UKRAINE

NATIONAL REPORT

On Compliance of Ukraine with Obligations under the Convention on Nuclear Safety

KYIV 2019

FOREWORD

Ukraine signed the Convention on Nuclear Safety 20 September 1994 and carried it into effect by the Law of Ukraine "On Ratification of the Convention on Nuclear Safety" on 17 December 1997.

Ukraine took an active part in review of the National Reports of the Contracting Parties, exchange of written questions and comments, as well as discussions during the seven Review Meetings.

This Eighth National Report has been developed in full compliance with the Convention on Nuclear Safety and Guidelines Regarding National Reports under the Convention on Nuclear Safety (International Atomic Energy Agency, Information Circular INFCIRC/572/Rev. 6, 7 February 2017).

By submitting this National Report, Ukraine completely fulfils its obligations set forth in Article 20 of the Convention on Nuclear Safety.

This Report, as the previous ones, is the result of joint efforts of Ukrainian state authorities responsible for implementation of the state nuclear energy policy and state enterprises (operating organisations):

- National Nuclear Energy Generating Company *Energoatom*;
- State Specialised Enterprise *Chornobyl NPP*.

This Report is based on the legislative and regulatory documents in force in Ukraine and official reports of the central executive bodies implementing the national nuclear energy policy.

The objective of this Report is to provide impartial and unbiased information on the safety of nuclear installations and on the measures implemented to enhance its level and protect the public and the environment of Ukraine, as well as to highlight changes and progress in the development of legislative and regulatory framework and in the nuclear energy sector of Ukraine over the last three years.

Based on the information presented in this National Report and in accordance with the authorities granted by the Cabinet of Ministers of Ukraine, the Chairman of the State Nuclear Regulatory Inspectorate of Ukraine declares the following:

- the priority of human safety and environmental protection is adhered to in the use of nuclear energy in Ukraine.

In this context, Ukraine completely fulfils its obligations under the Convention on Nuclear Safety as confirmed by:

- development of the legislative and regulatory framework to ensure the safe use of nuclear energy;
- establishment of the duly authorised state nuclear regulatory body, which sets safety criteria and requirements, develops and approves regulations and standards on nuclear and radiation safety and conducts licensing and state oversight independently of licensees and other state authorities;

- independence of the state nuclear regulatory body from any governmental bodies, institutions and officials dealing with nuclear energy and independence from the local authorities, self-administrations and associations of citizens;
- comprehensive safety assessments of existing nuclear installations and safety improvement measures;
- development of the emergency preparedness and response system;
- full responsibility of the licensee for ensuring safety and taking measures to protect the public and the environment;
- development of safety culture and implementation of safety self-evaluation practices.

The data in this Report, except as otherwise stated, are provided as of June 2019. The changes that may take place by March 2020 will be additionally reported by the delegation of Ukraine at the Eighth Review Meeting.

Kyiv, June 2019

Hryhorii Plachkov

Chairman of the State Nuclear Regulatory Inspectorate of Ukraine

TABLE OF CONTENTS

ABBREVIATIONS AND ACRONYMS

AMP	Ageing Management Programme
C(I)SIP	Comprehensive (Integrated) Safety Improvement Programme for Nuclear Power Plants
CCR	Central Control Room
CDF	Core Damage Frequency
ChNPP	Chornobyl Nuclear Power Plant
CPRAC	Center for Prediction of Radiological Accident Consequences
CSFSF	Centralised Spent Fuel Storage Facility for WWER NPPs in Ukraine
DerzhTsentrYakosti	State Center for Quality Regulation of Supplies and Services
DSF	Damaged Spent Fuel
DSFSF	Dry Spent Fuel Storage Facility
DSS	Decision Support System
EBRD	European Bank for Reconstruction and Development
ECCS	Emergency Core Cooling System
EIA	Environmental Impact Assessment
EIC	Emergency Information Center
Energoatom	National Nuclear Energy Generating Company *Energoatom*
EOP	Emergency Operating Procedure
Euratom	European Atomic Energy Community
GPET	General Plant Emergency Training involving *Energoatom* Top Management
HPIS	High-Pressure Injection System
IAEA	International Atomic Energy Agency
ICRP	International Commission for Radiological Protection
IMS	Integrated Management System
ISE	Interim Spent Fuel Storage Facility
KADO	Online Radiological Analysis Software Package
KhNPP	Khmelnitsky Nuclear Power Plant
LERF	Large Early Release Frequency
LPIS	Low-Pressure Injection System
MCR	Main Control Room
NEURC	National Energy and Utilities Regulatory Commission
NPP	Nuclear Power Plant
NRS	Nuclear and Radiation Safety
NSC	New Safe Confinement
NSDC	National Security and Defence Council of Ukraine
PSA	Probabilistic Safety Assessment
PSRR	Periodic Safety Review Report
QMS	Quality Management System
Radwaste	Radioactive Waste
RNPP	Rivne Nuclear Power Plant
SAMG	Severe Accident Management Guideline
SAR	Safety Analysis Report
SESU	State Emergency Service of Ukraine
SFP	Spent Fuel Pool
SG	Steam Generator

