRBU and OSPORB is necessary, but both documents are under the responsibility of Ministry of Health of Ukraine not under the responsibility of SNRIU. This is the reason that the lack of revision of NRBU and OSPORB is not recognized as a threat in this report, nevertheless, is strictly connected and impacts the documents and regulations which lie under SNRIU responsibility.

At the same time, the current assessment has identified a number of new challenges, which are described in detail in previous sections of this Report. Overcoming these challenges is necessary to further ensure nuclear and radiation safety in accordance with current international standards and is a priority for SNRIU activities.

The Report sets up the fundaments for DSA to identify areas of support to strengthen relevant SNRIU capabilities in its activities and serve as a base for further cooperation and coordination of efforts between the nuclear regulatory authorities of Norway and Ukraine for 2021-2025 period. This approach has already proved to be highly efficient and gained international recognition.

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Appendix 1

No.	Identified threat	Report	Status	How is it solved?	Other comments
		(TAR I, TAR II)	Solved/Not solved/In progress		
1. Organization and General Principles for Activities of the Regulatory Authority					
1.1.	There is a constant risk of changing the SNRIU status, loss of its independence, as well as irretrievable loss of highly skilled personnel and, consequently, loss of institutional memory.	TAR 2015, TAR 2018	solved	The issue of SNRIU independent status has been solved through the persistent SNRIU actions over the last years, comprehensive international assistance, and appropriate decisions of governmental authorities (see Section 2.3 of this Report for details). **Nevertheless, it is a continuous task and the continuous attention has to be paid to this to ensure that the SNRIU status is further supported.**	
1.2.	Need for extension and improvement of the regulatory framework for nuclear security	TAR 2018	In progress	Implementation of the FRAMEWORK project within the bilateral cooperation between DSA and SNRIU was the first step towards improvement of the national regulatory framework on nuclear security. The next steps intended to eliminate this threat are described in Section 9.7 of this Report.	

No.	Identified threat	Report	Status	How is it solved?	Other comments
		(TAR I, TAR II)	Solved/Not solved/In progress		
1.3.	Need for support of the SNRIU in harmonization of national regulatory requirements on nuclear and radiation safety with WENRA reference levels	TAR 2018	In progress	The harmonization of national regulatory requirements on NRS with WENRA reference levels is a priority area of the SNRIU activities (see Section 2.4 of this Report). This challenge is dealt with through a direct interaction with ENSREG (Ukraine became an observer in the ENSREG forum in 2020), active participation of SNRIU representatives in WENRA working groups, and ongoing and planned SNRIU rule-making activities. The main source of international support for SNRIU in the coming years in this area is participation of DSA in the ongoing INSC projects [106] and [107] that are planned to be continued in the future (see Section 10 of this Report for details).	No (further) harmonization work is foreseen in the remaining components UK/TS/57-58 INSC AP 2021: • (Task 1) • Task 5
2. Safety of Nuclear Installations					
2.1.	Lack of funding sources for activities related to prompt and technological analysis of operational events at Ukrainian NPPs and analysis of operational safety.	TAR 2015	solved	SNRIU own budget since 2016, Analytical reports two times per year	
2.2.	Lack of a regulatory document to govern the procedure for accounting and investigation of operational events at nuclear facilities of Ukraine.	TAR 2015	solved	INSC UK/TS/55	Regulation “Provisions for Investigation and Accounting of NPP Operational Events” was approved by SNRIU Order No. 411 dated 12 July 2021 and submitted to the Ministry of Justice for state registration. UK/TS/55 is addressing NPPs but not research nuclear facilities

No.	Identified threat	Report	Status	How is it solved?	Other comments
		(TAR I, TAR II)	Solved/Not solved/In progress		
2.3.	Need for a unified regulatory document that will include requirements for NPP emergency operating documentation.	TAR 2015, TAR 2018	solved	GUIDLINE project (DSA)	NP 306.2.233-2021 "Requirements for the Structure and Contents of NPP Emergency Documents" approved by SNRIU Order No. 290 of 17 May 2021 and registered in the Ministry of Justice of Ukraine on 30 june 2021 under No. 864/36486.
2.4.	Need for support of licensing process and safety assessment for implementation of C(I)SIP measures	TAR 2018	In progress	SNRIU and SSTC NRS own recources and support of the US NRC and European Commission INSC Project: - assistance to SNRIU in enhancing and ensuring robustness of models for severe accident analysis based on EU up-to-date experience and Fukushima-Daiichi lessons, - strengthening of Ukrainian nuclear safety regulatory capabilities in the external hazard assessment area, - assessment of licensing and other operator activities, which are aimed at dealing with the identified challenges of the highest priority	

