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Ukrainian Regulatory Threat Assessment: identifying priorities for improving supervision of nuclear and radiation safety

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Executive summary

On 18 November 2014 an agreement was signed by the Norwegian Radiation Protection Authority (NRPA) and the State Nuclear Regulatory Inspectorate of Ukraine (SNRIU). This agreement set up a bilateral regulatory cooperation program under which the parties will exchange technical information and cooperate in the fields of nuclear and radiation safety and security. As part of the implementation of that agreement, a project was put in place to assess the main nuclear and radiation threats to safety from a regulatory perspective, with the objective to identify the current main challenges, threats and gaps in the Ukrainian regulatory framework.

This report sets out the results of that Regulatory Threat Assessment, outlines the progress with three further projects that have been implemented based on those results, and sets out a Road Map for continued regulatory cooperation. A Regulatory Threat Assessment is defined here as a study to identify the most significant nuclear and radiation threats which require the most urgent and significant improvements regarding their regulatory supervision. Regulatory supervision is defined here as the regulatory framework and the measures adopted to ensure that the framework is implemented.

The Regulatory Threat Assessment was carried out by the SNRIU with support from NRPA experts. It included a comprehensive analysis of the SNRIU's activities, as the central executive authority entrusted with ensuring safety of the public, environment, nuclear installations and radiation sources.

The threat assessment identified priorities for regulatory improvement in the areas of safety of nuclear installations, radioactive material transport, emergency preparedness and response, radioactive waste management and decommissioning, and radiation safety. The results have given a holistic overview of the current situation in Ukraine in the area of nuclear and radiation safety legislation and provided a solid basis for further bilateral regulatory cooperation projects, which are now in progress or in planning. As a result, projects are now in progress to prepare enhanced and up to date regulatory documents in the areas of uranium mining and milling, radioactive waste management and the safe use of radiation sources in medicine. Proposals for work to address other priority threats are in preparation. These projects and proposals take account of recent developments in international standards recommendations and guidance as well as recognized

The first phase of cooperation between the NRPA and SNRIU reported here has focused on identifying priorities (as for the middle of 2015) for enhanced regulatory documentation and preparation of relevant drafts, covering protection of workers, the public and the environment. When this phase has progressed appropriately, the next step will be to work on the practical application of the new and enhanced regulations and guidance, so as to provide effective and efficient regulatory supervision of industrial and other activities connected with the use of radioactive material and ionizing radiation.

The key features of this application work are planned to include the following.

- Regulation of the application of the principle of optimization to radiation hazards while also taking into account other physical and toxicity related hazards, so as to take a holistic view of the risks involved.
- Development and application of effective stakeholder engagement and communication strategies.
- Improvement and use of scientific information to support and build confidence in radiological and other assessments used to support regulatory decisions.

- Development of a common understanding of and willingness to apply the concept of safety culture

The success in all these areas among other things depends on coordinated actions of the SNRIU in cooperation with other relevant Ukrainian regulatory authorities and governmental agencies. It is anticipated that this work will benefit from further interaction with international organizations and other authorities in other countries. At the same time, experience in Ukraine will be of value to other experts and contribute to the continuous improvement of international recommendations and guidance.

List of abbreviations and acronyms

C(I)SIP	Comprehensive (Integrated) Safety Improvement Program for Nuclear Power Plants
Cabinet	Cabinet of Ministers of Ukraine
CCDP	Conditional Core Damage Probability
ChNPP	State Specialized Enterprise 'Chernobyl Nuclear Power Plant'
CIS	Commonwealth of Independent States
CLTSF	Centralized Long-term Storage Facility for Spent Radiation Sources
DSFSF	Dry Spent Fuel Storage Facility
EBRD	European Bank for Reconstruction and Development
ECCS	Emergency Core Cooling System
EMP	Event Mitigation Procedure
Energoatom	National Nuclear Energy Generating Company *Energoatom*
ENSDF	Engineered Near-Surface Disposal Facility for Solid Radioactive Waste
EOP	Emergency Operating Procedure
ETSON	European Technical Safety Organizations Network
EU	European Union
FA	Fuel Assembly
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
ICSRM	Industrial Complex for Solid Radioactive Waste Management
IEC	Information Emergency Center
INSP	International Nuclear Safety Program
KhNPP	Khmelnitsky Nuclear Power Plant
MOH	Ministry of Heath of Ukraine
NORM	Naturally Occurring Radioactive Material
NPP	Nuclear Power Plant
NPT	Treaty on the Non-proliferation of Nuclear Weapons
NRBU	Radiation Safety Standards of Ukraine
NRPA	Norwegian Radiation Protection Authority
NSC KIPT	National Science Center 'Kharkov Institute of Physics and Technology'
PSAR	Preliminary Safety Analysis Report

R&D	Research & Development
Radon	Ukrainian State Association 'Radon'
Radwaste	Radioactive Waste
RICP	Radioactive Waste Interim Confinement Point
RNPP	Rivne Nuclear Power Plant
RWDP	Radioactive Waste Disposal Point
SAMG	Severe Accident Management Guideline
SAR	Safety Analysis Report
SIP	Shelter Implementation Plan
SISP	State Interregional Specialized Plant for Radioactive Waste Management
SNRIU	State Nuclear Regulatory Inspectorate of Ukraine
SRTP	Solid Radioactive Waste Treatment Plant
SRW	Solid Radioactive Waste
SSTC NRS	State Scientific and Technical Center for Nuclear and Radiation Safety
SUNPP	South Ukraine Nuclear Power Plant
TENORM	Technologically Enhanced Naturally Occurring Radioactive Material
UARMS	Unified Automated Radiation Monitoring System
USA	United States of America
USSCP	Unified State System for Civil Protection
USSR	Union of Soviet Socialist Republics
VVR-M	Water-Cooled Water-Moderated Modernized Reactor
WENRA	Western European Nuclear Regulators Association
WWER	Water-Cooled Water-Moderated Power Reactor
ZNPP	Zaporizhzhya Nuclear Power Plant

1 Background and introduction

On 18 November 2014 an agreement was signed by the Norwegian Radiation Protection Authority (NRPA) and the State Nuclear Regulatory Inspectorate of Ukraine (SNRIU). This agreement set up a bilateral regulatory cooperation program under which the parties will exchange technical information and cooperate in the fields of nuclear and radiation safety and security. The scope of the agreement includes:

- safety of nuclear installations,
- radioactive waste management including disposal,
- safety and security of radiation sources,
- emergency preparedness and response,
- remediation of legacies including uranium mining and processing sites,
- radiation protection,
- transport of radioactive material,
- management of naturally occurring radioactive material,
- medical exposure, and
- physical protection.

As part of the implementation of that agreement, a project was put in place to assess the main nuclear and radiation threats to safety and security from a regulatory perspective, with the objective to identify the current main challenges and gaps in the Ukrainian regulatory framework. Here, a threat is defined as the potential for harm to arise as a result of lack of regulation or outdated regulation of radiation exposure of humans and other biota. If the potential for harm is significant, but modern regulatory supervision[1] is already in place, then that threat would not be identified as a regulatory priority. If the potential for harm is small, then again the threat would not be identified as a regulatory priority, even if the regulatory supervision was considered weak in some way. The intention of the current regulatory threat assessment is to identify those activities or objects involving radioactive material which present a significant threat and are in most urgent need of improved regulatory supervision.

This report sets out the results of that Regulatory Threat Assessment, outlines the progress with three additional projects that have been implemented based on those results, and sets out the directions for continued regulatory cooperation.

The Soviet Union left a legacy of numerous institutions and industrial enterprises that used radiation sources, enterprises that used radioisotope devices and radioactive ore mining and processing enterprises. However, there was no legislative framework that would regulate relations in the area of nuclear energy. For this reason, Ukraine began active development of its national nuclear legislation in the first years of independence.

[1] Regulatory supervision is defined here as the regulatory framework and the measures adopted to ensure that the framework is implemented.

The first step was approval of the Concept for State Safety Regulation and Management of Nuclear Industry of Ukraine [4] by the Government of Ukraine on 25 January 1994.

In particular, the Concept directly stated that it was required to develop an appropriate legislative framework to:

- govern any activities in nuclear energy,
- ensure a systematic approach to the development of nuclear legislation,
- establish a system of state regulation and supervision over compliance with safety rules and standards at nuclear power facilities and enterprises applying radiation technologies and materials and issue licenses (permits) for activities in this area.

The next step was Ukraine's entering into a series of important international acts. First was the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), which Ukraine joined in December 1994 as a non-nuclear weapon state. Then the Vienna Convention on Civil Liability for Nuclear Damage of 1963, establishing the operator's exceptional liability for nuclear damage came into force for Ukraine on 12 July 1996. Ukraine is also signatory of the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (26 September 1986), Convention on Early Notification of a Nuclear Accident (30 December 1986), Convention on the Physical Protection of Nuclear Material and Nuclear Facilities (5 September 1993), Convention on Nuclear Safety (17 December 1997) and Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (20 April 2000).

Pursuant to Articles 19-20 of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management and Articles 7-8 of the Convention on Nuclear Safety, Ukraine undertook to:

- establish and maintain a legislative and regulatory framework to govern the safety of nuclear energy use. This framework provides for appropriate national safety requirements and regulations for nuclear and radiation safety, a system for licensing of nuclear energy use, a system for prohibition of nuclear energy use without a license, a system of appropriate institutional and regulatory control, documentation and reporting, enforcement of applicable regulations and licensing terms, clear allocation of responsibilities for bodies involved in different stages of spent fuel and radioactive waste management;
- establish and designate a regulatory authority entrusted with implementation of the legislative and regulatory framework and provided with adequate authority, competence and financial and human resources to fulfill its responsibilities;
- take appropriate steps to ensure effective independence of the regulatory functions from other functions.
- Regulatory activities are aimed at ensuring nuclear and radiation safety in operation and decommissioning of nuclear installations and protecting personnel, the public and the environment. The SNRIU implements these activities through functions and planned tasks, resolutions of the President and Cabinet of Ministers of Ukraine and international obligations.

According to Article 5 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety", state policy in the area of nuclear energy and radiation protection is exercised, in particular, through establishing an optimum system to govern the aspects pertaining to nuclear and radiation safety.

The optimum nature of this system is ensured, among other things, by graded safety requirements depending on potential hazards peculiar to specific activities at specific facilities.

Moreover, the Law of Ukraine "On Authorizing Activity in Nuclear Energy" envisages that one of the main principles of authorization in the area of nuclear energy is a graded approach to various activities and radiation sources taking into account their potential nuclear and radiation hazards.

These requirements of Ukrainian laws comply with IAEA General Safety Requirements Part 1 "Governmental, Legal and Regulatory Framework for Safety" envisages that the national policy and strategy for safety shall be subject to a graded approach in accordance with the radiation risks. This publication also states that a graded approach shall be applied in the development of regulatory requirements, issue of authorizations, conduct of inspections and assessment of facilities and activities.

The SNRIU takes into account the above provisions in its activities. At the same time, it is obvious that efficient and well-grounded implementation of regulatory tasks requires the identification and analysis of threats and challenges currently faced by the SNRIU, particularly given the history of development of nuclear and other technologies involving radioactive materials in what is now Ukraine. Recognizing this need, the SNRIU has completed a regulatory threat assessment with support from NRPA experts to identify the current status of these threats and challenges, with a view to identifying the priorities for improving supervision of nuclear and radiation safety.

Section 2 of this report sets out the organization and general principles for activities of the regulatory authority in Ukraine. The following Sections give details of the results of the assessment in the areas of safety of nuclear installations, emergency preparedness and response, radioactive waste management and radiation safety. The main threats from a regulatory perspective are presented in Section 7. Section 8 set out the directions for continuing regulatory cooperation based on the threat assessment and conclusions are provided in Section 9.

2 Organizational and general principles for activities of the regulatory authority

2.1 State Regulation of Nuclear Safety

Ukrainian legislation has a hierarchic structure. The highest level represents the Constitution of Ukraine, international treaties, and Laws of Ukraine. The second level contains regulations issued by the Cabinet of Ministers and the President of Ukraine. The third level includes regulations of ministries and other executive bodies. Summarizing, system of nuclear regulation consists of legislative framework governing the use of nuclear energy and infrastructure for state regulation of safety in the use of nuclear energy.

The Law of Ukraine "On Nuclear Energy Use and Radiation Safety" dated 8 February 1995 [5] is the basic one in terms of dealing with the issues of nuclear energy and radiation safety. This law was the first to establish, at the legislative level, the priority of human safety and environmental protection, define rights and duties of citizens in the area of nuclear energy, regulate activities related to the use of nuclear installations and radiation sources, etc. The law also defines the competence of governmental and regulatory authorities in the field of nuclear energy and radiation safety, sets up state regulation of nuclear safety and determines the legal status of entities and individuals dealing with nuclear energy and radiation safety.

This document also identifies requirements for siting, construction, commissioning and decommissioning of nuclear installations and radioactive waste management facilities. It establishes a special regime on the territory of nuclear installations and radioactive waste management facilities, governed the issues of the operating organization's liability for nuclear damage and established liability for violation of legislation in the field of nuclear energy and radiation safety.

To implement provisions of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety", in 1997 the Radiation Standards of Ukraine (NRBU-97) were put in force, but since in 2014 new IAEA General Safety Requirements Part 3 "International Basic Safety Standards: Radiation Protection and Safety of Radiation Sources" have been issued, the document is due to be updated.

The legislative framework in the field of nuclear safety also includes the following laws of Ukraine:

- On Radioactive Waste Management dated 30 June 1995 [6], On Uranium Ore Mining and Processing dated 19 November 1997 [7],
- On Human Protection against Ionizing Radiation dated 14 January 1998 [8],
- On General Principles for Further Operation and Decommissioning of Chernobyl NPP and Transformation of Destroyed Chernobyl Unit 4 into an Environmentally Safe System dated 11 December 1998 [9],
- On Authorizing Activity in Nuclear Energy dated 11 January 2000 [10], On Physical Protection of Nuclear Installations, Nuclear Materials, Radioactive Waste, and Other Radiation Sources dated 19 October 2000 [11],
- On Civil Liability for Nuclear Damage and Its Financial Coverage dated 13 December 2001 [12], On Resolution of Nuclear Safety Issues dated 26 June 2004 [13],
- On Making Decision on Siting, Design and Construction of Nuclear Installations and Radioactive Waste Management Facilities of National Importance dated 8 September 2005 [14],

- On Amendment of the Law of Ukraine On Authorizing Activity in Nuclear Energy dated 11 February 2010 [15],
- On Spent Fuel Management in Siting, Design and Construction of the Centralized Storage Facility for Spent Nuclear Fuel of National WWER Nuclear Power Plants dated 9 February 2012 [16].

The system of national nuclear legislation also includes Cabinet regulations for the safety of nuclear energy and radiation safety [17-24] and regulations on nuclear and radiation safety developed by the SNRIU [25]

After the Association Agreement between Ukraine and the European Union was signed on 16 September 2014 and ratified by the Government of Ukraine and European Parliament, Ukraine initiated efforts to adapt national legislation to EU legislation for the safety of nuclear energy.

To fulfill the Action Plan to implement the Association Agreement, approved by Cabinet Resolution No. 847-r dated 17 September 2014, the SNRIU prepared the draft Cabinet Resolution "On Plans Developed by the State Nuclear Regulatory Inspectorate of Ukraine for Implementation of Some EU Legal Acts" for 2014-2017, which was approved by the Cabinet of Ministers.

In accordance with this resolution, Ukrainian legislation is to be adapted to the EUROATOM directives:

1. Council Directive 2013/59/Euratom of 5 December 2013, laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation, and repealing Directives 89/618/Euratom, 90/641/ Euratom, 96/29/ Euratom, 97/43/ Euratom and 2003/122/ Euratom;
2. Council Directive 2006/117/Euratom of 20 November 2006, on the supervision and control over shipments of radioactive waste and spent fuel;
3. Council Directive 2014/87/Euratom of 8 July 2014, amending Directive 2009/71/ Euratom establishing a Community framework for the safety of nuclear installations.

2.2 Obligations and Functions in State Regulation of Nuclear Safety

In order to ensure proper state regulation of nuclear energy safety, Ukraine established a state nuclear regulatory authority[2]. As a state institution, retains information and knowledge regarding regulated facilities on the territory of Ukraine, follows the evolution of nuclear and radiation technologies and maintains an appropriate regulatory framework with safety rules and requirements. It also exercises licensing and supervision, within its powers, to ensure that the authorized activities are carried out in compliance with safety standards and rules as well as licensing conditions.

In order to improve state regulation of nuclear and radiation safety in compliance with Presidential Decree No. 1303/2000 dated 5 December 2000 [26], the State Nuclear Regulatory Committee of Ukraine (SNRCU) become central executive authority with a special status.

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[2] According to Ukrainian legislation, “use of nuclear energy” covers all activities associated with the use of nuclear technologies, nuclear material and radiation sources in science, production, medicine and other areas as well as uranium ore mining and processing and radioactive waste management, including decommissioning. Therefore, the main SNRIU tasks fully apply to radioactive waste management and decommissioning.

In 2005, structure of SNRCU was renewed, which enhanced internal and external coordination. Next in 2007 the quality control system was introduced, and successfully recertified in 2014.

In 2007 the territorial bodies, State Nuclear and Radiation Safety Inspectorates, eight regional inspectorates[3] covering the entire territory of Ukraine were established, to ensure reliable regulatory control over use and fabrication of radiation sources, radioactive waste management, radioactive material transfer and uranium ore processing and to ensure safeguards of nuclear material non-proliferation and security (physical protection) of radiation sources.

The main functions of the regional inspectorates are:

- ensure protection of personnel, the public and the environment against harmful effects of ionizing radiation and radioactive contamination that may be caused by practices at nuclear installation and radioactive waste and spent fuel management facilities as well as by accidents;
- oversight of legal entities and individuals for compliance with regulations and standards on nuclear and radiation safety during operation and maintenance of safety-related systems (components) at stages of construction, commissioning, operation and decommissioning of nuclear installations as well as construction and operation of radioactive waste and spent fuel management facilities;
- oversight of compliance with conditions of licenses (permits) issued to national and foreign legal entities and individuals regardless of their ownership for individual life cycle stages of nuclear installations and radioactive waste and spent fuel management facilities;
- assessment of compliance with operational safety of nuclear installations and radioactive waste and spent fuel management facilities with design requirements.

Under the administrative reform pursuant to Presidential Decree No. 1085 dated 9 December 2010 "On Optimizing the System of Central Executive Authorities" [27], the State Nuclear Regulatory Committee was renamed the State Nuclear Regulatory Inspectorate of Ukraine. Its status of a central executive body directly subordinated to and coordinated by the Cabinet of Ministers remained unchanged. The Government of Ukraine adopted the Law of Ukraine on 16 October 2012 to amend the Laws of Ukraine "On Nuclear Energy Use and Radiation Safety" [5], "On Authorizing Activity in Nuclear Energy [10], and "On Physical Protection of Nuclear Installations, Nuclear Materials, Radioactive Waste, and Other Radiation Sources" [11]. These amendments primarily relate to a clear legislative definition of tasks and functions of the state nuclear regulatory authority. In addition, these amendments provide a basis for giving the SNRIU the status of a unified regulatory authority to govern the safety in nuclear energy. The SNRIU organizational structure is shown in Figure 1.1.

The SNRIU, in performance of its tasks interacts with other state authorities, support bodies and services established by the President of Ukraine and local governmental bodies, public units, trade units and employers' organizations as well as with respective foreign bodies and international organizations and establishments in accordance with Statute [27].

To ensure adequate legislative regulatory framework for SNRIU activities in accordance with amendments to the Constitution of Ukraine, the SNRIU Statute was revised and approved by the

[3] Currently seven, as the Crimean inspectorate is officially disbanded.

Cabinet in 2014 [29]. The SNRIU retained all functions pertaining to state regulation of nuclear and radiation safety so that they are focused in one central executive body.