SIP	Shelter Implementation Plan
SNRIU	State Nuclear Regulatory Inspectorate of Ukraine
SSE ChNPP	State Specialised Enterprise *Chornobyl NPP*
SSTC NRS	State Scientific and Technical Center for Nuclear and Radiation Safety
SUNPP	South Ukraine Nuclear Power Plant
UCPS	Unified State Civil Protection System
WANO	World Association of Nuclear Operators
WENRA	West European Nuclear Regulators Association
WWER	Water-Cooled Water-Moderated Power Reactor
ZNPP	Zaporizhzhya Nuclear Power Plant

INTRODUCTION

The years that have passed since the Seventh Review Meeting of the Contracting Parties to the Convention were full events that would influence the assurance of nuclear and radiation safety in our country not only in the near future but would also have long-term consequences.

The signature of the Ukraine–European Union Association Agreement in 2015 initiated efforts on the implementation of EU nuclear law into the Ukrainian legislation.

In compliance with the implementation plans that were subsequently approved by the Ukrainian Government in 2015 and 2017, the SNRIU made considerable efforts to implement EU nuclear legislative acts in 2015–2019. They are as follows:

- Council Directive 2013/59/Euratom laying down basic safety standards for protection against the dangers arising from exposure to radiation;
- Council Directive 2006/117/Euratom on the supervision and control of shipments of radioactive waste and spent fuel;
- Council Directive 2014/87/Euratom establishing a Community framework for the nuclear safety of nuclear installations.

On 26 March 2015, the State Nuclear Regulatory Inspectorate of Ukraine became a full member of WENRA, which was the main step in Ukraine's transfer to EU standards in the regulation of nuclear and radiation safety. The participation in WENRA allows Ukraine to improve national legislation on nuclear and radiation safety in accordance with the WENRA reference levels and to take part in their development.

The Report presents information on the improvement of the regulatory and legal framework on nuclear and radiation safety of Ukraine.

The efforts are ongoing to improve authorising procedures and bring them into compliance with the laws adopted in Ukraine, considering international documents and best practices of other countries. A series of draft laws were developed to reduce the regulatory pressure and resolve the issues caused by ignoring the peculiarities of nuclear activities in the deregulation process.

As of 2019, there are 15 WWER power units in operation at four NPPs in Ukraine. Three power units of the Chornobyl NPP are under decommissioning. The Chornobyl Shelter is being transformed into an environmentally safe system. The power units and their main features are listed in Annex 1.

Ukraine makes considerable efforts to deal with the following important issues:

- safety upgrading of operating NPPs;
- lifetime extension of operating NPPs based on safety reviews, determination of residual lifetime, implementation of safety upgrades and ageing management of systems and equipment important to safety;
- diversification of nuclear fuel suppliers for NPPs;
- spent fuel management;
- Chornobyl NPP decommissioning and Shelter transformation into an environmentally safe system.

Implementation of safety improvement measures during the period under review was based on C(I)SIP approved by the Cabinet of Ministers of Ukraine by Resolution No. 1270 dated 7 December 2011 and aimed at:

- enhancing NPP operational safety;
- minimising risks of NPP accidents in case of natural events or other hazards;
- improving the management of design-basis accidents and beyond-design-basis accidents at NPPs and mitigating their consequences.

The C(I)SIP includes the safety improvement measures identified upon safety analyses and IAEA recommendations on the enhancement of design safety of Soviet-design reactors. C(I)SIP was also supplemented with measures to implement recommendations of international experts upon comprehensive safety assessment of Ukrainian NPPs within the Joint EC–IAEA–Ukraine Project and post-Fukushima measures identified upon the stress tests.

The C(I)SIP measures enhance the operational safety of NPPs in compliance with international standards.