No.	Identified threat	Report	Status	How is it solved?	Other comments
		(TAR I, TAR II)	Solved/Not solved/In progress		
2.5.	Need for effective support of the oversight function using operating experience for Ukrainian NPPs	TAR 2018	solved	EXPERIENCE project (DSA) EC (INSC Project: "Enhancement of the national regulatory framework and relevant regulatory capabilities in the frames of operational experience feedback system")	Regulation “Provisions for Investigation and Accounting of NPP Operational Events” was approved by SNRIU Order No. 411 dated 12 July 2021 and submitted to the Ministry of Justice for state registration. SNRIU "Guideline for Assessment of Safety Culture and Human and Organisational Factors in Operating Experience Analysis" is in force.
2.6.	Need for improvement of the existing regulatory framework governing operation of research reactors	TAR 2018	in progress	EC (Component “Strengthening of SNRIU capabilities in licensing of new nuclear installations (except NPPs)” of INSC Project)	
2.7.	Need for support of the SNRIU in licensing and safety assessment for construction and commissioning of new nuclear installations	TAR 2018	in progress	SNRIU and SSTC NRS own recources and support of the US NRC and European Commission	
3. Emergency Preparedness and Response					
3.1.	Emergencies of social nature have shown that the location of IEC is vulnerable in terms of 24-hour communication under the Conventions and access to its information resources.	TAR 2015	In progress	The "COVID experience" shown that it is possible to do it in the remote mode with apication fo the modern means and solutions for communication	SSTC NRS opinion
3.2.	Lack of proper conditions for operating the RanidSONNI mobile radiological laboratory as a tool for independent radiation assessment of the environment for emergency response purposes	TAR 2015	In progress	STUK - SNRIU - SSTC NRS communication has been launched in order to solve this issue	

No.	Identified threat	Report	Status	How is it solved?	Other comments
		(TAR I, TAR II)	Solved/Not solved/In progress		
3.3.	Review and approval of new standard provisions on functional and territorial USSCP subsystem, as well as provisions on notification about a threat or emergencies and communication in the area of civil protection.	TAR 2015	In progress	SNRIU and SSTC NRS own recources	
3.4.	The National Action Plan upon Stress-Test Results. Cabinet Resolution No. 44-r dated 25 January 2012. Recommendations of the NATO Advisory Support Group mission of 2014 to determine the role of RODOS center in the state emergency response system.	TAR 2015	In progress	SNRIU and SSTC NRS own recources	
3.5.	Improvement of the emergency preparedness and response system for its harmonization with the IAEA standards, WENRA reference levels, provisions of new EU/Euratom Directives, HERCA initiatives in terms of consistency of the national procedures in responding to remote nuclear or radiological situations.	TAR 2015	In progress	PREPAREDNESS project (DSA). The final version of "National Response Plan for Nuclear and Radiological Emergencies" developed by the SSTC NRS is under SNRIU consideration since December 2019	
3.6.	Lack of administrative procedures for operation of the central station for monitoring of engineered features of physical protection systems for facilities using radiation sources and radioactive waste management facilities	TAR 2018	In progress	SNRIU and SSTC NRS own recources	
3.7.	Events in the area of nuclear and radiation safety that are of public concern but do not relate to NPPs are not currently assessed in Ukraine using INES	TAR 2018	not solved	The threat remains valid	New respective projects planned to be implemented under DSA and SNRIU cooperation untill 2025
3.8.	Emergency exercises of state level under USCPS are not conducted on a regular basis	TAR 2018	solved	EXCERCISE project (DSA)	See para 5.6 of the Report for details
4. Radioactive Waste Management and Decommissioning					