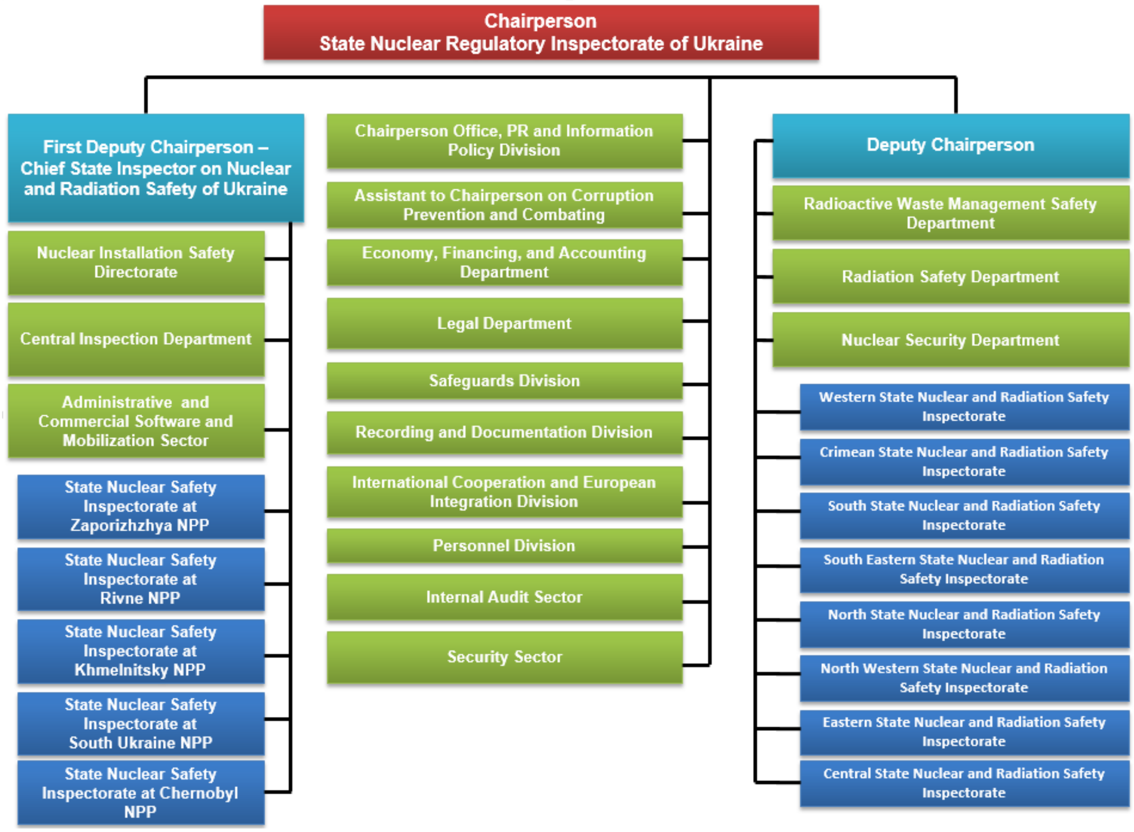

Figure 1.1 – Organizational structure of the State Nuclear Regulatory Inspectorate of Ukraine

The SNRIU conducts state regulation of nuclear and radiation safety for:

- 15 nuclear power units operating in Ukraine;
- Chernobyl NPP units under decommissioning;
- operating spent fuel storage facilities at the Zaporizhzhya and Chernobyl NPPs and two storage facilities under construction in the exclusion zone;
- research reactors;
- neutron source based on a subcritical assembly driven by a linear electron accelerator under construction on the territory of the Kharkov Institute of Physics and Technology;
- radioactive waste disposal facilities and radioactive waste management enterprises:
- 6 specialized 'Radon' plants,
- radioactive waste disposal and temporary confinement sites of Specialized Enterprise 'Complex',
- disposal facilities for radioactive waste from territories contaminated in the Chernobyl accident, operated and constructed by Specialized Enterprise 'Tekhnocenter';
- Shelter facility;

- uranium processing plants;
- radioactive material transport through Ukraine;
- use and fabrication of radiation sources and radiation technologies, including their application in medicine, industry, research etc.

The main SNRIU functions are to:

1) establish and implement state policy for the safety of nuclear energy;

2) exercise, within its powers, state regulation of nuclear energy safety;

3) 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, on safe transport of radioactive material in compliance with rules for nuclear and radiation safety for radioactive material transport and on emergency notification in compliance with the Convention on Early Notification of a Nuclear Accident;

4) identify safety criteria and requirements to be met in the use of nuclear energy, which are applied in the development and approval of regulations, rules and standards on nuclear and radiation safety, standards and rules on physical protection of nuclear installations, nuclear material, radioactive waste and other radiation sources, regulations on accounting and control of nuclear material, nuclear weapon non-proliferation standards, requirements on quality management system for use of nuclear energy and nuclear and radiation safety;

5) establish the procedure for training and examination of personnel and officials who are responsible for ensuring nuclear and radiation safety in the use of nuclear energy subject to state regulation, supervise compliance with this procedure and participate in personnel examinations;

6) assess the safety of nuclear installations, radioactive waste management facilities, uranium plants and other radiation sources, conduct state review of nuclear and radiation safety and state review of physical protection of nuclear installations, nuclear material, radioactive waste and other radiation sources and issue appropriate authorizing documents;

7) establish the procedure for release of regulatory control for activities with radioactive materials and activities on sites of nuclear installations and radioactive waste management facilities after completion of their decommissioning.

In compliance with nuclear legislation, the operating organization's activities or individual life stages of a nuclear installation or radioactive waste (RW) disposal facility are licensed by the SNRIU.

The following activities are subject to mandatory licensing: uranium ore mining and processing; radioactive material transport; treatment and storage of radioactive waste, production of radiation sources; use of radiation sources; personnel training for operation of a nuclear installation (in accordance with the list of positions and specialties identified by the Cabinet of Ministers of Ukraine); training, retraining and professional development of experts in physical protection of nuclear installations, nuclear material, radioactive waste and other radiation sources.

A license for activities or a specific life stage of a nuclear installation or RW disposal facility is issued by the SNRIU to the applicant based on a comprehensive safety assessment and evaluation of the applicant's capability to take all safety measures. The SNRIU issues a license (authorization) based upon analysis of justification provided in the Safety Analysis Report (SAR). The SNRIU also identifies a list of documents to be submitted to obtain a license/authorization in the licensing process and requirements for SARs.

2.3 Basis of State Physical Protection System

In 2008 Ukraine ratified the amendment to the Convention on the Physical Protection of Nuclear Material and made a series of changes to the national nuclear legislation, including the Law of Ukraine "On Physical Protection of Nuclear Installations, Nuclear Materials, Radioactive Waste, and Other Radiation Sources", which is fundamental to nuclear security. Now Ukraine has started implementing the IAEA recommendations on nuclear security since the requirements for physical protection were historically addressed in greater detail than nuclear security in national legislation.

To ensure the physical protection regime at the state level, Ukraine established a state system of physical protection. Entities covered by the physical protection regime are executive bodies authorized with state control and regulation in the field of nuclear energy, law enforcement bodies, as well as operating organizations and other licensees.

The SNRIU is the competent authority of the state physical protection system, which regulates nuclear security and nuclear and radiation safety. It issues licenses for activities related to the use of nuclear installations and radiation sources, including physical protection, develops standards and rules on physical protection, exercise state supervision of compliance with physical protection requirements. SSTC NRS provides technical and analytical support to the SNRIU.

The design-basis threat underlies the state physical protection system and is the main criterion for assessing physical protection systems at specific facilities. The design-basis threat was introduced by a Presidential Decree in 2011 and updated in 2012. In view of the current challenges such as the armed conflict and occupation of some part of the Ukrainian territory, the design-basis threat is being reviewed.

According to the standards and rules on physical protection, the operating organizations and other licensees assess the state and effectiveness of the physical protection systems at their facilities. Taking into account the increasing threats, the physical protection systems for nuclear facilities and nuclear materials are being upgraded under the projects agreed upon by the regulatory authority.

2.4 SNRIU International Cooperation

The SNRIU actively participates in international cooperation to

- exchange experience in regulation of nuclear and radiation safety,
- support introduction of the best world practices into Ukrainian regulatory activities,
- support harmonization of Ukrainian national legislation, including regulations and rules on nuclear and radiation safety and security, with IAEA standards, EU directives, WENRA reference levels provided by the Western European Nuclear Regulators Association (WENRA) [40], and so on.

International cooperation also aims to promote the development of Ukraine's regulatory infrastructure and mitigate threats arising in performance of the SNRIU functions and tasks, as well as to provide support to the continuing development of international recommendations and standards.

3 Safety of nuclear installations

3.1 Nuclear Installations

3.1.1 General description

For Ukraine, nuclear power is a strategically important element in the production of electricity. Its current and projected contribution comprises approximately 50% of the electricity produced and consumed in the country. Effective and sustainable nuclear power is one of the necessary conditions to ensure national safety and security.

Ukraine's energy sector had evolved over many decades and was governed by the former USSR's energy policy and the use of a single energy system. Ukraine belonged to the republics that had scarce energy resources and could cover only 50% of needs for coal, 10-12% for oil and 20-25% for natural gas. During the 1970s-1980s, construction of nuclear power plants began in the country. The Chernobyl NPP was the first to be constructed. ChNPP unit 1 was commissioned in 1977. In the subsequent years, construction of the Rivne, Zaporizhzhya, South Ukraine and Khmelnitsky NPPs was started. After gaining independence in 1991, Ukraine became the owner of five nuclear power plants, with 15 power units being in operation at that time.

Zaporizhzhya NPP

Beginning of construction - 1979

Commissioning of first unit - 1984

Number of power units - 6

Reactor type - WWER-1000

Total power - 6000 MW

Plant satellite town – Energodar, Zaporizhzhya region

The Zaporizhzhya NPP (ZNPP) is located in the steppe zone of Ukraine on the bank of the Kakhovka reservoir. It is the largest nuclear power plant in Europe and in Ukraine. The decision on its construction was made in 1978.

The plant generates 40-42 billion kW·h of electricity annually. This constitutes one fifth of the total electricity production in the state and half of its production at Ukrainian nuclear power plants.

The Zaporizhzhya NPP is the first WWER plant in Ukraine where a dry spent fuel storage facility has been constructed (DSFSF).

The technology of Zaporizhzhya DSFSF is based on storage of spent fuel assemblies in ventilated concrete containers located on the site within the nuclear power plant.

Commercial operation of DSFSF was started on 10 August 2004. Its designed capacity is 380 containers, which store irradiated fuel assemblies for the entire service life of the plant. There are currently 80 containers on the storage site.

South Ukraine NPP

Beginning of construction - 1975

Commissioning of first unit - 1982

Number of power units - 3

Reactor type - WWER-1000

Total power - 3000 MW

Plant satellite town – Yuzhnoukrainsk, Mykolayiv region

The South Ukraine energy system is the only enterprise in Ukraine with integrated use of the main nuclear and hydroelectric storage resources as well as water resources of the Yuzhny Buh river. It is located in the north of Mykolayiv region. Today, the energy system includes the South Ukraine NPP, Oleksandriv hydroelectric power station and Tashlyk hydroelectric pumped storage plant.

The South Ukraine energy system is based on the South Ukraine nuclear power plant. SUNPP construction was started in 1975. Three WWER-1000 units, comprising two stags, are operated at SUNPP. Power unit 1 was commissioned on 31 December 1982, unit 2 on 6 January 1985 and unit 3 on 20 September 1989. According to SNRIU Board Resolution No. 17 of 28 November 2013, the service life of SUNPP-1 was extended to 2 December 2023 upon safety review.

The energy system at Yuzhny Buh annually produces 17-20 billion kW·h of electricity, constituting about 10% of the total electricity production in the country and about 20% of its production at Ukrainian nuclear power plants.

Rivne NPP

Beginning of construction - 1973

Commissioning of first unit - 1980

Number of power units - 4

Reactor type - WWER-440 (units 1 and 2),

WWER-1000 (units 3 and 4)

Total power - 2835 MW

Plant satellite town – Kuznetsovsk, Rivne region

Design of the plant began in 1971. The Rivne NPP is the first plant in Ukraine with WWER-440 reactors. Units 1 and 2 with this reactor type were commissioned in 1980 and 1981 and unit 3 with WWER-1000 in 1986.

In 1990, the construction of power units was suspended by resolution of the Government of Ukraine "On Moratorium on the Construction of New Nuclear Power Plants ...". The construction was resumed in 1993, and RNPP unit 4 was commissioned in October 2004. In April 2006, Rivne-4 was accepted into commercial o.

After startup of unit 4, the annual electricity production by the plant exceeded 17 billion kW·h.

At the meeting in Kuznetsovsk on 10 December 2010, the SNRIU Board adopted the decision to extend the service life of RNPP units 1 and 2 for 20 years, provided that safety review of these power units is conducted every 10 years.

Khmelnitsky NPP

Beginning of construction — 1981

Commissioning of first unit — 1987

Number of power units — 2

Reactor type — WWER-1000

Total power — 2000 MW

Plant satellite town — Netishin, Khmelnitsky region

The Khmelnitsky NPP is situated in the central part of western Ukraine on the border of Khmelnitsky, Rivne and Ternopil regions.

The plant was originally designed to include four power units.

Its construction began in 1981 and unit 1 was put into commercial operation at the end of 1987. Sites for three other units were prepared. The construction of unit 2 was started in 1983 and it had to begin commercial operation at the end of 1991. The main process equipment had been assembled and personnel had been trained by the time the moratorium on construction was introduced.

The construction of Khmelnitsky unit 2 was resumed in 1993. It was connected to the grid on 8 September 2004. In September 2005, the unit was accepted into commercial operation.

After commissioning of unit 2, the Khmelnitsky NPP produces almost 15 billion kW of electricity annually.

The current priorities for the Khmelnitsky NPP include completion of units 3 and 4.

Besides nuclear installations, Ukraine has a great number of industrial, research and medical enterprises that use radiation sources and radioactive materials, resulting in the generation of radioactive waste.

3.1.2 NPP safety improvement

Ukraine operates 15 power units and takes the tenth position in the world by this indicator and the seventh position according to the installed capacity of Ukrainian nuclear power units. The National Nuclear Energy Generating Company Energoatom (henceforth – Energoatom) is the only operator of all operating nuclear power plants in Ukraine. Energoatom includes four nuclear power plants. The total installed capacity of operating Ukrainian power units makes 13,835 MW as of 2014.

After closure of the Chernobyl NPP, Ukraine operates nuclear power plants with WWER reactors. There are eleven power units with WWER-1000/320, one WWER-1000/302, one WWER-1000/338 and two WWER-440/213 (see Figure 2.1).

Figure 2.1 – Nuclear installations in Ukraine

The operating organization completes implementation of IAEA recommendations on solving safety issues defined in IAEA Reports [31]-[33]. The operating organization implemented a majority of safety improvement measures in the framework of solving safety issues defined in these reports. In particular, measures have been performed to improve the reliability of control rod insertion into the core (RC2), to deal with reactor pressure vessel embrittlement and conduct its monitoring (CI1), use non-destructive inspection methods (visual, ultrasonic, eddy current) (CI2), eliminate clogging of ECCS sump tanks, replace thermal insulation of primary side equipment at all reactors (S5), replace pilot-operated relief valves of steam generators at all units with model 320 (S9), replace storage batteries and uninterrupted power supply units with expired life at all power units (E5), ensure the redundancy of reactor protection systems (I&C5), took measures for fire prevention (I&C5), etc.

The majority of safety improvement recommendations defined upon safety analyses have already been performed. The remaining measures are included into the current safety improvement program.

The measures are included into the Comprehensive (Integrated) Safety Improvement Program for Nuclear Power Plants (C(I)SIP), which was approved by Cabinet Resolution No. 1270 of 7 December 2011. These measures include all C(I)SIP safety upgrades, taking into account changes introduced into the Program. In addition, (C(I)SIP) was completed with measures identified upon the final report on targeted safety reassessment at Ukrainian NPPs to learn lessons from the Fukushima-1 accident. The integrated C(I)SIP measures include those that are:

- aimed at implementing recommendations set forth in the IAEA reports on safety issues;
- to be completed at all power units under the concept for safety improvement of operating nuclear power plants;
- included upon summary SARs;
- recommended by IAEA experts upon assessment of design safety of NPPs;
- required for upgrading of Khmelnitsky-2/Rivne-4;
- intended to prevent severe accidents, such as the accident at Fukushima-1 in Japan;
- developed upon results of operating experience.

Conclusions of the SARs on Ukrainian NPPs fully agree with findings of experts from international safety assessment missions at Ukrainian NPPs.

At present, safety improvement measures are performed in accordance with the current safety improvement program – Comprehensive (Integrated) Safety Improvement Program (C(I)SIP), the status of which was enhanced after the Fukushima-1 accident [34].

The operating organization arranged activities related to C(I)SIP implementation: planning and financing, continuous monitoring of program implementation, reporting (annual, quarterly, monthly on each program measure), as well as developing and maintaining a database on the state of measures. Energoatom is to perform a total of 1311 measures at all NPP power units in the framework of C(I)SIP up to 2017. The number of C(I)SIP measures may vary according to the results of periodic safety review, operating experience and new research efforts in the sphere of safety in order to consider recommendations of international experts, etc.

The status of C(I)SIP implementation is under constant control of the SNRIU, Ministry for Energy and Coal Industry of Ukraine and Cabinet of Ministers of Ukraine.

After the Fukushima-1 accident, Energoatom performed target extraordinary assessment of NPP safety (stress tests) in accordance with decisions of the National Security and Defense Council of Ukraine made on 8 April 2011 and put into force by Presidential Decree No. 585/2011 dated 12 May 2011.

According to results of the stress tests, a series of measures were identified to prevent severe accidents, similar to that at the Fukushima-1 NPP. Implementation of such measures is a necessary condition for long-term operation of NPP units, in particular:

- resistance to earthquakes of at least 7 magnitudes on the MSK-64 scale, but with ground acceleration not less than 0.1 g (0.12 g for the SUNPP site) for equipment, piping, buildings and structures that are required to perform critical safety functions: safe reactor shutdown and maintenance of its subcriticality, heat removal from the core and spent fuel pool and prevention of radioactive releases into the environment;
- operability of equipment important to safety in harsh environments;
- introduction of emergency filtered containment venting at NPP units with WWER-1000;
- implementation of measures on emergency makeup of steam generators at NPPs (emergency reactor cooldown in the secondary side) and spent fuel pools in conditions of long-term station blackout and/or loss of ultimate heat sink, emergency supply of cooling water for essential loads;
- implementation of guidelines on management of beyond design-basis accidents with potential severe fuel damage of the reactor core and spent fuel pool and symptom-oriented emergency operating procedures for reduced power.

According to recommendations of the National Report [35] of Ukraine on stress-test results and its peer review, Energoatom developed additional safety improvement measures and included them into C(I)SIP. It should be stated that a part of the post-Fukushima measures was included into C(I)SIP before the Fukushima-1 accident.

C(I)SIP was supplemented with a series of measures for heat removal from nuclear fuel during severe accidents (measures aimed at makeup of steam generators, spent fuel pool, operability of essential service water loads during unwatering of spray pools) and emergency power supply in conditions of long-term station blackout using mobile diesel generators. C(I)SIP also includes measures for qualification of components to operate in harsh environments that may occur during severe accident management, measures for makeup of the primary system during accidents with loss of power supply and/or ultimate heat sink and measures for in-vessel corium retention, etc.

Energoatom performed a set of measures on improving NPP resistance to seismic impacts:

- equipment qualification;
- justification of resistance for structures and piping during possible seismic impacts;
- examination of NPP site seismicity and implementation of continuous seismic monitoring.

Energoatom developed conceptual decisions on the strategy for mitigating accidents with total station blackout using mobile diesel generators, mobile pump stations and motor pumps for each type of reactors at Ukrainian NPPs (models 213, 302/338, 320) and agreed them with the SNRIU to implement additional safety improvement measures based on the stress tests and to ensure a unique technical approach during their implementation. It is planned to implement the whole set of measures at each power unit prior to the end of design lifetime, but not later than by 2017, which meets the approaches accepted in EU for post-Fukushima measures.

In addition, a set of measures is planned at NPPs in order to improve emergency response system:

- implementation of additional measures on uninterrupted operation of communication means at NPP sites and NPP connection with the emergency centers of Energoatom and SNRIU;
- continued implementation of the “System for Prompt Analysis of Dosimetric Situation within NPP Area";
- provision of mobile power supply sources, additional mobile laboratories for radiation monitoring and individual dose monitoring.

In fulfillment of Presidential Decree No. 585/2011 dated 12 May 2011, the Cabinet of Ministers of Ukraine issued Resolution No. 44-r dated 25 January 2012 “On Approval of Action Plan for Development of the Unified Automated Radiation Monitoring System by 2015” [36]. Integration of the plant automated radiation monitoring systems into the Unified Automated Radiation Monitoring System of Ukraine is envisaged within C(I)SIP.

Measures aimed at prevention of accidents, similar to the Fukushima-1 accident, are implemented under the National Action Plan upon Stress Test Results, which was approved by Resolution No. 8 of the open SNRIU Board meeting of 5 March 2013. The National Action Plan together with the relevant national plans of European countries was discussed in Brussels on 22-26 April 2013 at the ENSREG working meeting.

Implementation of safety improvement measures is a necessary condition for long-term operation of NPP units and is also related to important strategic areas of energy industry in Ukraine. Considering the possibility of NPP long-term operation, peculiar attention is paid to measures on life and ageing management. The most important issues of life and ageing management are connected with buildings, structures and equipment whose replacement is impossible or is very expensive, in particular, reactor pressure vessels. Therefore, the following aspects are continuously monitored during operation:

- mechanical properties of reactor pressure vessel materials through testing of surveillance specimens in certain time intervals;
- accumulation of fast neutron fluence on reactor pressure vessel material in the beltline region using calculation and experimental methods;
- impact of operational factors on the occurrence of defects in the most stressed areas of the reactor pressure vessel by periodic (every four years) non-destructive testing of base metal, welding joints and cladding.

According to monitoring results, reactor pressure vessel safe operation is estimated during design-basis life. Calculations to justify the integrity and brittle fracture resistance are performed considering non-destructive testing, surveillance specimen testing, fast neutron fluence accumulated on the reactor pressure vessel and IAEA recommendations on analysis of pressurized thermal shock for various emergencies.

Therefore, measures implemented by the operating organization are designed to ensure compliance with international obligations of Ukraine on improving safety of operating NPPs.

These efforts give confidence that the Ukrainian NPPs can be operated in a safe manner during design lifetime, and allow planning and implementation of long-term operation measures.

3.1.3 Nuclear fuel diversification

Activities started in 2000 within the Implementing Agreement between the Government of Ukraine and the Government of the United States of America concerning the Ukraine Nuclear Fuel Qualification Project signed on 5 June 2000. These activities were aimed at the development, supply and qualification of alternative nuclear fuel compatible with Russian nuclear fuel for Ukrainian NPPs.