The diversification of nuclear fuel supplies for Ukrainian NPPs, including regulatory support, remains a strategic area. In 2015, the SNRIU reviewed a package of the operator's documents that justify potential extension of trial operation of the Westinghouse nuclear fuel to other Ukrainian NPPs. The trial operation of FA-WR was started at SUNPP Unit 3 in 2015. As of the end of 2018, FA-WR were also loaded to SUNPP Unit 2 and ZNPP Units 1, 3, 4 and 5 within extended trial operation. The core of SUNPP Unit 3 was operated only with FA-WR in 2018 after the refuelling outage. Upon positive results for operation of this fuel loading, a decision will be made on transfer to FA-WR commercial operation.

The construction of NSC above destroyed ChNPP Unit 4 and its transformation into an environmentally safe system, one of the most significant projects, has proceeded to its final stage. The installation of the NSC arch into its design position above the Shelter in November 2016 was an important stage in the NSC project implementation. The construction of the dry spent fuel storage facility on the Chornobyl site is in its final stage. The dry storage facility is to be completed and the so-called hot tests are to be started at the end of 2019.

Chornobyl NPP Units 1-3 are under decommissioning. Since the accident in April 1986, Chornobyl NPP Unit 4 has been referred to as the Shelter.

In ratifying the Convention on Nuclear Safety in 1997, the Verkhovna Rada (Parliament) of Ukraine declared that Article 3 of the Convention would not apply to the Shelter.

General information on activities at Chornobyl NPP Units 1-3 and the Shelter is provided in Annexes 8 and 9 to this Report.

Taking into account ongoing armed conflict in eastern Ukraine, the SNRIU together with relevant ministries and administrations continued efforts on enhancing the physical protection of nuclear installations. At present, law-enforcement institutes are able to ensure NPP protection against external actions, such as armed aggression, sabotages, terroristic acts and criminal assaults.

SUMMARY

This Report covers the following main aspects that were addressed in the previous National Report of Ukraine and require further consideration:

- improving the system of NRS regulations and standards (para. 7.2.1);
- implementing measures for training and professional development of the state nuclear regulatory body's staff (ARTICLE 8 Section);
- proceeding with NPP safety improvement measures (ARTICLE 6 Section);
- updating Safety Analysis Reports to incorporate completed activities (ARTICLE 6 Section; ARTICLE 14 Section, para. 14.1);
- constructing CSFSF for WWER spent fuel (ARTICLE 17 Section, para. 17.4);
- proceeding with in-depth safety analysis of NPPs (ARTICLE 14 Section, para. 14.1).

This Report also takes into account results of the Seventh Review Meeting of the Contracting Parties regarding further provision of information on issues that are of interest for all Parties to the Convention on Nuclear Safety, considering the Report of the IAEA Secretariat to the Contracting Parties, Synopsis of the Relevant IAEA Requirement Statements Reflecting the Issues Addressed by Articles 6 to 19 of the Convention on Nuclear Safety (Synopsis).

This Report does not provide any information on the Synopsis-related matters that was included in the previous Reports that Ukraine submitted to the attention of the Parties.

Compliance with the Vienna Declaration on Nuclear Safety

The Vienna Declaration on Nuclear Safety was adopted at the Diplomatic Conference on 9 February 2015. The Vienna Declaration on Nuclear Safety sets forth principles to be met by the Contracting Parties in implementing the objectives of the Convention on Nuclear Safety to prevent accidents and mitigate radiological consequences.

Principle 1: new nuclear power plants are to be designed, sited and constructed in consistency with the objective of preventing accidents in the commissioning and operation and, should an accident occur, mitigating possible releases of radionuclides causing long-term off-site contamination and avoiding early radioactive releases or radioactive releases large enough to require long-term protective measures and actions.

Ukraine is taking efforts to improve the system of national regulations and to incorporate to the extent possible the principles of the Vienna Declaration and IAEA and WENRA recommendations.

To implement the objective of preventing accidents, the following measures are to be considered in the design and safety verification of existing NPP units:

- all natural and man-induced site-specific hazards are to be addressed at the design stage, by conducting special analyses to justify the characteristics of these hazards and consider combinations of external hazards using a conservative approach. For the most significant hazards, justified margins are to be accounted for in safety assessments (seismic events, floods, tornados);
- qualification of NPP components (equipment and building constructions) for harsh environments and seismic impacts is to be confirmed;
- defence in depth including five levels with specific measures at each of the levels is to be ensured;
- design-basis accidents are to be prevented and, should a design-basis accident occur, safety measures that rely on safety systems designed in different

redundant trains using the train independence principle and measures to prevent potential common-cause failures using the diversity and physical separation principles are to be implemented;

- design extension conditions are to be considered in the design process, which requires considering of a number of failures and ensuring the proper level of safety. Practical elimination of an accident involving core damage at high pressure is one of the required conditions;
- based on analysis of exiting design features and operating experience for existing NPPs, C(I)SIP was developed and is under implementation, including, inter alia, measures to prevent accidents and mitigate their consequences.