No.	Identified threat	Report	Status	How is it solved?	Other comments
		(TAR I, TAR II)	Solved/Not solved/In progress		
4.1.	Lack of a comprehensive approach to ensure safety of radwaste management taking into account consistency of individual radwaste management stages up to final disposal. Lack of clear and unambiguous criteria for radwaste sorting in situ taking into account waste classification in accordance with acceptable disposal concept and specific requirements and rules for radwaste management stages	TAR 2015	solved	This threat was eliminated by establishing a comprehensive approach to safe radioactive waste management. With DSA support (Project code: WASTE)	See references to the respective details para. 6.2 INSC UK/TS/56 Guidelines for predisposal and disposal under development, INSC AP 2021: Task 2
4.2.	Lack of regulatory requirements for remediation of interim radwaste confinement sites in the exclusion zone and legacy waste disposal facilities on 'Radon' site taking into account modern approaches to regulation of existing exposure situations determined in IAEA Standard	TAR 2015	solved	This threat was eliminated. The following regulatory documents were developed with the financial support of the European Commission, involving leading European experts: - Guideline for Safety Assessment of Radioactive Waste Interim Confinement Sites in the Chornobyl Exclusion Zone; - Guideline for Safety Reassessment of the Existing Storage/Disposal Facilities and Decision-Making Criteria Concerning Subsequent Measures at These Facilities.	See references to the respective details para. 6.2
4.3.	Need to consider the specifics of emergency response for radwaste management facilities.	TAR 2015			
4.4.	Lack of systemized requirements for safety assessment methodology and safety justification for radwaste management facilities and activities. Improvement of regulatory requirements for development of safety justifications. Lack of requirements for the structure and contents for the Safety Analysis Report on Geological Disposal Facility.	TAR 2015	In progress	To eliminate this threat, the following regulatory documents are under development as of autumn 2017 with support of the European Commission and involvement of leading European experts: - Guideline with requirements for the structure and contents of the safety analysis report for radioactive waste treatment facilities; - Guideline with requirements for the structure and	

No.	Identified threat	Report	Status	How is it solved?	Other comments
		(TAR I, TAR II)	Solved/Not solved/In progress		
				contents of the safety analysis report for radioactive waste disposal facilities.	
4.5.	Lack of specific requirements on integrated management system and safety culture for radioactive waste management activities and facilities	TAR 2015	In progress	SNRIU and SSTC NRS own recources	
4.6.	Lack of specific safety requirements for nuclear installations in decommissioning, including safety requirements for nuclear installations after complete removal of nuclear fuel, requirements for management system for decommissioning, particularly taking into account long duration of the decommissioning process, requirements for safety assessment and justification of nuclear installation decommissioning, and structure and contents of licensing documents	TAR 2015	solved	The following regulations were development with DSA support (Project code: DECOMMISSIONING): - General Safety Provisions for Decommissioning of Nuclear Facilities; - Requirements for the Structure and Contents of the Operator's Documents for Licensing Application for Decommissioning of Nuclear Facilities.	See references to the respective details para 6.2
4.7.	Lack of detailed technical requirements and procedure for decommissioning of nuclear installations.	TAR 2015	In progress	SNRIU and SSTC NRS own recources and international support, including new respective projects envisaged by the Roadmap of DSA and SNRIU cooperation untill 2025	
4.8.	Lack of specific requirements for the management system for decommissioning, in particular, taking into account long duration of the decommissioning process.	TAR 2015	In progress	SNRIU and SSTC NRS own recources and international support, including new respective projects envisaged by the Roadmap of DSA and SNRIU cooperation untill 2025	