Trial operation of six pilot Westinghouse fuel assemblies during six fuel campaigns was conducted at SUNPP-3 within Stage 1 of the Qualification Project in 2005-2009. Trial operation of the reload batch consisting of 42 Westinghouse fuel assemblies was started at Stage 2 of the Qualification Project in March 2010.

On 30 March 2008, Energoatom and Westinghouse Electric Sweden AB Company (Västerås, Sweden) signed a contract on supply of nuclear fuel in 2011-2015 for annual reloading of three WWER-1000 units.

During scheduled outage in 2012, there were certain difficulties revealed in the reloading of SUNPP-2 and SUNPP-3 mixed cores related to specific features of the TVEL and Westinghouse fuel assemblies used in the core load.

After the events of 2012, Energoatom and Westinghouse developed a set of measures including improvement and modification of the fuel design in order to restore trial operation of Westinghouse fuel assemblies. The SNRIU agreed these measures and conceptual technical decision “On Implementation of Robust Westinghouse Fuel Assemblies at SUNPP-3”.

Westinghouse completed the entire set of tests on the upgraded, robust assemblies (hereinafter FA-WR). The SAR was developed for the upgraded assemblies.

Quality of Westinghouse Electric Sweden AB products supplied to Ukrainian NPPs is confirmed by the Energoatom Board, which audited quality control systems of this company in 2014 and accepted a batch of fuel FA-WR assemblies to be supplied to SUNPP-3.

As of April 2015, a reload batch consisting of 42 FA-WR has been delivered to the SUNPP site and passed acceptance inspection, which revealed no issues with the assemblies that would prevent their loading to the SUNPP-3 core.

3.1.4 Analysis of operating experience and accounting of Ukrainian NPP operational events

According to international approaches, IAEA guidelines and requirements [37], [38] ETSON technical safety assessment guide [39] and WENRA reference levels [40], operational experience assessment, including analysis of operational events, is one of the organizational and technical principles of ensuring NPP safety. Analysis of operational experience allows efficient assessment of current operational safety level and identification of challenging areas and features that require proper attention and timely response. Activity of the regulatory authority includes learning and sharing the lessons from operational experience, both national and international.

By SNRIU request, during the last 20 years SSTC NRS performs research and development activities (R&D) on analysis of operational experience including operational events at Ukrainian NPP (Figure 2.2 shows the dynamics of events at Ukrainian NPPs).

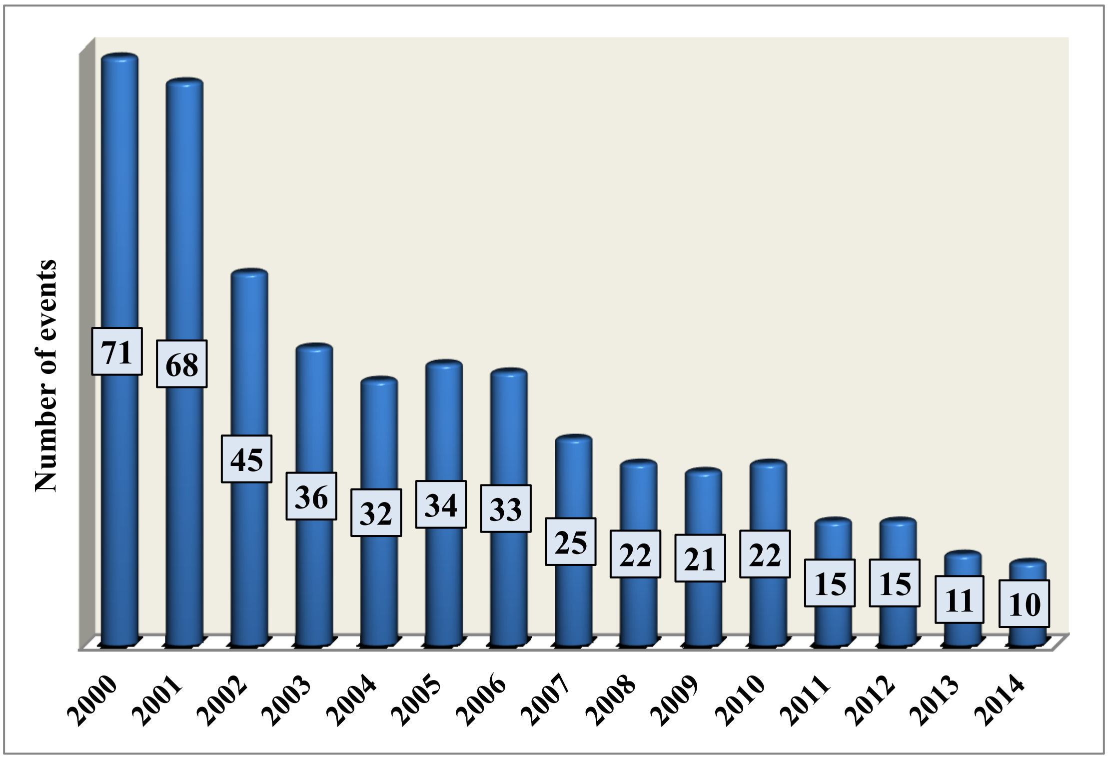

Figure 2.2 – Number of operational events at Ukrainian NPPs from 2000 to 2014

The main areas of this activity include:

- analysis of reports on operational events including quality assessment of reports on investigation of operational events at Ukrainian NPPs submitted to the SNRIU and development of recommendations on the need to improve the investigation reports;
- technological analysis of operational events that consists of statistical assessment of event flow for Ukrainian NPPs, analysis of causes of negative factors revealed in assessment of the events and specific analytical efforts on analysis of national and international experience in NPP operation;
- estimation of the safety performance indicators within the SNRIU Integrated Oversight System and further identification of areas and aspects of inspections at NPP sites (since 2015).

According to the analysis of operational events at Ukrainian NPPs, the main conclusions are made for each area of assessment, the most significant trends are evaluated, recommendations are given for elimination of revealed negative features that can reduce operational safety, and proposals are made on the need for target inspections in order to improve operational experience feedback.

In order to ensure systematic assessment of NPP operating experience to identify and rank events involving the highest potential hazard of insufficient reactor core cooling and/or damage, R&D on analysis of NPP operational events uses quantitative methods of risk analysis.

Extensive experience in probabilistic safety analysis has been accumulated in the world and can be used to assess the risk of operational events at Ukrainian NPPs. Probabilistic analysis methods are applied in R&D on prompt and technological analysis of NPP operational events by inclusion of failures that occurred during events into the probabilistic model of a power unit. This allows evaluation of changes in conditional core damage probability (CCDP), identification and ranking of accident sequences that are most likely to lead to a severe accident, identification of failures with the highest impact on CCDP and determination of reactor states in which the event will most probably affect power unit safety.

Despite the obvious importance of this activity for the operating NPPs and SNRIU, the current economic situation in Ukraine compromises the NPP operational event analysis and assessment of operational safety level on a systematic basis in order to learn lessons and effectively use operational experience. In order to save state money, a decision was made to refuse from funding of efforts related to prompt and technological analysis of NPP operational events from the state budget in 2015. At present, sources for funding these efforts are unclear. There is a potential threat that SNRIU may lose experience in comprehensive systematic and prompt analysis of operational safety relying on complete and reliable historical data (for more detail, see Section 8.2, issue 8.2.1).

3.1.5 Emergency documentation of Ukrainian NPPs

The acceptable level of NPP safety is ensured and maintained by consistent implementation of defense-in-depth strategy. The main tasks of the mentioned strategy are early detection and elimination of factors leading to abnormal operation as well taking measures for reducing the probability of their occurrence, emergencies and prevention of their progression into accidents, restriction and mitigation of accident consequences. Along with technical means for the defense-in-depth strategy, organizational measures are taken. The most important among them include the development and use of NPP emergency documents. Event-oriented emergency operating procedures (EOPs) developed in the Soviet era were in use at Ukrainian NPPs until the beginning of 2003.

In recent years, NPP operational experience showed the need for considering more realistic situations concerning a combination of the initial reactor state, initiating events and possible deviations of the operator's actions, protective systems and equipment than theoretically predicted accident scenarios.

The development of symptom-oriented EOPs is one of the methods to implement the above principles in emergency procedures. These procedures establish direct connection between "symptoms" defined by unit parameters and required actions to manage such parameters.

Since 2003, the Ukrainian emergency operating procedures for NPP units have been improved within the International Nuclear Safety Program (INSP). Such improvement is based on the symptom-oriented approach developed in the USA after the Three Mile Island accident, which is now widely used worldwide. At present, symptom-oriented emergency operating procedures have been developed and implemented at all Ukrainian NPPs. Recently, severe accident management guidelines (SAMG) have been developed and implemented for a number of Ukrainian NPP units. Besides, event mitigation procedures (EMP) have been developed and implemented at NPPs to ensure detailed prescriptions on operational event management at NPPs starting from abnormal operation to design-basis and beyond design-basis (including severe) accidents.

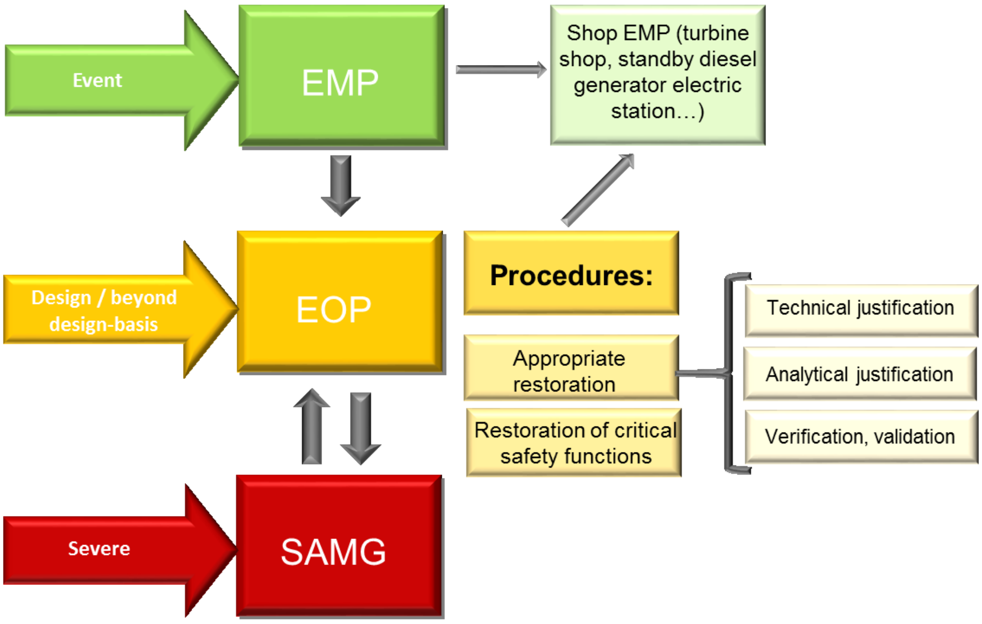

Figure 2.4 – Flow chart for NPP emergency operating documentation

At present, Ukrainian NPPs use emergency operating documentation developed with the use of novel international approaches. The current system of emergency operating documentation is branched and includes mutual links and connections between different levels of documents. For example, operating personnel will be guided by EMP prescriptions in case of abnormal operation. With further progression to an emergency or accident, the EMP includes justified transfers to EOPs.

Based on a comprehensive analysis of packages of NPP emergency documentation carried out by the SNRIU, the operating organization was proposed to establish/develop a comprehensive approach to improve development, verification, maintaining and use of emergency procedures and guidelines. For this purpose, it is necessary to develop a document on requirements for NPP emergency documentation, including development, verification, maintaining and use of the entire package of emergency documents.

Energoatom NPPs develop and implement emergency procedures and guidelines for each NPP unit (procedures for mitigation of abnormal operation, emergency operating procedures, severe accident management guidelines, etc.) in order to implement defense-in-depth principles. In recent years, the scope of emergency documentation has grown significantly: emergency procedures for shutdown, emergency operating procedures for spent fuel pool, and severe accident management guidelines for rated power, reduced power and shutdown are developed within the Comprehensive (Integrated) Safety Improvement Program. Besides, according to results of technical safety improvement measures, the current guidelines and procedures need significant revision in certain cases.

At present, current regulations and rules on nuclear and radiation safety establish only general provisions on the need for development, validation/verification and agreement of emergency procedures and guidelines with the regulatory authority. Current Energoatom guidelines concerning emergency documentation were developed within symptom-oriented EOPs and do not sufficiently take into account the entire package of emergency documentation. Therefore, there are no detailed requirements for emergency documentation at the level of regulations.

According to the lessons learnt from the Fukushima-1 accident, a range of safety improvement measures were developed for Ukrainian NPP units. The safety improvement measures for Ukrainian NPPs based on lessons learnt from the Fukushima-1 accident are aimed at providing NPP sites with the relevant quantity of additional mobile equipment. The additional equipment is independent of regular NPP systems, and conditions for storage and production of this equipment ensure its operability in various combinations of external hazards. The main task of such measures is to ensure operability of equipment powered from reliable power supply systems in case of total blackout and to ensure heat removal to the ultimate heat sink to the extent sufficient for management of accidents at NPP site and transfer of power units into safe end state or mitigate severe accident consequences. Implementation of the envisaged measures necessitated additional revision of NPP emergency documentation. At present, it is needed to perform systematic revision of emergency procedures (EOP, SAMG). Besides, installation of additional mobile equipment at NPP sites necessitates the development of new or/and revision of current emergency operating procedures and guidelines. The current NPP emergency procedures should include prescriptions on treatment of equipment stored on site and equipment stored off site, which is to be delivered to the connection places when required. At present, similar efforts are taken in the USA concerning the development and implementation of FLEX procedures (Diverse and Flexible Coping Strategies).

Therefore, a regulatory document should be developed and put in force to establish requirements for the list of emergency documentation. This emergency documentation is used by plant operating personnel to deal with and manage emergencies and accidents at NPP units (for more detail, see Section 8.2, issue 8.2.2):

- establish unified technical policy for NPP emergency documentation by setting detailed requirements for development and verification of emergency documents in the regulatory and legal framework on nuclear and radiation safety;
- consider experience in using emergency documents at full-scale simulators (based on training results). Currently, information on emergency training results is not properly accumulated by the operating organization and is not analyzed, including the purpose of developing new and maintaining current procedures and guidelines;
- develop requirements and provisions to regulate the scope of analysis to establish interface of transfer from EOP to SAMG;
- establish regulatory requirements concerning the scope of appropriate justification and list of plant emergency procedures with prescriptions on arrangement of coolant supply and/or restoration of power supply in conditions of design-basis and beyond design-basis accidents, and concerning conditions of accident progression to a severe phase (regulatory requirements for FLEX procedures).

3.2 Construction of New Nuclear Installations

At present, several new nuclear facilities are under construction in Ukraine:

- Khmelnitsky NPP units 3 and 4;
- Nuclear Subcritical Assembly “Neutron Source Based on a Subcritical Assembly Driven by a Linear Electron Accelerator”;
- Centralized Spent Fuel Storage Facility;
- Dry Interim Spent Fuel Storage Facility at the Chernobyl NPP.

3.2.1 Construction of Khmelnitsky NPP units 3 and 4

After development and approval of the Feasibility Study for Construction of Khmelnitsky NPP unit 3 and 4 by Cabinet Resolution No. 498-r dated 4 July 2012 according to the established procedure and after approval of Law of Ukraine No. 5217-VI dated 6 September 2012 “On Siting, Design and Construction of Khmelnitsky Nuclear Power Plant Units 3 and 4” [41], efforts on construction of KhNPP units 3 and 4 were suspended.

Figure 2.5 – Khmelnitsky NPP unit 3

On 17 October 2014, Energoatom developed the Conceptual Decision “Construction of Khmelnitsky NPP Units 3 and 4” and agreed it with the SNRIU, Ministry for Energy and Coal Industry of Ukraine and Ministry of Regional Development, Construction and Communal Living of Ukraine in order to ensure compliance with requirements of national regulations. According to this Conceptual Decision, design of these units envisages implementation of additional safety improvement measures, namely:

- use of additional systems for ensuring containment integrity (system of filtered venting, hydrogen recombiners);
- use of alternative fuel assemblies;
- improvement of electrical equipment by improving reliability;
- use of state-of-the-art instrumentation and control systems at power units;
- implementation of measures envisaged by the Comprehensive (Integrated) Safety Improvement Program and NPP stress tests during design of KhNPP units 3 and 4;
- use of additional systems for cooling reactor pressure vessel in order to eliminate possibility of severe accident progression with release of radioactive substances beyond the reactor compartment over the established limits;
- possibility of power uprate to 107%.

At present, Energoatom takes measures to revise the Feasibility Study and develop draft Law of Ukraine on Amendment of Law of Ukraine No. 5217-VI "On Siting, Design and Construction of Khmelnitsky NPP Units 3 and 4".

3.2.2 Construction of the Neutron Source based on a subcritical assembly driven by a linear electron accelerator

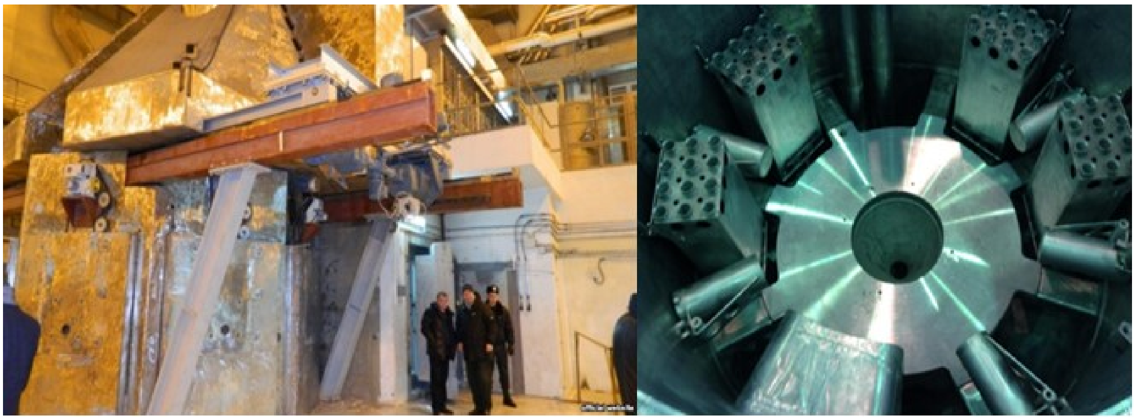

Figure 2.5 – Neutron source of the Kharkov Institute of Physics and Technology

The Nuclear Subcritical Assembly "Neutron Source Based on a Subcritical Assembly Driven by a Linear Electron Accelerator" (Neutron Source) is being constructed at the National Science Center "Kharkov Institute of Physics and Technology" (NSC KIPT) in accordance with arrangements of the Washington Summit presented in the Joint Statement of the President of Ukraine and the President of the USA in April 2010 and the Memorandum of Understanding between the Government of Ukraine and the Government of the United States of America concerning Cooperation on Nuclear Security signed on 26 September 2011. The Project related to construction of the Neutron Source is supported by the Argonne National Laboratory.

The Neutron Source is intended for scientific applied studies in nuclear physics, radiation material science, biology, chemistry and for production of medical radioisotopes. General description of the Neutron Source was presented in detail in the "Report on Nuclear and Radiation Safety of Ukraine in 2012".

The Neutron Source is created in accordance with SNRIU License Series EO No. 001018 issued for its construction and commissioning on 10 October 2013, based on review of the agreed package of documents, in particular, the Design and Preliminary Safety Analysis Report for the Neutron Source.

According to this license, the operating organization NSC KIPT constructed the Neutron Source during 2013-2014, developed and agreed engineering documentation with the SNRIU (technical specifications for equipment important to safety). As of 1 January 2015, the SNRIU preliminary agreed 36 documents out of 78 reviewed. According to the licensing terms, a package of technical documentation on systems and equipment is developed in the construction stage of the Nuclear Source (technical specifications, testing programs, PSAR revised upon construction results etc.) to be agreed prior to issuing an authorization for commissioning. Commissioning of the Neutron Source is foreseen in the nearest future.

3.3 Research Reactors

The VVR-M nuclear research reactor of the Kyiv Nuclear Research Institute, National Academy of Sciences of Ukraine, is shown in Figure 2.6.

VVR-M is a 10 MW pool-type reactor with maximal neutron flow in the core to 1.2*1014 n/(cm2*sec).

The reactor has 27 vertical and 10 horizontal process channels for scientific and applied research. Low-enriched nuclear fuel is used at reactor (19.75% of enrichment by U-235).

The VVR-M nuclear research reactor was commissioned on 12 February 1960.