Technical criteria and standards are used to mitigate consequences of potential radiological accidents:

- national regulations that establish NRS requirements primarily focus on preventing radiological impacts on the environment, the public and plant personnel that would exceed the criteria defined in national regulations;
- the above-stated principles for the design of systems incorporate requirements for systems that ensure confinement of radioactive substances within established boundaries and integrity of these systems (implementation of containment overpressure protection systems in case of beyond design-basis accidents, hydrogen safety measures etc.);
- technical decisions and organisational measures are taken to prevent severe accidents and mitigate their consequences including accidents involving station blackout, failure of heat removal to the ultimate heat sink and their combinations. The prevention or mitigation of these initiating events requires the use of special systems or equipment that are to be as independent of other design systems as possible;
- human actions in the event of occurrence and development of beyond design-basis and severe accidents are identified in special operating documents (EOP, SAMG) that have been developed and verified for each NPP unit;
- special measures for protection of personnel, the public and the environment in emergencies and accidents have been developed for each Ukrainian NPP. The measures have been implemented considering interaction of respective state structures.

Principle 2: comprehensive and systematic safety assessments are to be carried out periodically and regularly for existing installations throughout their lifetime in order to identify safety improvements that are oriented to meet the above objective. Reasonably practicable or achievable safety improvements are to be implemented in a timely manner.

Modern national requirements and regulatory principles on NRS of existing NPPs are aimed at complying with safety objectives and principles that fully meet the process for NPP safety verification.

If some safety issues were not addressed in the design, construction, commissioning and operation, activities are conducted on a permanent basis to bring the NPP units into compliance with new regulatory requirements. These activities are also carried out during of periodic safety assessment of Ukrainian NPPs.

When new regulatory documents on NRS are implemented, the operator in accordance with regulatory requirements shall develop a plan for bringing of the existing power units into compliance with the new regulatory document based on the analysis of differences and agree the plan with the SNRIU.

The safety measures under C(I)SIP are implemented to ensure that the safety achieved at Ukrainian NPPs complies with the NRS regulations in force and the principles set forth in the Vienna Declaration on Nuclear Safety (see ARTICLE 6 Section).

The most important aspects in implementing the principle of the Vienna Declaration for existing NPPs include activities (planned and completed) to take the following measures at Ukrainian NPPs:

- containment protection in the event of accidents by introducing hydrogen control and removal systems, containment filtered venting systems and other measures;
- emergency power supply from independent mobile diesel generators;
- heat removal from the reactor core and SFP when this function can be performed by design systems, using mobile pumps for makeup of SG and SFP;
- SAMGs (for full and low power levels) containing human actions for various severe accident scenarios, which have been developed and implemented for all NPPs.

National requirements and regulations in force govern the scope and timeframes for periodic comprehensive and systematic safety assessments of existing NPPs. Ukrainian regulations in force establish requirements for periodic safety review whose results are finalised in the PSRR (see para. 14.1):

- General Safety Provisions for Nuclear Power Plants, NP 306.2.141-2008;
- Requirements for Periodic Safety Review of Nuclear Power Plants, NP 306.2.214-2017;
- General Requirements for Long-Term Operation of NPP Units upon Results of Periodic Safety Review, NP 306.2.099-2004;
- Requirements for Safety Assessment of Nuclear Power Plants, NP 306.2.162-2010;
- General Requirements for Ageing Management of Components and Structures and Long-Term Operation of NPP Units, NP 306.2.210-2017.

These regulations establish specific requirements for periodic safety reviews of NPPs.

A regulatory requirements for periodic safety review (NP 306.2.214-2017) was approved in 2017, which incorporates Ukrainian experience in periodic safety reviews appropriate international experience presented, in particular, in IAEA publications.

Pursuant to the regulations:

- periodic safety review of power units is carried out every 10 years. The review results serve as a basis for PSRR development;
- periodic safety review is based on a comprehensive analysis of safety factors to justify the potential and period for further operation of power units;
- measures are identified and justified upon safety review to be implemented to maintain the required safety level for each safety factor.

Principle 3: national requirements and regulations for addressing this objective throughout the lifetime of nuclear power plants are to take into account the relevant IAEA Safety Standards and, as appropriate, other good practices as identified inter alia in the Review Meetings of the Convention on Nuclear Safety.