No.	Identified threat	Report	Status	How is it solved?	Other comments
		(TAR I, TAR II)	Solved/Not solved/In progress		
4.9.	Lack of detailed requirements for structure and contents of licensing documents particularly for safety assessment and justification of nuclear installations in decommissioning	TAR 2015	In progress	SNRIU and SSTC NRS own recources and international support including new respective projects envisaged by the Roadmap of DSA and SNRIU cooperation untill 2025	
4.10.	Management of accident-origin waste in the new safe confinement over the Shelter of the destroyed ChNPP unit 4	TAR 2018	In progress	SNRIU and SSTC NRS own recources and international support	
4.11.	Management of disused sealed radiation sources declared as radioactive waste	TAR 2018	In progress	ACCEPTANCE project (DSA)	
4.12.	Release of radioactive materials from regulatory control	TAR 2018	In progress	CLEARANCE project (DSA)	
5. Radiation Safety					
5.1.	Lack of a regulatory document with modern safety requirements for management of radiation sources in compliance with basic international safety requirements in new EU/Euratom directives and IAEA documents	TAR 2015	In progress	SOURCE project (DSA) "Basic Safety Requirements for the Use of Radiation Sources"	
5.2.	Lack of a national system for accounting and control of personnel exposure doses.	TAR 2015	In progress	SNRIU and SSTC NRS own recources	
5.3.	Lack of a comprehensive approach to ensure radiation protection for medical exposure and harmonization with Directive 2013/59/Euratom of 5 December 2013.	TAR 2015	In progress	MEDICINE project (DSA), SNRIU and SSTC NRS own recources and international support, including new respective projects planned to be implemented under DSA and SNRIU cooperation untill 2025	

No.	Identified threat	Report	Status	How is it solved?	Other comments
		(TAR I, TAR II)	Solved/Not solved/In progress		
5.4.	Need to improve legislation in the field of state registration of radiation sources.	TAR 2015	In progress	Swedish Radiation Safety Authority (SSM)-support of software for the State Register of Radiation Sources, SNRIU and SSTC NRS own resources and international support, including new respective projects planned to be implemented under DSA and SNRIU cooperation until 2025	
5.5.	Lack of current radiation safety requirements for activities on uranium ores mine and millings facilities, including remediation of uranium legacy sites.	TAR 2015	In progress	URAN project (DSA), SNRIU and SSTC NRS own resources and international support including new respective projects planned to be implemented under DSA and SNRIU cooperation until 2025	INSC ongoing EC Project: U4.02/16A1, STCU Project code: 9700, Contract No. 2018-08, Implementation of Emergency Measures Relating to the Pridniprovskiy Chemical Plant, at Kamyanske (formerly Dneprodzerzhinsk), Ukraine, Implemented by Ukrainian Radiation Protection Institute
5.6.	Lack of a regulatory system for radiation safety and radiation protection of personnel and the public at enterprises managing materials that contain naturally occurring radioactive material (NORM).	TAR 2015	In progress	SNRIU and SSTC NRS own resources and international support	
5.7.	Need to support the state policy on limiting the public exposure to radon.	TAR 2015	In progress	SNRIU and SSTC NRS own resources and international support	
5.8.	Need to establish and ensure a quality system for radon monitoring in the air of residential houses and at workplaces. Establishment of databases on radon activity in residential houses and at workplaces	TAR 2015	not solved	SNRIU and SSTC NRS own resources and international support	

No.	Identified threat	Report	Status	How is it solved?	Other comments
		(TAR I, TAR II)	Solved/Not solved/In progress		
5.9.	Need for improvement of legislation governing nuclear and radiation safety in compliance with new basic IAEA standards and EU/Euratom directives.	TAR 2015	In progress	SNRIU and SSTC NRS own resources and international support	INSC ongoing EC Project: U4.02/16A1, STCU Project code: 9700, Contract No. 2018-08, Implementation of Emergency Measures Relating to the Pridniprovskiy Chemical Plant, at Kamyanske (formerly Dneprodzerzhinsk), Ukraine, Implemented by Ukrainian Radiation Protection Institute INSC AP 2021: • Task 5 (but not explicitly)
6. Radioactive Material Transport					
	Need for improvement of legislation for regulation of nuclear and radiation safety in radioactive material transport in compliance with IAEA standards		solved	TRANSPORT project (DSA)	See references to the respective details para 4.2
	2 Need for improvement of the regulatory framework for compliance with rules for radioactive material transport		In progress	TRANSPORT project (DSA) and respective on-going projects of DSA and SNRIU bilateral co-operation	See references to the respective details para 4.2
	Need for improvement of the regulatory framework for management systems for radioactive material transport		solved	TRANSPORT project (DSA)	See references to the respective details para 4.2

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