Figure 2.6 – Research nuclear reactor VVR-M of the Nuclear Research Institute of the National Academy of Sciences of Ukraine

The reactor was designed for research in nuclear physics, solid state physics, radiation physics, radiation material science, radiobiology, nuclear engineering, radioecology, neutron activation analysis, for production of radioactive isotopes for various purposes. The main research areas for the nuclear reactor:

- nuclear and neutron physics – peculiarities of excited nucleus state in the process of radioactive decay; interaction of nucleus with atom electronic shell in radioactive decay; structure of light atomic nuclei and its features in reactions involving neutrons; using quasi-monoenergetic filtered beams – full neutron cross-sections, neutron scattering cross-sections, angular distribution of scattered neutrons, cross-sections of radiation neutron capture;
- radiation physics of semiconductors – processes of generation and transformation of radiation defects in silicon and binary semiconductors; change of physical peculiarities of semiconductors in radiation fields; mechanisms and speed of generation of radiation defects; impact of neutron exposure on radiation safety of detectors;
- neutron physics of condensed medium – correlation of certain acts of neutron interaction with substance; mass transfer and complex peculiarities of natural porous systems;

dynamics of water molecules under impact of components of adsorbing systems and its role in adsorption processes; mechanisms of proton and ion conductivity in gel polymer electrolytes and solid electrolytes modified by metal complex compounds; dynamic peculiarities of molecules in biological objects;

- radiation and reactor material science – mechanisms of radiation damage of reactor pressure vessel steel and in-vessel elements; impact of neutron exposure on structure and peculiarities of various alloys, corrosion resistance of structural materials; concentration of radionuclides in structural elements of power and research nuclear reactors;
- radiation biology, medicine and ecology – cytogenetic effects in aquatic organisms under conditions of joint impact of ionizing radiation and chemical contamination; microelement composition of the environment samples using instrumental and radiochemical methods of neutron activation analysis; efforts on creation and validation of comprehensive computer systems to assess impact of nuclear facilities on the environment and people;
- applied neutron technologies – methodologies of producing radioactive sources for medicine and industry; technologies of electrochemical decontamination of alloys and metal surfaces; methods for uninterrupted control of radioactivity of the primary side coolant at nuclear reactors; nuclear and physical principles and methods in research of natural isotopic anomalies, micro- and nanostructure of rare metal minerals and diamonds; minerals are irradiated to define their ultimate composition and age.

The research reactor of the Nuclear Research Institute is referred to facilities that constitute national heritage of Ukraine.

Requirements for investigation of operational events at research reactors were developed at the beginning of the 1990s and since then they have never been yet reviewed. At present, these requirements are not fully compliant with state-of-the-art international requirements for ensuring safety of research nuclear reactors. The following requirements should be reviewed and put into compliance with international standards: general requirements for analysis of operating experience, classification of events, procedure for accounting of events, reporting, decommissioning, etc.

Taking into account recommendations of international IAEA standards [37], [38], [44] and others considering the need for analysis of research nuclear facility operating experience, including accounting and analysis of operational events (definition of causes and assignment of corrective measures), there is a question on the need for development of the relevant regulatory requirements. Therefore, development of the relevant regulatory requirements based on international experience is one of the priority areas of ensuring safety of research nuclear facilities and it meets the urgent need for renovation and extending of the national regulatory and legal framework in nuclear and radiation safety (for more detail, see Section 7.2, issue 8.2.3).

4 Radioactive material transport

4.1 Overview of Ukrainian Legislation on Radioactive Material Transport

The following regulatory and legal framework has been established to ensure safe transport of radioactive material:

Laws of Ukraine:

- On Nuclear Energy Use and Radiation Safety [5];
- On Authorizing Activity in Nuclear Energy [10];
- On Transport of Hazardous Cargoes [43].

Resolutions of the Cabinet of Ministers of Ukraine:

- On Approval of the Procedure for Transport of Radioactive Materials through the Territory of Ukraine No. 1373 dated 15 October 2004 [19];
- Some Issues of Radioactive Material Transport No. 1196 dated 03 October 2007 [20], approving the procedure for issuing permits for international shipment of radioactive materials;
- On Approval of the Procedure for State Control of International Transfer of Dual-Use Goods No. 86 dated 28 January 2004 [21].

The following regulations have been approved to ensure financial compensation for third parties in case of a nuclear or radiation accident during transport of radioactive materials:

Laws of Ukraine:

- On Joining the Vienna Convention on Civil Liability for Nuclear Damage [44];
- On Civil Liability for Nuclear Damage and Its Financial Coverage [45].

Cabinet Resolution No. 733 dated 1 June 2002 " On Approval of the Procedure and Rules for Compulsory Liability Insurance of Entities Dealing with Transport of Hazardous Cargoes in the Event of Adverse Effects during Transport of Hazardous Cargoes" [46].

Since the main condition for ensuring safety during transport of radioactive materials includes the use of approved packages, supplier of cargoes holds direct responsibility for safe transport of radioactive materials in accordance with Article 54 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety" [5].

According to requirements of the legislation, appropriate measures and infrastructure are ensured in Ukraine for safe transport of radioactive materials. There is a state system of emergency response and intervention developed and emergency preparedness of entities performing transport of radwaste ensured.

SNRIU developed and approved:

- Rules for Nuclear and Radiation Safety in Transport of Radioactive Materials, (PBPRM-2006) [47];
- Requirements for Quality Assurance Programs during Transport of Radioactive Materials, approved by SNRIU Order dated 25 July 2006, registered in the Ministry of Justice of Ukraine under No. 1092/12966 dated 05 October 2006;

- Provisions on Planning of Measures and Actions in the Event of Accidents in Radioactive Material Transport (NP 306.6.108-2005) [48], approved by SNRIU Order No. 38 dated 07 April 2005 and registered in the Ministry of Justice of Ukraine under No. 431/10711 dated 22 April 2005;
- Procedure for Issuing Certificates on Safe Transport of Radioactive Material, approved by SNRIU Order No. 119 dated 06 September 2007, registered in the Ministry of Justice of Ukraine under No. 1079/14346 dated 20 September 2007;
- Requirements and Safety Conditions (Licensing Terms) for Radioactive Material Transport (NP 306.6.095-2004) [49], approved by SNRIU Order No. 141 dated 31 August 2004, registered in the Ministry of Justice of Ukraine under No. 1125/9724 dated 09 September 2004;
- Requirements for the Safety Analysis Report on Radioactive Material Transport (NP 306.6.096-2004) [50], approved by SNRIU Order No. 141 dated 31 August 2004, registered in the Ministry of Justice of Ukraine under No. 1127/9726 dated 09 September 2004;
- Procedure for Submitting Conclusions of the State Nuclear Regulatory Committee of Ukraine in International Transfer of Radioactive Materials (NP 306.6.097-2004) [51], approved by SNRIU Order No. 138 dated 26 August 2004, registered in the Ministry of Justice of Ukraine under No. 1119/9718 dated 08 September 2004;
- Reference material to Rules for Nuclear and Radiation Safety in Transport of Radioactive Materials (PBPRM-2006), approved by Order of SNRIU Deputy Chairperson dated 20 November 2009;
- Methodological Recommendations on Development of Radiation Protection Program during Radioactive Material Transport, approved by SNRIU Order No. 101 dated 02 August 2010.

The applicant shall submit an application and relevant documents to the SNRIU in accordance with the established procedure in order to get a license for transport of radioactive materials, permit of international transfer of radioactive materials and approval certificate.

4.2 SNRIU Functions and Tasks on Radioactive Material Transport

The SNRIU is responsible for safety regulation during radioactive material transport.

According to the Statute of the State Nuclear Regulatory Inspectorate of Ukraine approved by Cabinet Resolution No. 363 dated 20 August 2014 [28], the SNRIU is responsible for issuing official permits (licenses for radioactive material transport, permits of international transport of radioactive material, issuing approval certificates), holding regular reviews and assessments, inspections and using sanctions, development and implementation of principles, provisions and guidelines for safe radioactive material transport.

The SNRIU:

- develops and approves regulations, rules and standards of nuclear and radiation safety during 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 transfer;

- defines the list of documents submitted for getting a license for radioactive material transport and requirements for their finalization and contents, and procedure for reporting by licensees;
- licenses activities of radioactive material transport;
- issues permits of international transport of radioactive materials;
- gives 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 can be used for production of nuclear weapons;
- approves the design of packaging sets, radioactive materials, transport and special conditions;
- agrees technical conditions for transport packaging;
- performs oversight and inspection of transport operations;
- enforces the established requirements;
- performs functions of competent authority responsible of safe radioactive material transport.

4.3 Procedures for Obtaining Licenses/Permits

The legislation defines the format and requirements for application documents and review procedure, in particular:

1. To obtain a license for radioactive material transport:
    - application form, list of documents and requirements for their contents are defined by Order No. 153 dated 06 August 2012 "On Approval of Provisions on the List and Requirements for the Format and Contents of Documents Submitted to Obtain a License for Specific Activities in Nuclear Energy";
    - procedure for review of the application, issuing a license, amendment of the license is established in the Law of Ukraine "On Nuclear Energy Use and Radiation Safety" [5];
2. To obtain a permit for international transport of radioactive material:
    - the format of application and the format of permit are defined by SNRIU Order No. 198 dated 17 December 2008;
    - procedure for review of application, issuing a permit is defined by the Procedure for Issuing Permit for International Transport of Radioactive Material approved by Cabinet Resolution No. 1196 dated 3 October 2007 "Some Issues of Radioactive Material Transport" [20];
3. To obtain certificates on approval of special radioactive material, low dispersible radioactive material, special conditions, transport and design of packaging sets:
    - contents of the application, list of documents, procedure for review are approved by SNRIU Order No. 119 dated 6 September 2007 "Procedure for Issuing Certificates on Safe Radioactive Material Transport".

SNRIU Orders on issuing a license, permits and certificates or rejection of their issuing and refection of issuing a license, including notifications (letters) that are sent to the applicant are considered official documentation on recording of made decisions on issuing of licenses.

State oversight of compliance with requirements for nuclear and radiation safety are performed in accordance with the Procedure approved by Cabinet Resolution No. 824 dated 13 November 2013 [22]. The SNRIU conducts scheduled inspections envisaged by annual plans and schedules, and unscheduled inspections. Inspection frequency, foundations for inspections, procedure, criteria for assessing risk of radioactive material transport, finalization of inspection results are defined by Cabinet Resolution No. 824 dated 13 November 2013 [22].

The SNRIU may terminate or cancel a license upon conditions defined in Article 16 of Law of Ukraine "On Authorizing Activity in Nuclear Energy". Responsibility for breach of laws in nuclear energy and radiation safety is defined in Articles 81, 82 of Law of Ukraine "On Nuclear Energy Use and Radiation Safety" [5] and in Article 17-1 of Law of Ukraine "On Authorizing Activity in Nuclear Energy" [10].

4.4 Conclusions and Proposals for Further Development

The following is required for further improvement of the regulatory and legal framework on safe radioactive material transport in 2016-2018:

- Revision of the "Rules for Nuclear and Radiation Safety in Transport of Radioactive Materials" PBPRM-2006 [47].
- Development of a regulatory document to provide guidance on ensuring compliance with rules of safe transport of radioactive material. According to para. 1.2 of "Rules…" PBPRM-2006, this regulatory document has to be developed based on IAEA publication "Compliance Assurance for the Safe Transport of Radioactive Material", IAEA Safety Standards Series No. TS-G-1.5. IAEA. Vienna, 2009 [53]. This regulatory document is to be developed in accordance with recommendations of IRRS mission (S22).
- Development of a regulatory document to provide guidance on safe transport of radioactive materials. According to IAEA document "Regulations…" dated 2012, this regulatory document can be developed based on IAEA publication "The Management System for the Safe Transport of Radioactive Material", IAEA Safety Standards Series No. TS-G-1.4. IAEA. Vienna, 2008 **Feil! Fant ikke referansekilden.**. This regulatory document is also to be developed in accordance with recommendations of IRRS mission (S21).

The most urgent threat in this area is necessity of revision of the regulatory document "Rules for Nuclear and Radiation Safety in Transport of Radioactive Materials" (for more detail, see Section 8, issue 8.10).

5 Emergency preparedness and response

5.1 SNRIU Functions and Tasks on Emergency Preparedness and Response

In Ukraine all measures on emergency preparedness and response are integrated into the Unified State System on Civil Protection (USSCP). The system was established in 1998 following the respective Resolution of the Cabinet of Ministers of Ukraine.

Now the structure and tasks of the system, its administrative provisions, performance modes, requirements for the planning of protective measures and other aspects of the USSCP are defined in the Code of Conduct on Civil Protection of Ukraine.

The main tasks of the USSCP are:

- ensure readiness of the central and local executive power bodies for activities on prevention of and response to emergencies;
- predict and assess social and economic consequences of emergencies;
- define needs for logistics, human resources, financial resources;
- accumulate and store resources;
- notify the population about threat and occurrence of emergencies;
- protect population, conduct rescue activities, ensure measures on social protection;
- train the population how to behave and how to act in case of an emergency.

The basic structural elements of the USSCP are functional and territorial subsystems that act at four levels: national, regional, local and facility level.

The territorial subsystems are established to prevent and respond to the emergencies within relevant administrative territorial borders.

Each level of the territorial subsystem has a permanent co-ordinating authority - Commission on Technical and Ecological Safety and Emergencies. Depending on the nature and scale of emergency, the response is to be managed by a commission of a corresponding level.

Functional subsystems are established by different ministries and some of the ministries could support more than one functional subsystem. For example, the State Service of Ukraine on Emergencies supports functional subsystem that is called “Emergency response and rescue activities”; the Ministry for Ecology supports some functional subsystems, such as “Monitoring of the environment”, “High-water measures”, “Prognosis of geological and geophysical processes”, the Ministry for Health - the functional subsystems “Medical, biological and psychological protection of population”, “Ensuring health and epidemiology wellbeing of population”, the State Nuclear Regulatory Inspectorate of Ukraine - the functional subsystem “Safety of Nuclear Power Facilities”.

The permanent manager of the USSCP is the State Service of Ukraine on Emergencies.

At national level the USSCP is managed by the State Commission on Technical and Ecological Safety and Emergencies. This Commission is a permanent body that ensures coordination of activities of the central and local executive authorities aimed at prevention of emergencies, response to emergencies of any kind, including terroristic and military threats, protection of population and territories against emergencies.

The main tasks of this Commission are to:

- ensure functioning of the USSCP;
- notify civil protection command units and forces;
- notify population;
- manage rescue activities;
- define boundaries of emergency zone;
- conduct humanitarian operations beyond the borders of Ukraine, etc.

The Commission is headed by the Prime Minister of Ukraine, his First Deputy is Vice Prime Minister – Minister on regional development, Deputy Head is Chairman of the State Service of Ukraine on Emergencies and is responsible for management of activities on mitigation of emergency consequences.

Among the members of the Commission, there are Minister of Defense, Minister of Internal Affairs, Minister of Foreign Affairs, Minister of Finance, Minister of Energy, Minister of Health, Minister of Agriculture, Minister of Infrastructure, Chairman of the SNRIU, Chairman of the Security Service, other ministers and chairpersons.

One of the documents that regulate interaction of the central executive power bodies in case of a radiological emergency is Radiological Emergency Response Plan (NP 306.5.01/3.083-2004). The document was developed in accordance with the Resolution of the Cabinet of Ministries of Ukraine, approved by the joint order of the State Nuclear Regulatory Committee of Ukraine and the Ministry for Emergencies. The document was registered in the Ministry of Justice in 2004; first revision of the document was done in 2010. This document addresses peculiarities of emergency planning and response to radiation emergencies.

According to Cabinet Resolution "On Approving the Statute of the State Nuclear Regulatory Inspectorate of Ukraine" No. 363 dated 20 August 2014 [29], the SNRIU performs the following functions in the sphere of emergency preparedness and response:

- exercises the powers of the competent authority for emergency notification and reporting under the Convention on Early Notification of a Nuclear Accident;
- coordinates the activities of central and local executive authorities responsible for nuclear and radiation safety according to the legislation;
- manages the creation and performance of the functional subsystem for nuclear facility safety of the unified state system for civil protection;
- early notifies via mass media on radiation accidents at the territory of Ukraine and abroad, if transboundary spreading of radioactive substances is probable;
- is the only communication point under the Convention on Early Notification of a Nuclear Accident or Radiological Emergency and the Convention on Assistance in Case of a Nuclear Accident or Radiological Emergency (Convention on Notification and Convention on Assistance);
- provides international exchange of operational information on nuclear events within the international nuclear and radiological event scale.

The Information and Emergency Center (IEC) was established to support the above SNRIU functions.

In the structure of the USSCP, the IEC is the executive unit of the functional subsystem “Nuclear Facility Safety”. (According to Cabinet Resolution “On Approval of the Procedure for State Supervision over Compliance with Nuclear and Radiation Safety Requirements” No. 824 dated 09 January 2014 [57], the SNRIU is the regulatory authority of the stated functional subsystem).

During daily activities, the information is collected and analyzed in the IEC related to operation state of the facilities, which regard to a hazard category defined in the IAEA requirements [58].

According to the decision of the SNRIU Chairperson, the IEC is activated in case of an emergency and should submit the information on the event to SNRIU management, the Cabinet and certain central executive bodies, notify the IAEA in accordance with the requirements of the Convention on Notification, and inform the public and the mass media.

The creation of a backup IEC has been under consideration for several years to support the SNRIU emergency response functions if the main IEC becomes unavailable. The concept for backup IEC has not been implemented to date. In conditions of the extraordinary events and external aggression against Ukraine, this increases risks that the SNRIU may lose emergency response capabilities in compliance with current legislation and international obligations (for more detail, see Section 8.3, issue 8.3.1, and Section 4.2).

According to Presidential Decree No. 139/2015 dated 12 March 2015, the Resolution of the National Security and Defense Council of Ukraine “On Additional Measures for Strengthening the National Security of Ukraine” was put in force on 18 February 2015 [60].

Among other tasks, the Presidential Decree of Ukraine charges the Cabinet of Ministers of Ukraine to revise and approve new model regulations on functional and territorial subsystems of USSCP and regulations on the procedure of notification on emergency threat or initiation and communication in the sphere of civil protection.

Implementation of the above task is intended to decrease risks of failure to ensure coordination within USSCP and necessitates the central executive authorities to revise their own documents regulating activities under USSCP (for more detail, see Section 8.3, issue 8.3.3).

In this regard, SNRIU should promptly develop a new revision of the following documents:

- Provisions on the functional subsystem of the unified state system for prevention and response to natural or man-made emergencies “Nuclear Facility Safety” approved by SNRIU Ordinance No. 16 of 20 January 2009;
- Response plan of the functional subsystem of the unified state system for prevention and response to natural or man-made emergencies “Nuclear Facility Safety” approved by SNRIU Ordinance No. 93 of 16 July 2010.

These documents should be revised considering the requirements of the new standard provisions on USSCP functional subsystem, and changes in the features of threats and USSCP increased preparedness mode introduced in Ukraine on 26 January 2015.

The National Action Plan [61] upon results of stress tests for Ukrainian NPPs envisages a series of measures particularly to develop the Concept of the Unified Automated Radiation Monitoring System (UARMS).

The action plan to develop the Unified ARMS for the period to 2015 was approved by the Order of the Cabinet No. 44-r of 25 January 2012. UARMS Concept Revision 1 was developed in 2012; however, this Concept has not been completed for many reasons.

In order to coordinate actions on radiation monitoring and appropriate decision-making at the state level, it is necessary to complete UARMS Concept development, prepare terms of reference for UARMS development, and develop a draft Cabinet Resolution on approval of provisions on UARMS (for more detail, see Section 8.3, issue 8.3.4).

The above documents should be developed considering the recommendations of the mission of NATO Advisory Support Team as of 2014 to determine the role of RODOS center in the state emergency response system.

The above-mentioned mission of NATO Advisory Support Team as of 2014 proposed also to improve SNRIU emergency response system through creation of a backup IEC.

5.2 Provisions on Emergency Response Infrastructure

The IEC is currently located on premises of the State Nuclear Regulatory Inspectorate of Ukraine in the center of Kyiv. Under conditions of a large-scale emergency caused also by civil unrest or terrorist acts, there is a threat that the IEC will not be able to perform its tasks, including international obligations of Ukraine.

It is proposed to create a special infrastructure that can be used for the needs of the backup IEC in case of an emergency on the one hand, and as a laboratory base of the regulatory authority in normal daily activities, on the other hand.

SNRIU has a mobile radiological laboratory RanidSONNI and a fleet of portable devices that can be used for qualitative measurements of low-active samples taken at environmental objects, if stationary biological shielding is available.

Figure 4.1 – Measurements using RanidSONNI mobile radiological laboratory

The SNRIU does not have currently its own room for maintenance of equipment and RanidSONNI vehicle or special room for stationary laboratory equipment.

The lack of appropriate conditions for operating the RanidSONNI mobile radiological laboratory increases the risk of losing important independent information in the event of radiation accidents involving radiation contamination, loss of radiation sources and threats of terrorist attacks using radioactive sources (for more detail, see Section 8.3, issue 8.3.2).

In establishing the backup IEC, the requirements should be considered for available communication, lighting, ventilation and air conditioning, uninterruptable power and heat supply, workplaces of specified group of experts, sanitary and other conditions for day and night personnel staying. It is also necessary to create conditions to obtain the measurement data of RanidSONNI mobile radiological laboratory in the backup IEC in real-time mode.

In order to take these measures and harmonize the Ukrainian regulatory framework with the IAEA safety standards, WENRA reference levels, new EU/Euratom Directives and HERCA initiatives in terms of coordination of national procedures in responding to remote nuclear or radiological situations, SNRIU considers it necessary to perform a comprehensive analysis of the national legislation regarding regulation/specification of the requirements relating to emergency preparedness and response to nuclear and radiation accidents as the first stage, namely:

- Law of Ukraine "On Public Protection against Ionizing Radiation";
- Law of Ukraine "On Health and Epidemiological Wellbeing of the Public";
- Law of Ukraine "On Nuclear Energy Use and Radiation Safety" [5];
- Radiation Safety Standards of Ukraine [61];
- Basic Health and Radiation Safety Rules of Ukraine [63].