The Ukrainian NRS regulations in force comply with up-to-date IAEA standards. In addition, the programme for improving the NRS regulatory framework is under way (see paras. 7.2.1 and 8.1). In the framework of these activities:

- a number of regulations that were developed and introduced in the Soviet era are being replaced;

- a number of regulations are being improved to incorporate NPP operating experience;
- regulations are under improvement to incorporate provisions of updated IAEA standards and EU directives.

COMPLIANCE WITH ARTICLES 6-19

ARTICLE 6 Existing Nuclear Installations

Each Contracting Party should take the appropriate steps to ensure that the safety of nuclear installations existing at the time the Convention enters into force for that Contracting Party is reviewed as soon as possible.

When necessary in the context of this Convention, the Contracting Party should ensure that all reasonably practicable improvements are made as a matter of urgency to upgrade the safety of the nuclear installation. If such upgrading cannot be achieved, plans should be implemented to shut down the nuclear installation as soon as practically possible. The timing of the shutdown may take into account the whole energy context and possible alternatives as well as the social, environmental, and economic impact.

After shutdown of the last Chornobyl NPP unit, Ukraine operates only WWER-type nuclear power plants.

Ukrainian NPPs operate WWER reactors including 11 WWER-1000/V-320 power units, one WWER-1000/V-302 unit, one WWER-1000/V-338 and two WWER-440/V-213 (nuclear installations are listed in Annex 1).

The share of electricity generated at NPPs remained high (above 50%) in 2018 in the total power production in Ukraine.

Since the 1980s, the operator has been implementing respective measures under safety improvement programmes to enhance safety. Major safety improvement programmes currently in effect are listed in Annex 2.

After the Chornobyl catastrophe, safety improvement programmes were developed to be implemented at Ukrainian NPPs. They included measures to bring the power units into compliance with new safety regulations, rules and standards, IAEA recommendations on safety improvement, operating experience, safety analyses and the operator's commitments on safety enhancement to international organisations. Based on analysis of operating experience, safety assessment and additional IAEA recommendations, these programmes were supplemented with individual measures.

The Comprehensive (Integrated) Safety Improvement Programme that was approved by the Government in 2011 is currently under way.

The C(I)SIP objective is to:

- bring the designs of operating NPPs into compliance with up-to-date national and international safety standards;
- prevent accidents in the event of natural disasters or other hazards and mitigate their consequences;
- improve the management of design-basis and beyond design-basis accidents at NPPs and minimise their consequences.

C(I)SIP passed state regulatory review in 2010 and was agreed by the SNRIU upon positive review results. In addition, C(I)SIP was additionally reviewed (within INSC Project UK/RA/07 Subtask 6.2) by the RISKAUDIT international expert organisation. The RISKAUDIT experts confirmed in their statement that all IAEA recommendations provided previously were incorporated in C(I)SIP.

As recommended by the National Report of Ukraine on Stress-Test Results and its peer review, *Energoatom* developed additional safety improvement measures that were included in the C(I)SIP.

To implement C(I)SIP, the operator ensured planning and funding, continuously monitored its progress, organised reporting (annual, quarterly and monthly for each measure), and developed and keeps a database on programme implementation status.

The C(I)SIP implementation progress is continuously supervised by the SNRIU, Ministry of Energy and Coal Industry, Cabinet of Ministers of Ukraine and SESU.

All C(I)SIP measures were to be implemented in 2012-2020, However, because of delays in obtaining the EBRD/Euratom loan for partial funding of C(I)SIP, difficulties in tendering for procurement of equipment and supplementation of the programme with post-Fukushima measures, the programme was extended by Resolution of the Cabinet of Ministers of Ukraine until 2023. *Energoatom*'s priority is to implement programme measures at power units for their long-term operation and post-Fukushima measures.

The number and content of C(I)SIP measures changed and are changing to incorporate results of safety assessments, operating experience, new research findings in the area of safety and recommendations of international experts to resolve technical difficulties and find optimal solutions.

The C(I)SIP included measures in the following areas.

1. Implementation of the IAEA recommendations related to resolution of safety issues determined in the IAEA reports.

The following reports were developed after the Chornobyl accident: Safety Issues and Their Ranking for WWER-1000 Model 320 Nuclear Power Plants (IAEA-EBP-WWER-05), Safety Issues and Their Ranking for Small Series WWER-1000 Nuclear Power Plants (IAEA-EBP-WWER-14) and Safety Issues and Their Ranking for WWER-440 Model 213 (IAEA-EBP-WWER-03).

The above IAEA recommendations have been implemented for all WWER-440/213, WWER-1000/302, 338 units and are in the final implementation stage at WWER-1000/320 units. To resolve safety issues identified in the above reports, the operator implemented a significant number of safety upgrades. In particular, they included measures on improvement of control rod insertion reliability (RC2), reactor pressure vessel embrittlement and monitoring (CI1), application of non-destructive testing (visual, ultrasonic, eddy current) (CI2), elimination of ECCS sump screen blocking and replacement of primary equipment insulation at all reactors (S5), replacement of steam generator pilot-operated relief valves at all V-320 power units (S9), replacement of storage batteries and uninterruptible power supply sources with expired lifetime at all power units (El5), backup of the reactor protection system (I&C5), fire prevention (IH2), qualification of equipment for V-302/338 units etc.

2. Measures identified in the final report on evaluation of Ukrainian power units for compliance with IAEA international standards.

The evaluation was carried out within the Joint EC–IAEA–Ukraine Project (2007-2010).

The Joint Project was initiated within the Memorandum of Understanding on Cooperation in the Field of Energy between the European Union and Ukraine singed on 1 December 2005. In the framework of this project, IAEA experts conducted 14 missions at all Ukrainian NPPs in 2008-2009 to carry out a unique (in scope) comprehensive evaluation of Ukrainian NPPs with IAEA standards. The evaluation covered the following areas:

- plant design safety;
- plant operational safety;
- radwaste management and decommissioning;
- regulatory aspects.

62 international experts from 23 countries and international organisations and 32 IAEA experts took part in the project. The experts confirmed that compliance with IAEA requirements was ensured in all areas. Incomplete compliance was found only for five aspects: equipment qualification, severe accident analysis and SAMG development, design seismic resistance, completion of SAR development and post-accident monitoring. The final report pointed out that all these issues were successfully resolved within the current safety improvement programme.

3. Measures developed upon stress tests after the Fukushima-Daiichi accident.

After the Fukushima Daiichi accident, *Energoatom* conducted extraordinary targeted safety assessment of Ukrainian NPPs (stress tests) in line with the decisions adopted by the NSDC at the meeting of 8 April 2011, which were enacted by Presidential Decree No. 585/2011 dated 12 May 2011.

Based on the stress tests, a list of measures for prevention of severe accidents similar to that at the Fukushima-Daiichi NPP was complied. These measures are to be implemented for NPP long-term operation and are intended to:

- ensure resistance to an earthquake for equipment, piping, buildings and structures required for critical safety functions: provide reactor safe shutdown and keep the reactor in safe condition, ensure heat removal from the reactor core and spent fuel pool, prevent radioactive releases to the environment;
- ensure performance of equipment important to safety in harsh environments;
- implement containment filtered venting systems at WWER-1000 NPPs for forced steam and gas release from the containment;
- implement measures to ensure emergency makeup of steam generators (reactor secondary system cooldown) and spent fuel pools under conditions of station blackout (SBO) and/or loss of ultimate heat sink, ensure emergency supply of essential service water;
- implement severe accident management guidelines addressing possible severe fuel damage both in the core and in the spent fuel pool, and symptom-based EOPs for low-power operation mode.

These measures were included into the National Action Plan following the stress tests, which was approved by SNRIU Board Resolution No. 8 dated 5 March 2013. The National Action Plan was developed by the SNRIU and presented at the ENSREG working meeting in Brussels on 22-26 April 2013. Ukraine presented a report on implementation of updated National Action Plan in Brussels in April 2015.

In 2017, the National Action Plan was updated again and the number and scope of measures were not changed. The current state and deadlines of the measures were specified.

Energoatom carries out a series of measures to improve NPP seismic resistance:

- equipment qualification is under completion;
- confirmation of piping and structure robustness under potential seismic impacts is ongoing;
- seismic surveys and introduction of systematic seismic monitoring are under completion at ZNPP, KhNPP and RNPP sites (completed for SUNPP). The seismic monitoring system has been commissioned at ZNPP and seismic data are collected and the seismic monitoring system is to be implemented at KhNPP in 2019.

To implement additional safety improvement measures upon stress-test results and to ensure a uniform engineering approach, *Energoatom* developed appropriate industrial conceptual decisions and agreed them with the SNRIU. These decisions deal with the

strategy of SBO accident mitigation using mobile diesel generators, mobile pumping units and motor pumps for each reactor design at Ukrainian NPPs (V-213, V-302/338, V-320). Mobile equipment has been introduced at all power units except for ZNPP-5, 6, SUNPP-3 and KhNPP-1, where post-Fukushima measures are to be completed in 2019.