The Ukrainian legal framework will be harmonized with international requirements within implementation of the Association Agreement between the European Union and Ukraine, signed in June 2014. In particular, according to Cabinet Resolution No. 110-r dated 18 February 2105, a number of regulations is to be developed, approved and introduced in order to implement provisions of the Council Directive 59 up to the end of 2018.

In particular, the following issues should be specified, revised and harmonized with the IAEA standard [64]:

- Improvement of the national procedures for emergency preparedness.
- Requirements for the structure and contents of emergency preparedness and response plans according to threat category.
- Updating of the national plan of response to radiation accidents considering the concept for planning preventive measures.
- Harmonization of the criteria related to protective means in case of an emergency with neighboring countries, particularly Belorussia (for RNPP).
- Assessment of on-site and off-site emergency preparedness: roles and functions of the operator, regulatory authorities, local governments, procedures of their efficient interaction to minimize effects of an accident and eliminate its consequences.
- Licensee's responsibility for timely response, emergency mitigation and protection of the public beyond NPP site.

6 Radioactive waste management and decommissioning

6.1 General Description of Radioactive Waste Management System in Ukraine

6.1.1 Radioactive waste management strategy

Safe radioactive waste management is one of the most important factors of sustainable nuclear energy development of the country according to the Energy Strategy of Ukraine until 2030, as well as radiation and nuclear technology application in medicine, science and industry.

Radioactive Waste Management Strategy in Ukraine is specified for a period of 50 years starting from 2009, and can be revised on regular basis.

The selected strategic option of the RW management system development in Ukraine envisages the following:

- NPP radwaste processing at NPP sites to the state, which is acceptable for disposal or long-term storage in the central storage facilities at the Vektor site;
- collection, conditioning, transport, temporary storage of RW and spent radiation sources generated in medicine, science, industry, and at the 'Radon' state interregional specialized plants (SISPs);
- centralized disposal of low- and intermediate level short-lived radwaste and long-term storage of long-lived high level RW of all manufacturers in Ukraine in storage facilities at the Vektor site;
- disposal of long-lived and high level RW in a geological repository.

Specific tasks and measures envisaged by the Strategy are taken in compliance with the provisions specified in:

- National Target Environmental Program for Radioactive Waste Management to be implemented by 2017;
- National Program for ChNPP Decommissioning and Shelter Transformation into an Environmentally Safe System .

According to the National Target Environmental Program for Radioactive Waste Management, practical tasks are being implemented for the period until 2017, namely:

- improving the radioactive waste management system at NPP to ensure radioactive waste processing at NPP sites to obtain waste forms acceptable for disposal or long-term storage in the centralized storage facilities at the Vektor site (see chapter 2.4);
- technical upgrading and conversion of 'Radon' SISPs into the sites for collection and temporary storage in containers for RW and spent radiation sources generated in medical, scientific and industrial establishments and institutions;
- safety reassessment of legacy disposal facilities at 'Radon' sites for making a decision on further measures and appropriate time constraints for their implementation (waste retrieval, remediation measures);
- construction, commissioning and operation of near-surface facilities at the Vektor site for disposal of short-lived waste generated by all radioactive waste entities in Ukraine;

- design and construction, within Vektor stage 2, of facilities for long term storage of long-lived and high-level radioactive waste, including disused sealed radioactive sources and vitrified RW that will be returned from the Russian Federation after reprocessing of WWER-440 spent fuel and other long-lived and high-level RW;
- design of Vektor RW processing facilities within stage 2;
- monitoring, modernization and safety improvement of storage/disposal facilities for emergency RW generated at ChNPP during the first years of Chernobyl accident, as well as mitigation and safety reassessment of these facilities in to support decisions on RW retrieval and measures related to remediation and appropriate timeframes;
- exploration and research and development to select a site for geological repository;
- establishment and development of the national organization for RW management, including long-term storage and disposal;
- personnel development and training;
- improvement of the state RW monitoring and accounting system;
- stable and sufficient funding of RW management measures;
- development of the regulatory and legal framework and international cooperation.

The main tasks and measures to develop the ChNPP RW management system are established in the National Program of Chernobyl NPP Decommissioning and Shelter Transformation into an Environmentally Safe System.

According to the National Program, the “Integrated RW Management Program at the Stage of ChNPP Decommissioning and Shelter Transformation into an Environmentally Safe System” is implemented and supported at ChNPP. The objective of this program is to develop and ensure functioning of the integrated optimized RW management procedure at ChNPP to ensure management of all waste streams at ChNPP that were accumulated during operation and generated during Chernobyl accident mitigation, including those that will be generated during decommissioning and activities at the Shelter. The following are also considered:

- existing RW management facilities;
- new RW processing and storage facilities, which were constructed during the last years, particularly, liquid and solid RW processing plants and storage for temporary facilities of long-lived RW;
- planned RW management facilities.

6.2 General Description of Radioactive Waste Management Facilities

6.2.1 RW management at the Vektor site in the Chernobyl exclusion zone

Near-surface RW disposal facilities

The engineered near surface disposal facility (ENSDF) was constructed at the Vektor site for disposal of packaged waste, mainly RW generated at ChNPP (see Figure 5.1).

Figure 5.1 – General layout of radioactive waste management facilities at the Vektor site

ENSDF was constructed with EU support within the ChNPP industrial RW management complex for disposal of ChNPP RW packages.

ENSDF is operated with some restrictions specified in the SNRIU license requirements. Measures are currently being taken to monitor the state of the physical structure of storage facility modules; up-to-date safety assessment methodologies are studied and implemented for ENSDF safety review and in order to extend the number of RW suppliers and actualize RW acceptance criteria for this storage facility. Disposal of RW packages generated at ChNPP in ENSDF was started on 26 April 2014.

Construction of two near-surface disposal facilities for solid RW (SRW), storage facilities of SRW-1 and SRW-2 type, are also almost completed at the Vektor site. SRW-1 is intended for radioactive waste disposal in reinforced concrete casks, SRW-2 is designed for radioactive waste disposal in bulk without packaging in the module.

The operator should further develop operational procedures for three existing near-surface disposal facilities for short-lived waste at the Vektor site (SRW-1, SRW-2, and ENSDF) after beginning of their operation, including monitoring of waste compliance with acceptance criteria for disposal, and making decisions on acceptability of waste forms and waste packages of different suppliers (exclusion zone, ChNPP, Ukrainian NPPs, 'Radon' Association).

RW long-term storage facilities

The centralized long-term storage facility for disused sealed radioactive sources (CLTSF) is constructed within Vektor stage 2 with support of the Department of Energy and Climate Change of Great Britain.

CLTSF is the key element in developing the system for safe management of radiation sources in Ukraine. This facility should provide centralized storage of disused sealed radioactive sources that are currently accumulated at 'Radon' SISPs and will be generated when using the radiation sources in medicine, science and industry. The CLTSF design envisages acceptance, processing, sorting, identification, conditioning, packing and placement of spent radioactive sources for long-term storage considering radiation type (α-, β-, γ-, n-radiation). Total number of disused sealed radioactive sources planned for acceptance is 500,000 items.

New facilities for long-term storage (100 years) of appropriate RW before its disposal in geological repository are designed within Vektor stage 2:

- long-term storage facility for vitrified high-level waste that will be returned from the Russian Federation after WWER-440 spent fuel processing. SNRIU approved the "Feasibility Study for Investment into Construction of Interim Storage Facility for High-Level Waste Returned from the Russian Federation after Reprocessing of Spent Nuclear Fuel of Ukrainian NPPs". The next step will be development of storage facility design;
- long-term storage facilities for high-level radioactive waste and long-term storage facilities for long-lived radioactive waste. It is expected that high-level and long-lived radioactive waste to be stored in these storage facilities will be generated during retrieval of RW and fuel containing materials from the Shelter, in ChNPP decommissioning as well as under operation and decommissioning of the existing NPPs.

RW processing facilities

In the near future, it is planned within Vektor stage 2 to start designing of new radioactive waste processing facilities for waste generated at ChNPP and outside the nuclear fuel cycle.

6.2.2 RW management facilities within the exclusion zone (except for ChNPP and Vektor site)

Near-surface disposal facility "Buryakivka RW disposal point" (RWDP)

Figure 5.2 presents the Buryakivka RWDP, which was commissioned in 1987. The RWDP consists of 30 near-surface disposal facilities (trenches). The main engineering barrier of the disposal facilities is compacted clay layer 1 meter thick, which confines radioactive waste from the environment. The Buryakivka RWDP is one of the key components of the management system for large scope of emergency radioactive waste generated after the Chernobyl accident. This disposal facility was built as the primary measure for accident mitigation. Until present, the disposal facilities of this RWDP provided disposal of a large scope of short-lived low-level waste generated during the activities at ChNPP site and at contaminated territories in the exclusion zone. The remaining available capacity of the Buryakivka RWDP is practically exhausted. Considering safety reassessment, possible decisions on its reconstruction in order to increase the capacity for low-level radioactive waste disposal will be examined.

Figure 5.2 – Buryakivka disposal facility for short-lived Chernobyl-origin radioactive waste

RWDP and RICP (radwaste interim confinement points)

RWDP and RICP in the exclusion zone are elements in the management system for large volumes of Chernobyl-origin waste. These facilities currently ensure RW confinement and isolation from the environment. At the same time, the operator should implement integrated measures related to maintenance and safety improvement of RWDP and RICP.   .

The Pidlisnyi RWDP was constructed within the primary measures aimed at Chernobyl accident mitigation. The most hazardous high-level long-lived emergency RW was placed in A-1 and B-1 modules of this RWDP from the end of 1986 until the end of 1988.

The ChNPP Stage 3 RWDP was established within the primary measures related to Chernobyl accident mitigation in uncompleted solid RW disposal facility of uncompleted ChNPP stage 3. Low-level and intermediate-level waste was placed in reinforced concrete modules of this facility and banking was constructed from the end of 1986 until the end to 1988.

Measures are taken to support and improve safety of the Pidlisnyi RWDP and ChNPP Stage 3 RWDP, in which the waste was placed during the first years after the Chernobyl accident. Safety reassessment with support of the EU is planned to ensure appropriate waste confinement for a period until waste retrieval and re-disposal in geological repository.

RICPs are the territories adjacent to ChNPP with a total area of about 10 km2, at which the trenches and pits for RW confinement were developed during primary measures for Chernobyl accident mitigation. Such RW is mostly the building structures, household items, topsoil, etc., contaminated resulting from accidental release. The exclusion zone includes nine RICPs: “Stantsiia Yaniv”, “Naftobaza”, Pischane Plato”, “Rudyi Lis”, Stara Budbaza”, “Nova Budbaza”, “Pripyat’”, “Kopachi” and “Chystohalivka” at the territories of which the trenches and piles for radioactive waste were developed. The estimated number of RICP trenches and pits makes up from 800 to 1000 pcs, the exact layout of some of them should be clarified. Activities related to RICP territories investigation are constantly performed in the exclusion zone, as well as activities to maintain trenches and pits in a safe state. After agreement with SNRIU, waste has been retrieved from some of the most hazardous RICPs, which may most adversely affect the personnel in the exclusion zone and the environment (Nova Budbaza near ISF-2 and New Safe Confinement under construction, and Stara Budbaza where seasonal flooding occurs).

Safety assessment is performed with support of the EU to make decisions on RW retrieval from the trenches/pits or other decisions on measures for RICP remediation and appropriate timeframe.

In the framework of on-going INSC Project U3.01/10 "Assistance to State Nuclear Regulatory Inspectorate of Ukraine in Regulation of Safe Radioactive Waste Management and Harmonization of Regulatory Requirements on Nuclear and Radiation Safety", a guideline is under development for safety assessment of RW temporary storage sites created in the Chernobyl exclusion zone during mitigation of accident consequences and for identification of decision-making criteria for these sites. After SNRIU agreement, the guideline will be submitted to the operator to be used in industrial INSC Project U4.01/10-D "Investigation of Radioactive Waste Storage/Disposal Sites in the Chernobyl Exclusion Zone". The project objective is to reassess the safety of RICPs to make a decision either to leave RW in place (considering the exclusion zone) or to retrieve waste from emergency trenches/pits. With assistance of the European Commission, a project has also been implemented to create a central analytical laboratory for RW characterization and a mobile laboratory for detection and examination of trenches and pits.

6.2.3 RW management at Chernobyl NPP

A temporary storage facility for packages containing high-level long-lived RW was commissioned, which includes into the industrial complex for SRW management (ICSRM).

The solid radwaste treatment plant (SRTP) constructed within ICSRM is being commissioned. The radwaste sorting and characterization system is tested, as well as the process systems for radioactive waste processing (incineration, compaction, and cementation). Processed radioactive waste will be placed in certified reinforced concrete containers KZ-3 with capacity of 3 m3 to send them for disposal in Vektor ENSDF.

Operation of the liquid RW treatment plant was started. Processing technology includes cementation of liquid RW cementing and placing of cemented liquid RW in 200-liter metal drums and sending for disposal to Vektor ENSDF. Package production and transport for disposal to ENSDF have already started.

Figure 5.3 – Chernobyl NPP solid radioactive waste treatment plant (SRTP)

The plant for fabrication of metal drums and reinforced concrete casks for RW is in operation.

The systems and equipment of the fragmentation line for high-level long fragments that will be generated during of Chernobyl NPP decommissioning are manufactured and mounted. The main function of this facility is fragmentation of special products and components of the reactor core (long fragments) with exhausted life. The main systems of this facility are hot cell to cut long fragments, which is equipped with special cutting devices, video surveillance system, radiation monitoring system, the system for RW package characterization, automation, and ventilation system. RW resulting from long fragments fragmentation will be placed in double packaging (165 l metal drums, which are put into 200 l metal drums) for temporary storage in the storage facility for packages with high-level and long-lived radioactive waste.

Studies related to creation of additional RW management facilities at ChNPP have been started:

- facilities for decontamination of liquid RW of the Shelter to remove organic compounds and transuranium elements,
- areas for storage, fragmentation and decontamination of dismantled structures and equipment;
- facilities for release of dismounted materials from regulatory control.

6.2.4 RW management at 'Radon' specialized plants

Collection and temporary storage of radioactive waste generated resulting from the use of radiation sources and radioactive materials in medicine, science and various spheres of industry in appropriate regions of Ukraine are performed by six state interregional specialized radioactive waste management plants (SISPs) of 'Radon' Association: Kyiv SISP, Kharkov SISP, Dnipropetrovsk SISP, Odesa SISP, Lviv SISP, Donetsk SISP.

SISPs perform the following activities:

- operation of storage facilities for solid radioactive waste storage incontainers;
- maintenance, control and monitoring of preserved radioactive waste storage facilities, which were filled during the previous period (up to 1996) according to the disposal technology;
- collection, conditioning and transport of radioactive waste within and beyond the sites;
- operation of decontamination stations for clothing, underwear, and personal protection means.

Containers with radioactive waste and disused sealed radioactive sources are stored in the storage facilities of hangar type. These buildings were erected at SISP sites in the 1990s after making a decision to transfer SISP to technology of radioactive waste storage.

Preserved RW storage facilities filled by 1996 according to the disposal technology represent the system of near-surface reinforced concrete RW storage facilities of modular type with a capacity of 200 m3. They were built based on typical designs in the 1960s-1970s. As regards these storage facilities (operated and closed as "disposal facilities"), SISPs perform maintenance, monitoring and safety reassessment in order to make decisions on safety levels of each individual storage facility; terms during which these storage facilities are capable to provide reliable radioactive waste isolation; technical specifications on radioactive waste retrieval and site remediation.

Well-type facilities for disused sealed radioactive sources are also located at SISP sites. Safety reassessment and decisions on retrieval of disused sealed radioactive sources located in these storage facilities are required.

According to the licenses issued to SISPs, SISPs started safety reassessment of radioactive waste storage facilities at SISP sites. Reassessment is performed for those storage facilities whose operation is based on the technology of temporary storage of RW and spent radiation sources in casks, as well as for preserved legacy RW storage facilities, which were operated during the previous period and were closed as "disposal facilities". Based on the safety reassessment results, the period will be determined during which the safety level could be considered reasonable and a decision can be made on the framework for radioactive waste retrieval.

RW retrieval from storage facilities is currently planned from Kyiv SISP storage facilities No. 5, 6, and 7. SNRIU approved the retrieval project. The design decisions were made for radioactive waste sorting and placing into protective casks to ensure further safe storage of retrieved radioactive waste before its sending for processing and disposal at Vektor facilities.

Since 2013, a new module-type storage facility has been operated at Dnipropetrovsk SISP for storage of radioactive waste and disused sealed radioactive sources, which was built due to the investments within technical cooperation with the USA. A large number of radiation sources has been retrieved and transferred to this SISP from bankrupt enterprises remaining since Soviet times under the projects related to decommissioning of irradiation facilities and safe storage of disused sealed radioactive sources supported by BMU/GRS (Germany), and improvement of disused sealed radioactive sources security in Ukraine supported by the United States. In 2013, experimental activities were started at the Kharkov SISP to implement the decontamination technology for tubing contaminated by naturally occurring radionuclides.

In 2014, a mobile system of equipment for safe discharge of disused gamma-radiation sources from biological shielding units was completed and prepared for operation (with support within cooperation with the Atomic Energy Commissariat of France). Operation of the system is expected at SISP sites in order to discharge disused sealed radioactive sources and place them into protective casks. This will minimize the scope of such radioactive waste, improve safety of its storage, and enhance efficiency of transport for storage in CLTSF.

6.3 Overview of Ukrainian Legislation on Radioactive Waste Management

6.3.1 General safety requirements are established in the following documents:

- Law of Ukraine "On Radioactive Waste Management" [6];
- Requirements and Safety Conditions (Licensing Terms) for Processing, Storage and Disposal of Radioactive Waste [65];
- Requirements and Rules for Long-Term Storage of Long-Lived and High-Level Radioactive Waste before Disposal in Deep Geological Formations (ND 306.4.143-2008) [66];
- General Safety Provisions for Radioactive Waste Disposal in Geological Repositories (NP 306.4.133-2007) [67];
- Requirements for Site Selection for the Radioactive Waste Disposal Facility (NP-306.4.149-2008) [68];
- Procedure for Clearance of Radioactive Materials from Regulatory Control in the Framework of Practices (NP-306.4.159-2010) [25];
- Radiation Safety Standards of Ukraine, Supplement: Radiation Protection against Ionizing Radiation Sources (NRBU-97/D-2000) [61];
- Basic Health and Radiation Safety Rules of Ukraine (OSPU) [63];
- Health and Safety Rules for Radioactive Waste Management (SPORO) [69];
- Health and Safety Rules for Design and Operation of Nuclear Power Plants (SPAS-88) [70].

In 2000, the Law of Ukraine (No. 1688-III of 20 April 2000) ratified the "Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management" confirming the need for compliance with the safety objectives and fundamental safety principles during RW management.

At the same time, the valid documents of Ukraine include the documents that were developed many years ago and should be revised and harmonized with the new requirements and standards of the IAEA and the EU, as well as accounting for wider developments within the Ukrainian regulatory framework. This problem will be partially solved after enforcement of two new regulatory documents, being developed in the framework of the Project "WASTE", supported by the NRPA. These documents will establish general safety requirements for predisposal radioactive waste management and for disposal of radioactive waste, harmonized with IAEA standards and WENRA reference levels.

Proposals for further development:

1) In accordance with current regulations, RW can be divided into groups (according to exemption levels for a group of radionuclides contained in RW), categories (according to specific activity), classes (according to type of generated RW) and types (according to acceptable type of disposal). Direct correspondence between groups, categories, classes and types of radioactive waste is not defined. There is no clear and unambiguous succession of radioactive waste sorting criteria by producers and waste separation criteria according to type of acceptable disposal. Specifics of classification and disposal of Chernobyl-origin RW are not shown either. The use of existing classifications and in situ sorting of radwaste by groups and categories ensure personnel safety in RW management but do not take into account acceptable disposal types. In many cases, this necessitates repeated sorting of waste prior to conditioning in order to meet safety requirements for disposal.

Taking into account new IAEA standard GSG-1 "Classification of Radioactive Waste" [71], international experience and recommendations of IRRS-2008 and IRRS-2010 missions, Ukraine initiated the revision and improvement of radioactive waste classification. The objective is to implement the radioactive waste classification system that would reflect the method of RW final disposal. In the framework of EC INSC, project U4.01/08-C "Improvement of the RW Classification System in Ukraine" was implemented during 2010-2012. Implementation of the recommendations obtained under this project into the national regulatory and legal system is in progress.

It is necessary to establish regulatory requirements for radioactive waste classification for disposal purposes considering modern approaches to the optimization of disposal systems and considering the specifics of disposal in the Chernobyl exclusion zone. The numerical limits for RW classes will be thus determined on the basis of safety assessment in accordance with disposal concepts.

The introduction of new classification for disposal purposes is intended to optimize radwaste management and does not exclude the application of existing classifications that properly address safety issues at individual stages of RW management (for more detail, see Section 8.4, issue 8.4.1).

2) The Ukrainian legal and regulatory framework does not establish regulatory requirements for "current exposure situation" and "remediation". In particular, the reference levels of doses for the public under current exposure situations are not defined, although this is necessary for regulating the safety of legacy storage/disposal facilities and sites in the exclusion zone and at 'Radon' enterprises. Thus, it is planned to develop regulatory requirements for "current exposure situation" and "remediation" as applied to legacy storage/disposal facilities and sites in compliance with the new International Basic Safety Standards (for more detail, see Section 8.4, issue 8.4.2).

3) The Ukrainian legislation contains mainly the general requirements for emergency preparedness. For nuclear facilities, detailed requirements are established on some issues. Requirements for emergency preparedness for radioactive waste management facilities have their specifics; therefore, it is necessary to establish appropriate regulatory requirements (for more detail, see Section 8.4, issue 8.4.3).

6.3.2 Requirements for safety assessment

According to the Law of Ukraine "On Authorizing Activity in Nuclear Energy [10], RW is managed based on licenses, individual permits and certificates. Basic principles of the authorizing activity during RW management are established in Article 5 of this Law; they specify the need for comprehensive safety assessment in making decisions on issuance or refusal to issue the authorizing documents.

It is required that the operator should develop safety justification to be submitted to the SNRIU for licensing of facilities or activities for RW predisposal and disposal management. The SNRIU conducts review and independent assessment of the operator's justifications and makes a regulatory decision.

The requirements for the structure and contents of SARs are established in the following documents:

- Requirements for the Structure and Contents of the SAR for Near-Surface Disposal Facilities for Radioactive Waste (ND 306.3.02/3.038-2000) [72];
- Requirements for the Structure and Contents of the SAR for Radioactive Waste Treatment Facilities (ND 306.3.02/3.043-2001[73];
- Requirements for the Structure and Contents of the SAR for Radioactive Waste Storage Facilities (ND 306.4.142-2008) [74].

However, these documents do not contain detailed requirements for safety assessment methodology and safety justification of relevant facilities; some aspects of these regulations are outdated.

SNRIU is supported by the EC within the International Cooperation Program on Nuclear Safety (TACIS and INSC) to assist the SNRIU and its TSO in developing their capabilities and application of Western European experience related to safety principles and best practices of RW management. In particular, Project INSC UK/TS/39 "SNRIU Support in Licensing of Radioactive Waste Management Facilities" was implemented during 2009-2013.

Two guidelines were developed in the framework of Project UK/TS/39 with participation of international experts:

- Guideline for common impact of the Vektor site with multiple facilities for radioactive waste processing, storage, and disposal (subtask 1a, revision 3, March 2013);
- Guideline for safety reassessment of the existing storage/disposal facilities and decision-making criteria concerning subsequent measures at these facilities (subtask 1b, revision 3, March 2013).

The guideline for safety assessment of temporary confinement points for radioactive waste in the Chernobyl exclusion zone was developed in the framework of new Project EC INSC UK/TS/46 "SNRIU Support in Safety Regulation of Radioactive Waste Management and Harmonization of Regulatory Requirements on Nuclear and Radiation Safety".

In addition, the development of "Guideline on Radioactive Waste Characterization, Accounting and Monitoring" is currently under development in the framework of Project EC INSC UK/TS/46 (Subtask 2.1).

Proposals for further development:

1) Regulatory requirements for safety assessment methodology should be developed based on IAEA Safety Standard GSR Part 4 "Safety Assessment of Facilities and Activity. General Safety Requirements", as well as lower-level documents establishing specific requirements for safety substantiation and assessment at different stages of RW management (for more detail, see Section 8.4, issue 8.4.4).

2) Since the Radioactive Waste Management Strategy in Ukraine envisages the development of a disposal facility for high-level and long-lived radioactive waste in deep geological formations, requirements for the structure and contents of the SAR for a geological repository should also be developed (for more detail, see Section 8.4, issue 8.4.4).

6.3.3 Safety culture and management system for the operator

Measures are taken to improve the radioactive waste management system including the development of the national RW management operator at the stage of long-term storage and disposal, namely the Centralized Enterprise for Radioactive Waste Management (CERM) to ensure conditions for efficient implementation of the state policy in the field of radioactive waste management.

At present, there are two regulatory documents with general requirements for the management system (quality system):

- General requirements for the quality system in nuclear energy use;
- Requirements for the quality system of the nuclear facility operator.

These documents pay special attention to safety culture formation, individual responsibility and duties of the operating organizations (operators).

Proposals for further development:

1) It is necessary to develop specific regulatory requirements for the operator's quality system at the stage of disposal, including requirements for safety culture during RW management (for more detail, see Section 8.4, issue 8.4.5).

2) Regulatory requirements for the operator's quality system for radioactive waste management before disposal should be developed based on the same approach for the licensee that undertakes radioactive waste storage and processing (for more detail, see Section 8.4, issue 8.4.5).

6.3.4 Conclusions

The analysis has revealed the following significant regulatory threats in the area of radioactive waste management.

1) There are no comprehensive regulatory requirements to ensuring the safety of RW management that would take into account the consistency of individual RW management stages up to final disposal. There are no clear and unambiguous criteria for RW sorting in situ that would take into account waste classes in accordance with acceptable disposal concept and specific requirements and rules for RW management stages. The national radioactive waste management strategy contains only general approach for radioactive waste management.

2) An effective classification system for radioactive waste is not in place.

3) There are no requirements for remediation of temporary RW confinement sites in the exclusion zone and legacy waste disposals at 'Radon' sites that would comply with modern approaches to regulation of existing exposure situations.

4) There are no specific requirements for safety culture and management of RW-related activities.

5) There are no systemized requirements on safety assessment and justification of RW management facilities.

6) There are no requirements for the structure and contents of the Safety Analysis Report SAR on Geological Disposal facility.

7) There are no specific requirements for the design, implementation and follow-up of the institutional control needed for disposal facilities.

8) There are no specific requirements on emergency preparedness for RW management facilities.

Also the operator should further improve the operational procedures for three existing near-surface disposal facilities for short-lived waste at the Vektor site.

Comprehensive regulatory requirements should be applied to mitigate the identified threats – a two-level system of regulations shall be developed. The existing regulations were developed at different times, govern separate RW management aspects and are not harmonized.

High-level regulations on safety provision during predisposal and for disposal are currently under development with NRPA support under on-going project M17-14/21.

These regulatory documents are intended to mitigate threats 1), 2), 3), and 4) regarding general safety provisions.

The general provisions of these documents shall be detailed/specified in lower-level regulations. The following structure of lower-level documents may be proposed as an option.

The following structure of lower-level documents is under consideration.

General Safety Provisions for Predisposal Radioactive Waste Management

⇩

Working title of regulation	Relation to existing regulations	Mitigation of threat
Requirements and rules for preliminary treatment of radioactive waste prior to processing and conditioning	To replace SPAS-88, SPORO-85	1) ; 8)
Requirements and rules for radwaste processing and conditioning to the state acceptable for storage and/or disposal	New	1); 8)
Requirements and rules for long-term storage of radioactive waste	Revision of ND 306.4.143-2008	1); 8)

Requirements for the management system for predisposal radwaste management	New	4)
Requirements for safety assessment methodology and safety justification for radwaste treatment facilities	New	5)
Requirements for the structure and contents of SAR for radwaste treatment facilities	New to replace NP 306.3.02/3.043 -2001, planned under AP-2012	5)
Requirements for safety assessment methodology and safety justification for radwaste storage facilities	New	5)
Requirements for the structure and contents of SAR for radwaste storage facilities	Revision of NP 306.4.142 - 2008	5)

General Safety Provisions for Disposal of Radioactive Waste

Working title of regulation	Relation to existing regulations	Mitigation of threat
Requirements for site selection for RW disposal facilities	Revision of NP 306.4.149-2008	1)
Requirements and rules for RW disposal in surface and near-surface facilities	New, to replace ND 306.604.95	1); 2); 7); 8);
General provisions for RW disposal in geological repositories	Revision of ND 306.4.133-2007	1); 2); 7); 8);
Requirements for the management system for RW disposal	New	4)
Requirements for safety assessment methodology and safety justification for surface and near-surface RW disposal facilities	New	5)
Requirements for the structure and contents of SAR for surface and near-surface RW disposal facilities	New, to replace NP 306.3.02/3.038-2000, planned under AP-2012	5)
Requirements for safety assessment methodology and safety justification for geological RW repositories	New	5); 6)
Requirements for the structure and contents of SAR for geological RW repositories	New	6)

The lack of regulatory documentation with systemized requirements for consistent stages of RW management up to final disposal, including those on the management system and quality system for RW-related activities, causes risks of applying a non-optimized waste management system. There are risks of waste accumulation without appropriate characterization and sorting as well as late transfer for further treatment. The main principle of RW minimization is not adequately implemented. Waste management does not fully take into account the goal of this activity – final disposal.

The existing regulatory requirements on RW disposal, in particular existing waste classification for disposal purposes, cause risks of using non-optimized disposal facility designs and do not allow for the specifics of RW disposal in the Chernobyl exclusion zone.

6.4 General Description of Decommissioning of Nuclear Installations in Ukraine

6.4.1 Nuclear power plant units

The Zaporizhzhya, Rivne, Khmelnitsky and South Ukraine NPPs are at the stage of operation. The strategy of NPP long-term operation assurance and justification over a period of 10-15 years was agreed at the national level, thus, the valid documents for decommissioning are decommissioning concepts (or "decommissioning plans" according to the IAEA glossary) for each NPP have been agreed by SNRIU. In these decommissioning concepts (or plans), deferred dismantling is defined as the decommissioning strategy. These concepts (or plans) are reviewed every 10 years and also in case of significant changes including long-term operation of individual power units.

The decommissioning program covering the entire decommissioning activity was approved for ChNPP units 1-3 (ChNPP site layout is shown in Figure 5.4). This program establishes decommissioning stages and a list of documents required to obtain individual written permits of the regulatory authority for each stage. At present, ChNPP has a permit for activities at the stage of final closure and preservation of ChNPP-1-3. Deferred dismantling as the decommissioning strategy is also adopted for ChNPP units 1-3.

Figure 5.4 – Chernobyl NPP site

6.4.2 *Spent fuel storage facilities of Ukrainian NPPs*

1) The wet interim spent fuel storage facility at ChNPP site (ISF) (see Figure 5.5) is operated according to the License valid until 2025. The ISF has the decommissioning concept approved in the Decommissioning Section of the SAR.

Figure 5.5 – ChNPP wet interim spent fuel storage facility

2) The Zaporizhzhya DSFSF has a decommissioning program agreed with SNRIU.

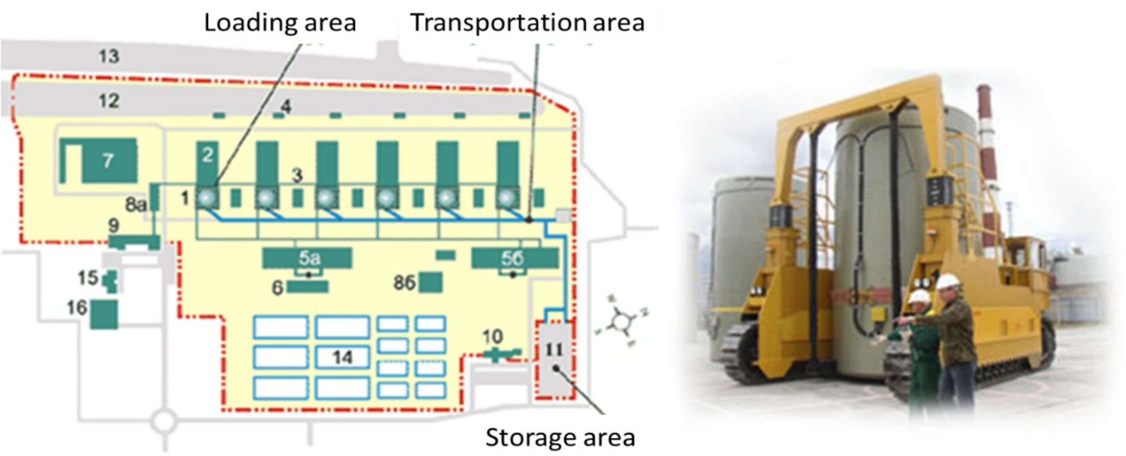

Figure 5.6 – Location of spent fuel storage site at ZNPP and transfer of a ventilated concrete container with spent fuel on a special vehicle to the storage area

3) The dry interim spent fuel storage facility at ChNPP has the decommissioning concept approved in the Decommissioning Section of the PSAR.

Figure 5.7 – ChNPP dry interim spent fuel storage facility

Nuclear research reactor and nuclear subcritical facility. The nuclear research reactor has a decommissioning program agreed with SNRIU.

The neutron source based on a subcritical assembly driven by a linear electron accelerator has an initial decommissioning concept agreed with SNRIU.

6.4.3 Conclusions

The analysis has revealed the following significant regulatory threats related to decommissioning.

1) There are no comprehensive full-scale general requirements for nuclear installations in decommissioning .

2) There are no detailed technical requirements and procedures for decommissioning of nuclear installations

3) There are no specific requirements for the management system for decommissioning, in particular, taking into account long duration of the decommissioning process.

4) There are no detailed requirements for structure and contents of licensing documents particularly for safety assessment and justification of nuclear installations in decommissioning.

The lack of regulatory documents with systemized safety rules and requirements for decommissioning, including the management system and safety justification for decommissioning, causes risks of untimely preparation for decommissioning, inadequate application of technical requirements for facilities at decommissioning stages (for example, closedown of facilities), incorrect determination of end states at different decommissioning stages, inadequate data on facilities required for decommissioning, insufficient application of the waste minimization principle etc.

7 Radiation safety

7.1 Safety Regulation in Use of Radiation Sources in Industry, Science and Training

Use of radiation sources (regardless of their application) is subject to state regulation through licensing, state supervision and enforcement. State regulation covers sealed and open radionuclide sources and radiation generating facilities.

SNRIU is a central executive body responsible for the state policy in safe nuclear energy use since 1995, which is exercised by establishing legislative and regulatory requirements, issuing authorizing documents, conducting inspections and applying sanctions.

SNRIU regulates the safety of radiation sources directly and through territorial bodies – seven state inspectorates on nuclear and radiation safety.

SNRIU and state nuclear and radiation safety inspectorates conduct regulatory control over the use of radiation sources at 4167 entities and fabrication of radiation sources at 22 entities. Among them 2481 entities use radiation sources that are not exempt from licensing and have appropriate licenses. For other entities, the authorizing procedure includes state registration of radiation sources.

One of the main principles of state regulation is a graded approach to different activities related to use of radiation sources taking into account their potential nuclear and radiation hazard through:

- exemption of radiation sources with low potential hazard from regulatory control. The levels and procedure for clearance from regulatory control are defined in Cabinet Resolution No. 84 dated 16 December 2011, registered in the Ministry of Justice on 20 August 2010 by No. 718/18013;
- registration of all radiation sources not exempt from regulatory control in the State Radiation Source Registry. State registration procedure of radiation sources is approved by the Cabinet Resolution No. 1718 dated 16 December 2000;
- licensing of use of radiation sources with average and high potential hazard in compliance with the requirements established in the Law of Ukraine "On Authorizing Activity in Nuclear Energy Use" [10]. A decision on the possibility to release the use of a radiation source from licensing is accepted by SNRIU if the radiation source complies with "Criteria for Release of Radiation Source Use from Licensing" approved by Cabinet Resolution No. 1174 dated 16 November 2011, through approving a corresponding list.

The international categorization of radiation sources (Categorization of Radioactive Sources, IAEA TECDOC 1344) has been implemented; in particular, categories for radionuclide radiation sources (1-5) according to their potential hazard were approved by Cabinet Resolution No. 1382 dated 5 December 2007.

Any activity on radiation sources is allowed if the entity confirms the ability to meet the requirements of radiation safety standards and rules and substantiates safety of these radiation sources.

Ukraine, like other countries, strives to ensure the international safety regimes through: implementation of international safety requirements, best international practices and implementation of the most effective instruments for state nuclear and radiation safety regulation.

Since 2014 a number of measures were launched on implementing Council Directive 2013/59/Euratom, which establishes the main safety standards for protection against hazard arising from ionizing radiation. These measures are envisaged by Cabinet Resolution No. 110-r dated 18 February 2015 "On Approval of Plans Developed by the State Nuclear Regulatory Inspectorate of Ukraine for Implementation of Some EU Legal Acts" [82], in particular:

- amend some Ukrainian laws in nuclear energy use;
- develop general requirements for radiation safety of activity with radiation sources (for more detail, see Section 8.5, issue 8.5.1).

The new system implemented in the Directive envisages a more flexible approach, according to which the standards and rules establish fundamental principles and reference levels for doses that are not to be exceeded, i.e. provisions that do not require frequent revision.

In addition to the "strict" regulatory system, there are other challenges. Many regulatory documents in force in our country were accepted in different time periods. Until now, some industries of Ukraine (e.g. uranium industry and medicine) are regulated by the USSR documents, although since 1991 the radiation protection system was fundamentally changed twice. Sources with natural radionuclide content, radon and cosmic irradiation of aircraft crews are not regulated at legislative level.

There are also new provisions not considered by the current radiation protection system (for example, optimization and justification of exposure from medical sources). These Directive provisions are absent in the national legislation and require full implementation.

It is necessary to note that individual Directive provisions will require not only appropriate amendments in the legislation, but also financial, labor and technical resources to ensure their implementation.

7.2 Radiation Protection of Personnel and Dosimetry Services

In compliance with Section 4 of the Statute of the State Nuclear Regulatory Inspectorate of Ukraine approved by Cabinet Resolution No. 363 dated 20 August 2014 [29], SNRIU established a unified state system for control and accounting of public individual exposure doses. This system is being developed for personnel (as part of the public). In future it is going to be extended to include patients and volunteers and, ultimately, the entire population of Ukraine.

There are around 50 thousands of category A employees, in contact with ionizing radiation, which is measured by human exposure dose. The main radiation protection principles are based on assessing doses received by employees during production activity. Actually, only one radiation protection principle (limitation) is partially met. The other two (justification and optimization) is practically not met due to lack of appropriate regulatory and methodological support. The limitation principle is not fully met because currently technical and organizational capabilities of available radiation monitoring services allow monitoring only certain critical parameters, namely, the whole body doses of hard gamma radiation. At the same time, X-ray and neutron radiation doses, as well as doses for skin, limbs and lens (all are standardized and should be monitored according to [61]) are not monitored. Additional dose limits, in particular, doses for women to 45 years. Absence of central (national) dosimetry registry in terms of labor mobility does not allow comprehensive control of meeting the main dose limit (100 mSv within 5 consecutive years).

It is planned to improve personnel radiation protection in Ukraine through forming up-to-date system for personnel exposure dose accounting and control and in future – for exposure doses from other sources (medical exposure, existing exposure).

The lack of appropriate dosimetry control and systematic accounting of individual personnel doses does not allow control and improvement of labor and working environment safety, as well as safety culture improvement and technology optimization.

7.3 Radiation Protection in Medical Exposure

Today, medical use of ionizing radiation for diagnosis and therapy needs the most significant reforms and changes for compliance with new Council Directive 2013/59/Euratom dated 05 December 2013.

This area is still mainly regulated by the USSR documents or departmental ordinances of the Ministry of Health of Ukraine (MOH) of the 1990s and later documents , although since 1991 the radiation protection system has fundamentally changed twice.

As far back as 2008 and 2010, the IAEA Integrated Regulatory Review Service (IRRS) mission highlighted the need to improve the radiation protection system in medical exposure in Ukraine.

Immediate measures were approved by Cabinet Resolution No. 1307-r dated 08 October 2008 “On Approval of the Action Plan to Implement Recommendations and Proposals of the IAEA Integrated Regulatory Review Service (IRRS) Mission” (amended by Cabinet Resolution No. 751-r dated 26 September 2013).

The medicine uses the majority (70% of all radiation sources, which is over 26,000 radiation sources and over 3,000 medical institutions without taking into account dental clinics) of radiation sources including those of the highest potential hazard level (category 1 radiation sources).

During medical exposure, not only personnel require protection against negative impact of ionizing radiation (over 10,000 people working with sources), but patients who undergo treatment (about 80,000 people per year) and diagnostics (about 20,000,000 examinations per year) each year and other members of the public directly or indirectly exposed to medical radiation sources, such as volunteer and persons that ensure comfortable conditions for patients, etc.

Absence of any information from medical institutions on emergency medical exposure confirms the fact that cases of unintentional or erroneous exposure in medicine is not recorded, not analyzed and corrective measures are not implemented and as a result they are not controlled or are concealed by MOH.

In most cases, measures intended to improve radiation protection in medical exposure are forced by the SNRIU and its territorial bodies through issuing prescriptions and establishing licensing conditions.

Radiation protection of the public (patients) in medical exposure in Ukraine is inadequate, and currently there are no instruments to encourage its enhancement, except for licensing of radiation source uses.

7.4 Registration of Radiation Sources

In compliance with Articles 1, 6, 11 of the Law of Ukraine “On Authorizing Activity in Nuclear Energy” [10]:

- state registration of radiation sources is introduction of information into the State Registry of Radiation Sources on radiation sources produced in Ukraine or imported or exported over the state border of Ukraine as well as on owners of these sources, individuals and legal entities to which they are allocated within economic or operating management or are in their possession or use on other grounds (Article 1);
- authorizing activity is a constituent part of the state regulation in nuclear energy use and envisages, among other, "state registration of radiation sources" (Article 6);
- radiation sources including those, the use of which is released from licensing are subject to state registration. The registration procedure is determined by the Cabinet of Ministers of Ukraine (Article 11).

The procedure of radiation source state registration and Provisions on the State Registry of Radiation Sources are approved by Cabinet Resolutions No. 1718 and No. 847. Sealed sources and radiation generating facilities are entered into the State Registry.

State registration of radiation sources is implemented by the Main Registering Center and six regional registering centers. Payment for state registration of radiation sources is allocated to the general budget fund. SNRIU is the holder of budget for the Registry operation.