159 (67%) post-Fukushima measures under C(I)SIP have completed out of the 238 measures; 34 (14%) post-Fukushima measures are to be completed in 2019 and 45 (19%) remaining measures in 2020. All post-Fukushima measures are to be completed by 2020.

In addition, a series of measures to upgrade the emergency response system are under way at NPPs:

- system for prompt radiological analysis in the NPP location area has been implemented;
- NPP radiation safety departments have been additionally equipped with mobile laboratories for radiological monitoring and individual dose monitoring;
- additional measures on uninterrupted operation of communications within NPP sites and communications between NPPs and the SNRIU and *Energoatom* emergency centres are being implemented;
- mobile power sources are being provided;
- for national-level accidents or accidents associated with transboundary radionuclide transfer, development of the innovative interagency RODOS-Ukraine real-time decision support system (DSS) based on the European RODOS system was completed within the European Commission Instrument for Nuclear Safety Cooperation (INSC) in Ukraine in June 2016; *Energoatom* introduced RODOS DSS into commercial operation by Order No. 87 of 26 January 2017 (as part of the national RODOS-Ukraine system).

Detailed information on the resolution of safety issues and compliance with international obligations of Ukraine on implementation of safety improvement measures is provided in Annex 3.

The safety level of Ukrainian NPPs is high, as confirmed by results of the safety improvement measures.

The SARs developed for all Ukrainian NPPs (detailed information is provided in ARTICLE 14 Section) and agreed by the SNRIU allow the following conclusions:

- power units are operated in a safe manner. The submittals prove that the requirements for reactor safety imposed by the design, scientific and technical documentation and international practices are adequately fulfilled;
- the operator analysed deviations from current regulatory requirements and identified appropriate compensatory actions to allow operation of power units within design limits without their shutdown for eliminating the deviations;
- implementation of safety upgrades already resulted in decrease in CDF and LERF for all NPP units.

The positive conclusions of SARs on the safety of Ukrainian NPPs agree with expert findings of international safety evaluation missions at Ukrainian NPPs within international cooperation (OSART, SALTO, PROSPER, WANO missions).

Implementation of safety improvement measures is a precondition for NPP long-term operation. The decisions on further safe long-operation of power units were and are made by the SNRIU on the basis of state NRS review of PSRR, implementation of safety improvement measures and comprehensive inspection of the power units.

From 2015 to 2018, the SNRIU adopted decisions on long-term operation of Zaporizhzhya Units 1-4, Rivne Unit 3 and South Ukraine Unit 2. Based on state NRS review of PSRR and results of public hearings conducted to discuss long-term operation,

the SNRIU concluded that the safety of long-term operation of these power units at declared power levels was justified and renewed the licences for their operation.

For all power units whose design-basis life expired in 2013–2018, *Energoatom* selected the 'second option' of long-term operation (in accordance with requirements of NP 306.2.099-2004 "General Safety Requirements for NPP Long-Term Operation Based on Periodic Safety Review"): power unit shutdown after expiration of its design-basis life and implementation of organisational and technical measures to continue lifetime and proceed to long-term operation.

At the end of 2018, Khmelnitsky Unit 1 was shut down for completion of all activities required for transfer to long-term operation. Activities associated with technical condition assessment and lifetime extension of equipment, piping and civil structures are carried out in compliance with the agreed licensing plan and measures of the long-term operation programme.

Upon results of these measures, a decision will be made in 2019 on the potential and period of long-term operation for Khmelnitsky Unit 1.

The required condition for long-term operation of an NPP unit is to develop and implement AMP. Ageing management is a system of technical and administrative measures implemented to keep the degradation of structures and systems (components) caused by their ageing and wear below acceptable limits. AMP and list of components and structures subject to ageing management have been developed for each NPP unit. Ageing management of a specific component or structure proceeds as follows: determination of degradation mechanism – determination of ageing effect – location of ageing effect on a component or structure – methods and tools to monitor degradation – analysis of monitoring results – measures to mitigate/keep degradation within limits – analysis of ageing management programme for effectiveness.

Effectiveness of the ageing management programmes is assessed by the operating organisation and evaluated by the regulatory body. In addition, the ageing management programmes are evaluated by international experts. Such evaluation was carried out within the Pre-SALTO mission at SUNPP-3 in 2018. The IAEA experts recognized the development of the "Book of Operational Defects in WWER NPP Steam Generator Heat-Exchange Tubes" as a good practice. They also additionally recommended to extend this practice to all WWER NPPs operating the same type of steam generators.