The following measures were launched in 2015 due to reduction of the budget for the Registry:

- restructuring of the Registry by closing down registering centers and state registration of radiation sources by SNRIU territorial bodies – state inspectorates on nuclear and radiation safety;
- revision of the Registry documents, in particular: procedure for radiation source state registration, provisions on the State Registry of radiation sources, registering card forms, registry use procedure, etc.;
- improvement of software for the Registry database.

7.5 Remediation of Legacy Sites Including Uranium Mining and Processing Plants

Currently in Ukraine, the territory of the former industrial association "Prydniprovsk Chemical Plant" (PChP) (see Figure 6.1), USSR legacy site, is of top priority from the viewpoint of decommissioning and remediation measures.

Figure 6.1- Part of Prydniprovsk Chemical Plant territory

Uranium ore from different deposits of the USSR and Eastern Europe was processed at PChP from 1946 to 1991. PChP restructuring after termination of its operation led to forming a large number of companies at its territory, most of which performed activities not related to uranium ores processing. Moreover, buildings and structures of former PChP were distributed between these companies without considering the peculiarities of their condition, location, contamination type and negative impact of waste from uranium ore processing accumulated on them on the environment and personnel (results of the radiation survey conducted under the joint project between the Swedish Radiation Safety Authority (SSM) and Ministry for Energy and Coal Industry, ENSURE-2, are provided in [83]). Figure 6.2 illustrates the state of some PChP objects.

Figure 6.2 – Abandoned PChP objects negatively affecting people and the environment

In order to eliminate negative ecological consequences of PChP activity and to protect the public and environment from harmful impact of ionizing radiation the Cabinet Resolution dated 30 September 2009 No. 1029 adopted "State Target Ecological Program to Bring PChP Uranium Facilities to Safe State". However, due to change of the economic situation in Ukraine this program has lost its relevance and should be revised on the basis of real possibilities of the country.

Currently, requirements for radiation safety during uranium ore processing are defined in regulatory document [84]. Requirements for radiation safety during termination of uranium ore processing are directly determined in [85].

SNRIU has planned to develop new revision of the regulatory document establishing requirements for radiation safety of uranium processing facility, radiation protection of personnel, public and environment, radiation monitoring, management with uranium ore processing waste and products, management with existing tailings storage facilities, their preparing for long-term stabilization and reclamation, etc. during the activity on uranium ore processing and during complete (liquidation and conversion of uranium processing facility) and temporary (conservation of uranium processing facility) termination of the activity and license conditions for implementation and termination of the activity on uranium ore processing.

7.6 Management of Radioactive Waste Containing Naturally Occurring Radioactive Material

Exposure due to naturally occurring radionuclides falls within the scope of Articles 100, 101, 102 of Directive 2013/59/Euratom [86]. In case of "existing exposure situations", relevant activities should be attributed to the situation of "planned exposure" and independent management strategies should be developed for them in compliance with the recommendations of Article 102 of Directive 2013/59/Euratom. It should be considered that the public exposure should be regulated and controlled under requirements for existing exposure situations.

Requirements for limitation of public and personnel exposure with materials containing naturally occurring radioactive material (NORM) are determined in the Radiation Safety Standards of Ukraine [61] (DGN 6.6.1.-6.5.001-98) and Basic Health and Radiation Safety Rules of Ukraine [63] (DSP 6.177-2005-09-02).

These regulatory documents present:

- quantitative criteria, compliance with which ensures radiation protection against NORM;
- requirements for personnel radiation protection against NORM at production sites;
- list of appropriate measures ensuring radiation safety and radiation protection for personnel and public exposure against NORM;
- list of production processes qualified as practices and natural sources within these practices defined as industrial;
- dose criteria for control and accounting of the natural sources that cause personnel exposure under practices;
- list of production processes in which NORM exposure of workers not referred to "personnel" category can be increased, ways of exposure and possible measures to monitor and, if necessary, decrease it;

- list of natural radiation sources that may have radiological impact on the public and list of facilities subjected to obligatory radiation monitoring with obligatory measurement certificates.

There are also a number of regulatory documents with requirements for radiation safety during certain activities that may cause personnel exposure to NORM, namely:

State health and safety rules during mining, enrichment and processing of ores containing technologically enhanced NORM (TENORM) at rare metal industrial plants (DSP 6.6.1.6.2-082-02) developed specifically for the Volnohorsk Mining and Ore Processing Enterprise, which is the only plant in Ukraine that deals with titanium ore mining;

System of standards and rules to decrease ionizing radiation of natural radionuclides in construction (DBN V. 1.4-0.01-97, DBN V. 1.4-0.02-97, DBN V. 1.4-1.01-97, DBN V. 1.4-2.01-97).

These regulatory documents determine requirements for:

- activities in mining, enrichment and processing of ores containing NORM at rare metal industrial plants;
- storage and transport of NORM containing mineral raw materials;
- collection and removal of waste of NORM containing mineral raw materials, cleaning of premises where activities with NORM are performed;
- individual protection means and personal hygiene products;
- radiation monitoring.

According to hydrogeological and natural conditions, the territory of Ukraine in terms of population exposure by radionuclides of natural origin is quite varied (Figure 6.3). Its third part is located on the crystalline shield with high content of natural radionuclides of uranium and thorium series.

Figure 6.3 – Tectonic map of Ukrainian territory

Radionuclides of the U and Th series come to the environment in one form or another during exploration and development of deposits, as well as extraction, primary processing and transport of oil and gas. During extraction and processing of oil and gas, the natural radionuclides in them are significantly redistributed – they settle on process equipment, work area surfaces, on ground of enterprise sites, etc. with concentration in some cases to levels, at which exposure of the public and personnel, as well as environment contamination is possible at levels of safety and protection interest. Currently, significant number of gas extraction enterprises is located in Ukraine. Geographic location of gas fields and gas extraction points is shown in Figure 6.4.

Figure 6.4 –Location of gas fields, gas metering and compressor stations, underground gas storages in Ukraine

Likewise, the national economy uses certain types of mineral raw materials, products of their industrial processing, in which content of natural radionuclides exceeds permitted by NRBU- 97 values for building materials used within settlements (Aef <= 740 Bq/kg). They particularly include: raw and burnt bauxite, refractory clay and other raw materials for refractory industry, ready refractory products and materials, etc.; polishing powders and pastes, special coating compositions for refractory coating of casting molds and process components of glazes and dyes, process raw materials for metals (zircon, rutile, ilmenite, loparite and tungsten concentrates, baddeleyite, etc.); allowing additions of rare metal and rare earth components (scandium, yttrium, lanthanum, cerium, lutetium, niobium, etc.) used in metallurgy, abrasive production, production of special glasses, etc.; other types of mineral raw materials, materials and products with increased content of natural radionuclides including materials based on natural potassium, natural minerals, etc.

The leading radiation factor in the majority of underground production processes is usually short-lived daughter products of radon isotopes. The main sources of radon in the air of underground structures are rocks surrounding underground facilities (pit) and groundwater. Intensity, ventilation circuit and used production technologies impacts retention of daughter products of radon isotopes in the air of underground facilities. In case of high dust concentration levels in the air and retention of long-lived natural radionuclides in dust, internal exposure through inhalation of natural radionuclides can dominate over all other radiation factors, for example, in some coal mines. Common features of work places with possibly high values of radiation factors is their location in blind or poorly ventilated sections (premises), high dust concentration in the air and watering, ventilation comes from other premises by air, etc.

Exposure caused by staying in buildings is partially regulated by the system of standards and rules to decrease the ionizing radiation of natural radionuclides in construction (DBN V. 1.4-0.01-97, DBN V. 1.4-0.02-97, DBN V. 1.4-1.01-97, DBN V. 1.4-2.01-97).

Overall; the threats existing in Ukraine that are related to exposure to NORM have not been adequately studied. Their study with further development of the strategy requires obtaining all necessary information primarily from iron and steel plants, oil refining and coal mining enterprises and conducting radiation surveys of their territories and industrial premises. The development of legislative framework to govern the safety of enterprises managing NORM is a significant factor that contributes to dose reduction for their workers (for more detail, see Section 8.5, issue 8.5.6). Nevertheless, it can be stated with a reasonable degree of confidence that these threats are local and in most cases affect only personnel directly involved in certain activities.

In compliance with the recommendations of Article 103 of Directive 2013/59/Euratom, it is necessary to introduce a national action plan on limiting the public exposure to radon, namely:

1) Pursuant to the provisions of part 1 of Article 100, the Member States should establish the national action plan aimed at settlement of long-term risks associated with exposure to radon in residential houses, buildings with public access and at workplaces, for any radon source coming from soil, building materials or water. This action plan should take into account the paragraphs listed in the Annex. The plan should be periodically updated.

2) The Member States should ensure measures to prevent radon ingress to new buildings. These measures can envisage setting specific requirements within building standards and rules.

3) The Member States should identify the areas, where in many buildings radon concentration (average annual value) is expected to exceed the relevant national reference level.

The issue of public exposure to radon is due to the following factors:

- average dose of the public in Ukraine from naturally occurring sources is about 6 mSv per year. More than 75% of this exposure is caused by radon in the air of houses;
- in individual regions of Ukraine, the annual average concentration of radon-222 in residential houses is almost ten times higher than the action level in accordance with NRBU-97 (100 Bq/m3) and almost three times higher than the reference level for the public (300 Bq/m3).

The first state radon-related program was introduced in 1991 and closed in 1999. This program included development of methodological and metrological base of radon measurement in indoor air. State standard of radon measurement unit - radon chamber was established. It was certified by the State Standardization Committee of Ukraine as a reference standard. The methodology of radon measurement – method of passive track radon meters –was developed. It allows integrated measurement of radon content in indoor air for the period to six months.

Regulations on radon levels in residential houses [61] were developed and approved under this program. Relevant regulations were approved at the level of departmental building standards, namely in System of Standards and Rules to Decrease the Ionizing Radiation Level of Natural Radionuclides in Construction (DBN V. 1.4-0.01-97, DBN V. 1.4-0.02-97, DBN V. 1.4-1.01-97, DBN V. 1.4-2.01-97). Most of the requirements of these documents were then canceled (2010).

Currently, more than 30,000 residential houses in 17 regions of Ukraine have been examined and radon hazardous areas are defined. This allows justification procedures and justification of state radon program at modern level, as well as minimization of the cost for its implementation.

8 The main identified threats and proposals for their elimination

The assessment has revealed the main gaps and challenges for SNRIU. The threats were analyzed in the following areas:

- organization and general principles for activities of the regulatory authority;
- safety of nuclear installations;
- radioactive material transport;
- emergency preparedness and response;
- radioactive waste management and decommissioning;
- radiation safety.

8.1 Organization and general principles for activities of the regulatory authority

It is found that the most common challenge is outdated or imperfect regulatory and legal framework governing certain activities in the above areas. Thus, improvement of the national legislation, including its adaptation to the EU legislation, requires implementation of a number of measures, in particular: amend a number of legislative instruments, develop new regulatory documents, review regulatory documents in force considering international recommendations such as IAEA Safety Standards, including the USSR documents that are still in force.

At the same time, the analysis identified the main risks and challenges for the SNRIU to be eliminated to ensure effective regulatory functions. Summary on the identified challenging issues and ways for their solution is presented below. This information is grouped in compliance with the analysis areas. Organization and General Principles for Activities of the Regulatory Authority

The following issues related to SNRIU activities were identified:

Issue 8.1.1 *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.*

Ways of solution: *Legislative establishment of the SNRIU status, functions and powers. Development of an appropriate draft law by 2017 is envisaged to reach this objective and to consider EU Council Directive No. 2014/87/Euratom.*

Priority: highest.

Risks: Loss of the SNRIU independence will primarily lead to pressure on the SNRIU in making objective decisions within its competences. This in turn may significantly affect the achieved level of nuclear and radiation safety.

8.2 Safety of Nuclear Installations

The following issues related to regulation and safety assurance of nuclear installations were identified:

Issue 8.2.1 *R&D "Prompt and Technological Analysis of NPP Operational Events" is carried out on a permanent basis upon SNRIU request. The goal of this R&D is to analyze* *operational events at Ukrainian NPPs to prevent their recurrence, efficiently use plant operating experience and enhance operational safety.*

In spite of the obvious importance of this effort for the SNRIU, the current economic situation in Ukraine jeopardizes its implementation.

The financial situation in Ukraine caused the government to take a series of tight measures to optimize expenditures. This included the termination of funding for R&D efforts conducted from the state budget. Therefore, it was a governmental decision to suspend funding for R&D "Prompt and Technological Analysis of NPP Operational Events" from the state budget.

Ways of solution: *Possibility to implement activities within international projects.*

Priority: highest.

Risks: Lack of a systematic and thorough analysis of operational events at Ukrainian NPPs will decrease the effectiveness of regulatory control and general safety level.

Issue 8.2.2 *Lack of a regulatory document to govern the procedure for accounting and investigation of operational events at research nuclear facilities of Ukraine.*

Requirements for the investigation of operational events at research reactors were developed as early as the beginning of the 1990s and have not been revised since that time. Now these requirements do not completely meet modern international approaches to ensuring the safety of nuclear research reactors. Hence, general requirements for operating experience analysis, classification of events, procedure for accounting of events, reporting, etc. need to be revised and brought to compliance with international requirements. It should be noted that there are no requirements at all for analysis of operating experience and investigation of events for subcritical facilities.

The development of appropriate regulatory requirements incorporating international experience is a high-priority safety area for nuclear research installations.

Drawbacks or lack of regulatory requirements for analysis and investigation of operational events at research reactors in Ukraine may further lead to degradation of the operating experience feedback system and, as a consequence, decrease the safety of research reactors because of untimely corrective actions.

Ways of solution: *Development of a draft regulatory document to determine regulatory requirements for the following:*

- *investigation and accounting of operational events at research nuclear facilities;*
- *assessment of operational experience for research nuclear facilities.*

The draft regulatory document will eliminate individual inconsistencies of regulatory documents in force in Ukraine for the safety of research nuclear facilities and ensure their harmonization with international approaches.

Priority: highest.

Risks: The proposed regulatory document is the key element for analysis of operating experience of nuclear research facilities in Ukraine. Lack of a modern regulatory document does not allow a thorough analysis of operating experience, including analysis of events, which leads to degradation of operating experience feedback system and, as a consequence, affects the safety of nuclear research facilities and timely regulatory decisions.

Issue 8. 2.3 *Need for a unified regulatory document that will include requirements for NPP emergency operating documentation.*

NPP emergency operating documentation in Ukraine consists of several levels: 1. Event mitigation procedures. 2. Emergency operating procedures. 3. Severe accident management guidelines. The lack of a unified approach to systematic development of emergency operating documents causes inconsistency between their parts and increases the probability of human errors in management of emergencies and accidents.

Ways of solution: *Development of an appropriate regulatory document based on current international experience. This document should:*

- *establish a unified technical policy in the development of NPP emergency documentation;*
- *consider practical experience in using emergency documentation at full-scale simulators (based on training results);*
- *include requirements for establishing the interface of transfer from EOP to SAMG;*
- *establish regulatory requirements for the scope of required justification and contents of emergency plant procedures, which should include clear and detailed prescriptions to arrange coolant supply and/or restore power supply in design-basis and beyond design-basis accidents, as well as in accident progression into a severe phase (regulatory requirements for FLEX procedures).*

Priority: high. The development of new FLEX procedures is currently in initial phase (see para. 2.1.5 of this Report). Therefore, there is some time margin for developing a single regulatory document that will contain requirements for NPP emergency operating documentation.

Risks: Lack of a unified approach to the organization of emergency operating documentation will cause loss of control over the process of its development and will decrease the effectiveness of emergency operating documentation and increase potential hazards during emergencies because of its inadequacy.

8.3 Emergency Preparedness and Response

The following issues related to emergency preparedness and response were identified:

Issue 8.3.1 *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.*

Ways of solution: *Creation of a backup IEC.*

Priority: highest. This measure is necessitated by the challenging socio-political situation in Ukraine in hybrid war conditions and complies with recommendations of the NATO Advisory Support Group mission of 2014.

Risks: There are higher risks for the SNRIU to lose emergency response functions.

Issue 8.3.2 *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.*

Ways of solution: *Creation of conditions for storage, maintenance and monitoring of the RanidSONNI mobile radiological laboratory in compliance with technical specifications on its equipment and emergency response tasks.*

Priority: highest. This measure is part of efforts on the creation of a backup IEC in accordance with recommendations of the NATO Advisory Support Group mission of 2014.

Risks: There are higher risks of losing important independent information in the event of radiation accidents involving radiation contamination, loss of radiation sources and threats of terrorist attacks using radioactive sources.

Issue 8.3.3 *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.*

Ways of solution: *Development of new revisions of the following documents: 1) Provisions on Functional Subsystem "Safety of Nuclear Facilities" of the Unified State System for Prevention of and Response to Man-Caused and Natural Emergencies, approved by SNRIU Ordinance No. 16 dated 20 January 2009; 2) Response Plan of Functional Subsystem "Safety of Nuclear Facilities" of the Unified State System for Prevention of and Response to Man-Caused and Natural Emergencies.*

Priority: high. The need for this measure is highlighted in Presidential Decree No. 139/2015 of 12 March 2015.

Risks: There are higher risks of failure to ensure coordination of actions under USSCP.

Issue 8.3.4 *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.*

Ways of solution: *Development of UARMS Concept, terms of reference for UARMS, draft law of the Cabinet of Ministers for approval of UARMS provisions.*

Priority: high. The need for this measure is highlighted in Cabinet Resolution No. 44-r of 25 January 2012 and recommendations of the NATO Advisory Support Group of 2014.

Risks: There are higher risks of failure to ensure coordination of actions on radiation monitoring at the state level and take proper decisions because of the lack of assessment and prediction of radiation accidents.

Issue 8.3.5 *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.*

Ways of solution: *Comprehensive analysis of the national legislation regarding harmonization/specification of the requirements for emergency preparedness and response to nuclear and radiological accidents. The legislation harmonization with the requirements of IAEA standard GSR Part 3 "Radiation Protection and Safety of Radiation Sources. International BSS":*

- *national procedures for emergency preparedness;*
- *requirements for the structure and contents of emergency preparedness and response plans according to threat category;*

- *updating the national plan of response to radiation accidents taking into account the concept for planning preventive measures;*
- *harmonization of criteria for preventive measures in case of accidents in neighboring states, in particular Belarus (for RNPP);*
- *assessment of on-site and off-site emergency preparedness.*

Priority: high. This measure is part of efforts under the Association Agreement between Ukraine and EU of 2014.

Risks: There are higher risks of inconsistent actions on response to radiation accidents at international level.

8.4 Radioactive Waste Management and Decommissioning

The following challenging issues related to radioactive waste management and decommissioning were identified:

Issue 8.4.1 *Lack of a comprehensive approach to ensuring the safety of radwaste management that would take into account the consistency of individual radwaste management stages up to final disposal. Lack of clear and unambiguous criteria for radwaste sorting in situ that would take into account waste classes in accordance with acceptable disposal concept and specific requirements and rules for radwaste management stages.*

Ways of solution: *Development of a two-level system of regulations in accordance with para. 5.3.4.*

Priority: highest. Development of a two-level system of regulations will exclude the accumulation of waste forms that are unacceptable for final disposal.

Risks: An effective classification system for radioactive waste is not in place. There are higher risks of inconsistent actions at interrelated radwaste management stages to ensure safety of final disposal and risks of additional radiological impacts.

Issue 8.4.2 *Lack of regulatory requirements for remediation of temporary 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 GSR Part 3 "Radiation Protection and Safety of Radiation Sources. International BSS".*

Ways of solution: *Development of a two-level system of regulations in accordance with para. 5.3.4.*

Priority: highest. This will exclude risks of radiological impacts on the public and environment.

Risks: There are increased risks of non-optimized radiological impacts on the public and environment.

Issue 8.4.3 *Need to consider the specifics of emergency response for RW management facilities.*

Ways of solution: *Development of a two-level system of regulations in accordance with para. 5.3.4.*

Priority: highest. This will promote prevention of accidents and reduce risks of emergency exposure for personnel and the public.

Risks: There are increased risks of radiation accidents associated with the specifics of radwaste management facilities.

Issue 8.4.4 *Lack of systemized requirements for safety assessment methodology and safety justification for RW 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.*

Ways of solution: *Development of a two-level system of regulations in accordance with para. 5.3.4*

Priority: highest. This will increase the level of confidence in the safety of RW management facilities and activities including disposal of high-level and long-lived radioactive waste in deep geological formations.

Risks: There are increased risks of unjustified and no well-regulated radiological impacts on personnel, the public and the environment resulting from radwaste management activities and operation of radwaste management facilities.

Issue 8.4.5 *Lack of specific requirements on integrated management system and safety culture for radioactive waste management activities and facilities*

Ways of solution: *Development of a two-level system of regulations in accordance with para. 5.3.4.*

Priority: highest. This will ensure consistency of safety requirements at individual waste management stages, quality of RW management and compliance with safety objectives in RW management.

Risks: There are increased risks of unjustified and inconsistent actions at interrelated radwaste management stages, leading to incompliance with safety objectives and principles for radwaste management.

Issue 8.4.6 *Lack of comprehensive full-scale general safety requirements for nuclear installations in decommissioning.*

Ways of solution: *Development of a two-level system of regulations in accordance with para. 5.4.5.*

Priority: highest. This will ensure optimized decommissioning, taking into account RW management.

Risks: There are increased risks of radiological and no well-regulated impacts on personnel, the public and the environment.

Issue 8.4.7 *Lack of detailed technical requirements and procedure for decommissioning of nuclear installations.*

Ways of solution: *Development of a two-level system of regulations in accordance with para. 5.4.5.*

Priority: highest. This will prevent unjustified risks of exposure to personnel and the public.

Risks: There are increased risks of radiological and well-regulated impacts on personnel, the public and the environment in decommissioning.

Issue 8.4.8 *Lack of specific requirements for the management system for decommissioning, in particular, taking into account long duration of the decommissioning process.*

Ways of solution: *Development of a two-level system of regulations in accordance with para. 5.4.5.*

Priority: highest. This will ensure consistent actions and operations, promote decommissioning quality and reduce risks of unjustified impacts on people.

Risks: There are increased risks of unjustified and no well-regulated actions in decommissioning, taking into account radwaste management, which causes higher risks of exposure for personnel and the public.

Issue 8.4.9 *Lack of detailed requirements for structure and contents of licensing documents particularly for safety assessment and justification of nuclear installations in decommissioning*

Ways of solution: *Development of a two-level system of regulations in accordance with para. 5.4.5*

Priority: highest. This will increase confidence in safety during decommissioning.

Risks: There are higher risks of unjustified and no well-regulated radiological impacts on personnel, the public and the environment resulting from decommissioning.

8.5 Radiation Safety

The following issues related to radiation safety were identified in the analysis:

Issue 8.5.1 *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.*

Ways of solution: *Development of a regulatory document with basic radiation safety requirements for use of radiation sources.*

Priority: highest. This area is still governed by NRBU-97 and OSPU-2005 in Ukraine although the international radiological protection system has been changed twice.

Risks: There are increased risks of radiation accidents associated with loss, illicit trafficking or incorrect use of radiation sources. This is primarily caused by the lack of modern (adequate) safety requirements for radiation sources, including recent radiation technologies introduced in medicine, industry and research.

Issue 8.5.2 *Lack of a national system for accounting and control of personnel exposure doses.*

Ways of solution:

1) Develop provisions on the unified system for accounting and control of personnel exposure.

2) Develop appropriate software for dose registration.

3) Develop regulatory documents on applying justification and optimization principles.

4) Develop methodologies to calculate exposure doses taking into account new recommendations of the International Comission on radiological Protection (ICRP).

Priority: high. This effort is included in the action plan to implement Directive 2013/59/Euratom, which is approved by Cabinet Resolution No. 110-r of 18 February 2015, deadline is 2018).

Risks:
There are higher risks of personnel doses above established limits. It is impossible to assess actual doses, apply the dose optimization principle and implement appropriate corrective measures.

Issue 8.5.3 *Lack of a comprehensive approach to ensure radiation protection for medical exposure and harmonization with Directive 2013/59/Euratom of 5 December 2013.*

Ways of solution:

1) Develop appropriate regulatory documents in compliance with Council Directive 2013/59/EURATOM of 5 December 2013 and IAEA standard GSR Part 3 – radiation safety rules in nuclear medicine, dental radiology, interventional procedures, computer-aided tomography, etc.

2) Implement international standards related to medical therapeutic and diagnostic equipment and installations, first of all international standards IEC 61223-2-6-2003 and IEC 61267-2001.

3) Develop and approve quality control sheets for physical and radiation characteristics of diagnostic and therapeutic eq.

4) Develop diagnostic reference levels for diagnostic procedures.

5) Develop provisions on experts in radiation protection, medical physics.

Priority: high. This effort is included in the action plan to implement Directive 2013/59/Euratom, which is approved by Cabinet Resolution No. 110-r of 18 February 2015, deadline is 2017.

Risks: There are higher risks of doses for medical personnel and third parties that exceed established limits and failure to comply with the justification principle for medical exposure of patients, which may cause undue harm.

Issue 8.5.4 *Need to improve legislation in the field of state registration of radiation sources.*

Ways of solution:

1) Revise the Procedure for State Registration of Radiation Sources and Provisions on State Registry of Radiation Sources and bring them into compliance with international standards.

2) Improve "Registry" software.

Priority: high. This effort is planned after reorganization of the Registry, tentatively after 2017.

Risks: There are increased risks of radiation accidents associated with loss and illicit trafficking of radiation sources.

Issue 8.5.5 *Lack of current radiation safety requirements for activities on uranium ores mine and millings facilities, including remediation of uranium legacy sites.*

Ways of solution:

Develop an appropriate regulatory document to determine the following:

- *general provision of radiation safety in uranium industry;*
- *radiation safety rules during wastes management from mine and milling of uranium ores;*
- *requirements to institutional control after decommissioning of uranium facilities;*
- *principles and criteria for remediation activity;*

- *requirements for planning of remediation measures;*
- *requirements for radiation protection program;*
- *requirements for assessing the state (characterization) of the territories to be remediated;*
- *requirements for the monitoring program for former uranium plants;*
- *methodology for safety assessment of former uranium plants;*
- *requirements for the management program for waste resulting from remediation.*

Priority: highest. Lack of appropriate regulatory framework does not allow remediation of the former Prydniprovsk Chemical Plant.

Risks: There are increased risks of doses for the public that exceed established limits, in particular, for workers of enterprises located on the Prydniprovsk Chemical Plant territory, for which this is existing exposure situation. Remediation of the former Prydniprovsk Chemical Plant territory is impossible.

Issue 8.5.6 *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).*

Ways of solution:

Development of a legislative framework to regulate safety of enterprises where NORM containing materials are managed:

- *amend Ukrainian legislation in nuclear energy use and SNRIU Statute;*
- *develop general provisions for radiation safety in management of NORM containing materials;*
- *develop radiation safety rules for enterprises where exposure to NORM containing materials is possible;*
- *develop general radiation safety provisions in case of existing, planned and emergency exposure;*
- *establish a state system to accounting and control exposure doses of the public in Ukraine.*

Priority: highest. This effort is included in the action plan to implement Directive 2013/59/Euratom, which is approved by Cabinet Resolution No. 110-r of 18 February 2015, deadline is 2017.

Risks: There are higher risks of doses for the public that exceed established limits.

Issue 8.5.7 *Need to support the state policy on limiting the public exposure to radon.*

Ways of solution:

Development of 'Radon' concept and state program.

Priority: highest. This effort is included in the action plan to implement Directive 2013/59/Euratom, which is approved by Cabinet Resolution No. 110-r of 18 February 2015, deadline is 2017.

Risks: There are higher risks of radon exposure for the public that exceeds established limits.

Issue 8.5.8 *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

Ways of solution:

Develop a number of regulations on public exposure to radon in residential houses and at workplaces (defining reference levels, rules for radiation monitoring of radon activity at workplaces, etc.).

Develop regulatory documents on measurement quality control (laboratory certification, collation procedures).

Establish a radon center as an organization to be responsible for radon monitoring in future.

Develop a number of regulations on public exposure to radon in residential houses and at workplaces (defining reference levels, rules for radiation monitoring of radon activity at workplaces, etc.).

Develop regulatory documents on measurement quality control (laboratory certification, collation procedures).

Establish a radon center as an organization to be responsible for radon monitoring in future.

Establish a state registry of radon exposure doses received by the public and personnel at workplaces.

Priority: highest. This effort is included in the action plan to implement Directive 2013/59/Euratom, which is approved by Cabinet Resolution No. 110-r of 18 February 2015, deadline is 2017.

Risks: There are higher risks of radon exposure for the public that exceeds established limits.

Issue 8.5.9 *Need for improvement of legislation governing nuclear and radiation safety in compliance with new basic IAEA standards and EU/Euratom directives.*

Ways of solution:

Revision of the “Radiation Safety Standards of Ukraine (NRBU-97)”, as the basic high-level regulatory document on radiation safety.

Priority: highest. This effort is included in the action plan to implement Directive 2013/59/Euratom, which is approved by Cabinet Resolution No. 110-r of 18 February 2015, deadline is 2017.

Risks: Lack of new Radiation Safety Standards will lead to inconsistency and incompliance between radiation safety regulations of different levels.

Issue 8.5.10 *Need for improvement of legislation governing nuclear and radiation safety in compliance with IAEA standards in the area of radioactive materials transport.*

Ways of solution:

Revision of the “Revision of the regulatory document “Rules for Nuclear and Radiation Safety in Transport of Radioactive Materials” (PBPRM-2006).

Priority: highest. The objective is to bring the regulation “Rules for Nuclear and Radiation Safety in Transport of Radioactive Materials” (PBPRM-2006) into compliance with modern international requirements. In addition, this regulation is to be revised to comply with the existing rules for transport of dangerous cargoes, which regulate international transfer of radioactive materials.

Risks: Lack of new Radiation Safety Standards will lead to inconsistency and incompliance with international requirements and rules.

9 Directions for continuing regulatory cooperation

9.1 Overview and strategic direction of SNRIU regulatory activities

Improvement of NPP operational safety

For Ukraine, nuclear power is a strategically important element in the production of electricity. Its current and projected contribution comprises approximately 50% of the electricity produced and consumed in the country. Effective and sustainable nuclear power is one of the necessary conditions to ensure national safety and security.

State safety regulation of nuclear installations is of top priority in SNRIU activities. Based on the plans of Ukrainian Government for long-term operation of nuclear power plants and results of post-Fukushima stress tests, the regulatory authority is to carry out a comprehensive assessment of the operator's safety justification and check associated calculations and implemented safety improvement measures.

Safety regulation in construction of new nuclear installations

Ukraine is currently implementing a number of construction projects for new nuclear installations. They include Khmelnitsky NPP units 3 and 4, a centralized spent nuclear fuel storage facility, a dry storage facility at the Chernobyl NPP, and a neutron source based on a subcritical assembly driven by a linear electron accelerator. Safety regulation and ensuring compliance during construction of these installations are among the main objectives of SNRIU.

There are also a number of very important projects that are being implemented on the Chernobyl site, such as construction and commissioning of the liquid radioactive waste treatment plant, industrial complex for solid radioactive waste management and activities under the Shelter Implementation Plan, including construction of the new safe confinement. There is a need for continuous regulatory control over compliance of design and technical documentation with regulations, standards and rules on nuclear and radiation safety and for a proper safety level in implementation of the above-mentioned construction projects.

Emergency preparedness and response

Maintaining emergency preparedness for nuclear and radiation accidents is amongthe top priorities of the regulatory authority, other central executive authorities, including the State Emergency Service of Ukraine, local government bodies, operating organization, etc. On the one hand, the importance of this area is caused by a high concentration of radiation and nuclear facilities in Ukraine, and on the other hand by escalation of social, political and economic situation in the country, and in the world. In so doing, social and political instability increases threats related to terrorist acts, while economic factors lead to additional risks related to Ukrainian NPPs and other facilities.

Improvement of safety in fabrication and use of radiation sources, radioactive waste management, radioactive material transportation and uranium ore mining and milling

State safety regulation of radiation sources is intended to ensure their regulatory control applying a graded approach to various activities and radiation sources and taking into account potential nuclear and radiation hazards. The current state safety regulation is based on the following aspects: an authorizing system (registration and licensing) has been implemented, state supervision is conducted, sanctions are applied as appropriate, regulatory framework has been established and is being improved and resources are allocated in accordance with the graded approach depending on risks in the use of certain types of radiation sources.

In the field of uranium ore mining and milling, Ukraine is currently conducting extensive upgrading and modernization of basic industrial plants and auxiliary facilities of the Eastern Mining and Processing Plant (SkhidGZK). This provides a complete process for uranium ore mining and milling in Ukraine, where an up-to-date system of personnel dose monitoring is being introduced, etc. Liquidation and reclamation of the former Industrial Association, Prindeprovsk Chemical Plant, are underway. Measures on upgrading, conversion and further operation of Section II of the Tailing Pit "Sukhachivske" are under review, conducted by the State Enterprise "Barier" under a license for uranium ore processing.

The objective of state regulation in the field of uranium ore mining and milling is to ensure regulatory control over uranium ore processing, including termination of these activities and comprehensive assessment of radiation safety of existing and "legacy" uranium plants in order to provide radiation safety of personnel, the public and the environment against hazardous radiological factors during operation of uranium plants and during their liquidation, preservation and conversion. The strategic objective is to maintain a proper safety level in operation of uranium mining and milling plants during their liquidation, preservation and conversion.

Regulatory activities in radioactive material transportation are aimed at protecting the people, property and environment against radiation and preventing accidents and incidents during transportation of nuclear fuel, radiation sources and radiation waste as well as individual doses associated with transportation. In the reporting period, there were no transportation accidents or incidents, and individual doses dis not exceed the regulated values.

State safety regulation in the field of radioactive waste management covers licensing and oversight of operation of

- existing radioactive waste management facilities,
- safety enhancement,
- liquidation and reclamation of existing "legacy" radioactive waste disposal facilities of the Radon State Association and facilities for Chernobyl-origin waste in the Exclusion Zone,
- construction of new radioactive waste management facilities for waste processing, long-term storage and disposal.

Licensing and inspection require interface with the applicants and licensees (including operators of radioactive waste disposal facilities) on issues of

- safety assessment, including updated assessments, of radioactive waste management facilities,
- implementation of an effective management system,
- identification of safety threats and possible ways for their elimination, and
- assurance of required safety culture in radioactive waste management.

Regulatory control in this field is intended to check the capability of applicants and licensees to comply with safety conditions and rules in radioactive waste management activities, provision of administrative and technical measures and means for safe implementation of activities and assessment of design and technical documentation for compliance with regulations, standards and rules on nuclear and radiation safety. The strategic objective is to ensure proper safety of existing and new radioactive waste management facilities and to determine the capability of applicants and licensees to implement radioactive waste management activities in compliance with relevant conditions and rules.

9.2 Status of on-going projects and proposals in the bilateral cooperation between NRPA and SNRIU

Substantial work done has been completed in parallel with the completion of the SNRIU regulatory threat assessment report. This has included analysis and improved understanding of the regulatory framework in other countries as well as review and description of the existing regulatory documents in Ukraine in the areas of radiation safety and radioactive waste management;

SNRIU actively participates in international cooperation to exchange experience in regulation of nuclear and radiation safety. This supports the introduction of the best practice into regulatory activities and harmonization of Ukrainian national legislation on nuclear and radiation safety with IAEA standards, EU directives, WENRA reference levels and so on. International cooperation also promotes the development of Ukraine's regulatory infrastructure and mitigate threats arising in performance of the SNRIU functions and tasks.

As part of the NRPA-SNRIU bilateral cooperation program there are currently three projects in progress. The Projects tasks are aimed at putting the Ukrainian regulatory framework in compliance with European and IAEA Safety standards. In addition to SNRIU, there are a number of other Ukrainian Authorities directly and indirectly responsible for, or involved in, the enforcement and regulation of nuclear safety and radiation protection in Ukraine. Therefore, when developing regulatory documents within the projects (outline further below) robust interfaces with other responsible Ukrainian Authorities are established through workshops and other activities.

URAN Project

The overall objective of the URAN project is to help the regulatory authorities of Ukraine to update the regulatory basis for nuclear and radiation safety in uranium industry in accordance with the international safety requirements.

Two draft regulatory documents establishing systematized radiation safety requirements in uranium industry in Ukraine will be developed within the Project:

- General Provisions for Radiation Protection and Safety in Uranium Industry;
- Safety Requirements to the Institutional Control at Former Uranium Processing Sites.

Taking into account tasks of uranium industry and considering the current state of the Ukrainian regulatory framework these two documents are considered to be of high priority. Compliance with the requirements of these documents will ensure a high level of radiation protection of workers in uranium mines, tailings facilities, as well as protection of the public and the environment through implementation of up-to-date principles of the radiation protection. It is anticipated that the draft documents will then be approved according to Ukrainian legal processes.

MEDICINE Project

The overall objective of the Project is to help the regulatory authorities of Ukraine to update the regulatory basis for nuclear and radiation safety in medicine in accordance with the international safety recommendations and guidance.

Two draft regulatory documents establishing systematized radiation safety requirements in medicine in Ukraine will be developed within the Project:

- General Provisions on Radiation Safety in Medicine - will establish objective, principles, safety criteria, as well as safety requirements for medical exposure;
- Radiation Protection and Safety in Brachytherapy - will establish objective, safety principles, and criteria of personnel and patients protection against radiation risks in Brachytherapy.

These safety requirements will be based on general safety principles and take account of the IAEA's International Safety Standards and relevant recommendations of the ICRP.

WASTE Project

The objective of the project is to develop two high-level regulations, establishing systematized nuclear and radiation safety requirements, to be met at mutually agreed RW management stages before and during disposal.

- Regulation "General Safety Provisions for Predisposal RW Management" will establish objective, principles, safety criteria, as well as safety requirements for coordinated RW management stages prior the radioactive waste disposal.
- Regulation "General Safety Provisions in Disposal of Radioactive Waste" will establish objective, safety principles, and criteria for human and environment protection against radiation risks from RW disposal facilities during their operation and after closure.

The efforts are aimed at updating the regulations according to the latest international recommendations and improving the effectiveness of safety regulation during RW management at RW generation sites and at sites for RW processing, long-term storage, and disposal. It is envisaged that the draft regulations will adopt a graded approach to safety regulation. Compliance with requirements of these regulatory documents will contribute to improving safety of current practices of radioactive waste management before and during disposal taking into account the interdependence of radioactive waste management stages.

All three projects are due for completion at the end of 2016 and output will be subject to review by NRPA experts and others, as appropriate.

Apart from this on-going work, proposals for further cooperation activities are in preparation, based on the results of the regulatory threat assessment. These cover the following topics:

- "Creation of an Information and Analytical Platform to Support Emergency Preparedness of SNRIU Emergency Centers"
- "Radioactive Waste Management and Decommissioning"
- "Development of safety requirements for management of radiation sources in line with IAEA's International Basic Safety Standards and wider international recommendations and regulatory practice"

9.3 Overall strategic direction and long-term objectives

The overall objective of NRPA's bilateral activities is to contribute to the safe management of nuclear legacy and technology applications through development of a robust and independent regulatory process supported by a broadly based and enhanced safety culture. This includes strengthening the skills and competence of staff in the relevant regulatory authorities, as well as widening their access to experience and practice in other countries, typified by the report of an international workshop reported in [87]. This sharing of experience can be of great benefit to experts from all the countries involved.

The first phase of cooperation between the NRPA and SNRIU reported here has focused on identifying priorities for enhanced regulatory documentation and preparation of relevant drafts, covering protection of workers, the public and the environment.

When this phase has progressed appropriately, the next step will be to work on the practical application of the new and enhanced regulations and guidance, so as to provide effective and efficient regulatory supervision of industrial and other activities connected with the use of radioactive material and ionizing radiation.

- As the presentations and discussion reported in reference [87] suggest as relevant, key features of this application work are planned to include the following. Regulation of the application of the principle of optimization to radiation hazards while also taking into account other physical and toxicity related hazards, so as to take a holistic view of the risks involved.
- Development and application of effective stakeholder engagement and communication strategies.
- Improvement and use of scientific information to support and build confidence in radiological and other assessments used to support regulatory decisions.
- Development of a common understanding of and willingness to apply the concept of safety culture

The success in all these areas among other things depends on coordinated actions of the SNRIU in cooperation with other relevant Ukrainian regulatory authorities and governmental agencies.

10 Conclusions

Positive experience in the early stages of bi-lateral regulatory cooperation between the NRPA and regulatory authorities in other countries was achieved through the carrying out of Regulatory Threat Assessments. A Regulatory Threat Assessment is a study to identify the most significant nuclear and radiation threats which require the most urgent and significant improvements regarding their regulatory supervision. Regulatory supervision is defined here as the regulatory framework and the measures adopted to ensure that the framework is implemented.

The Ukrainian regulatory threat assessment carried out by the SNRIU with support from NRPA experts consisted of a comprehensive analysis of the SNRIU's activities, as a central executive authority entrusted with ensuring safety of the public, environment, nuclear installations and radiation sources.

The threat assessment identified priorities for regulatory improvement in the areas of safety of nuclear installations, radioactive materials transport, emergency preparedness and response, radioactive waste management and decommissioning, and radiation safety. The results have given a holistic overview of the current situation in Ukraine in the area of nuclear and radiation safety legislation, and provided a solid basis for further bilateral regulatory cooperation projects which are now in progress or in planning.

The first phase of cooperation between the NRPA and SNRIU reported here has focused on identifying priorities for enhanced regulatory documentation and preparation of relevant drafts, covering protection of workers, the public and the environment.

When this phase has progressed appropriately, the next step will be to work on the practical application of the new and enhanced regulations and guidance, so as to provide effective and efficient regulatory supervision of industrial and other activities connected with the use of radioactive material and ionizing radiation. As the presentations and discussion reported in reference [87] show, key features of this application work are planned to include the following:

- Regulation of the application of the principle of optimization to radiation hazards while also taking into account other physical and toxicity related hazards, so as to take a holistic view of the risks involved.
- Development and application of effective stakeholder engagement and communication strategies.
- Improvement and use of scientific information to support and build confidence in radiological and other assessments used to support regulatory decisions.
- Development of a common understanding of and willingness to apply the concept of safety culture

To achieve success in all these areas will require coordination and cooperation between the SNRIU with other relevant Ukrainian regulatory authorities and government agencies. It is anticipated that this work will benefit from further interaction with international organizations and other authorities in other countries. At the same time, experience in Ukraine will be of value to other experts and contribute to the continuous improvement of international recommendations and guidance.

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