In the framework of the European integration process, Ukraine actively implements measures aimed at implementing European Union legislation into the national regulatory framework.

Updated Nuclear Safety Directive 2014/87/EURATOM is one of the European Union directives whose provisions are to be implemented in the Ukrainian legislation. In compliance with Article 8e of this Directive, each Member State of the European Union shall take place in topical peer reviews in specific technical safety areas. The first topical peer review in the area of ageing management took place in 2017 and covered NPP units and research reactors with power over 1 MW (that were in operation as of 31 December 2017 or in construction as of 31 December 2016).

The objective of the first topical peer review was to exchange information between the participating countries on ageing management of components and structures of nuclear installations, identify good practices and common issues and develop an action plan for improvement of the regulatory and legislative framework and practices in this area.

Results from the analysis of ageing management issues in Ukraine were set forth in the "National Report on the First Topical Peer Review on Ageing Management" and

approved by SNRIU Board Resolution in November 2017. The report is placed on the ENSREG website at http://www.ensreg.eu/sites/default/files/attachments/ukraine.pdf. According to the analysis of ageing management in Ukraine presented in the Report, the following can be stated from the regulatory perspective:

- The existing regulatory and legislative framework of Ukraine regarding ageing management requirements complies with IAEA and WENRA recommendations and documents. This was confirmed by independent reviews carried out by western experts within international projects.
- The ageing management activities are carried out on a regular basis and appropriately recorded in electronic databases.
- The ageing management approach relies on the understanding of ageing effects and prediction of degradation of components and structures.
- The AMP development and implementation are a necessary condition to proceed with power unit long-term operation.

Thus, the measures implemented by the operator in the reporting period will assure implementation of Ukraine's international obligations on safety improvement of operating Ukrainian NPPs.

The completed efforts ensure that Ukrainian NPPs can be operated in a safe manner over their design-basis and long-term lifetime.

Therefore, Ukraine complies with the provisions of Convention Article 6.

ARTICLE 7 Legislative and Regulatory Framework

Each Contracting Part shall establish and maintain a legislative and regulatory framework to govern the safety of nuclear installations.

The legislative and regulatory framework shall provide for:

7.1 Establishment and regulatory support

The Ukrainian nuclear safety legislation governs all relations associated with the use of nuclear energy and assurance of nuclear and radiation safety.

The Law of Ukraine "On Nuclear Energy Use and Radiation Safety" is a fundamental document in this area, which was adopted in 1995 and further amended and supplemented. The document establishes the priority of human safety and environmental protection. The Law identifies the main tasks of nuclear legislation, principles of state nuclear policy, rights and obligations of citizens in the use of nuclear energy and competences of state management bodies in nuclear energy use and radiation safety and provides for state regulation of safety in the use of nuclear energy.

7.2.1 National safety requirements and regulations

In compliance with Article 22 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety", SNRIU as a state nuclear regulatory authority establishes regulatory criteria and requirements to define safety conditions for operation of nuclear installations and use of radiation sources (rule-making). The same Law (Article 8) determines that national safety requirements and regulations are adopted taking into account recommendations of international organisations in the field of nuclear energy. Procedures for the development and approval of national requirements and regulations are specified by Cabinet Resolution No. 163 dated 8 February 1997 (as amended by Cabinet Resolution No. 89 dated 27 January 2016).

As mentioned in the previous National Reports, the legislative framework and regulatory control system in the field of nuclear energy fully embrace all safety principles and provisions of Article 7 of the Convention on Nuclear Safety.

In the reporting period, improvement of the nuclear regulatory and legislative framework continued, taking account of NRS state regulation and practices in Ukraine and experience of advanced countries considering scientific and technical achievements, international standards, as well as documents of the European Union and documents and recommendations of the IAEA and other international safety organisations. Analysis for compliance with WENRA reference levels was carried out and findings of the analysis were considered in the development/revision of regulatory documents.

Efforts were continued in 2018 to improve the procedure for issuing authorisations for activities in the area of nuclear energy and to bring the licensing system into compliance with the Laws of Ukraine "On Administrative Services", "On Licensing of Economic Activities" and "On Standardisation". After the Cabinet of Ministers called back the draft Law "On Amendment of Some Laws of Ukraine in the Area of Nuclear Energy" for revision, which was registered in the Verkhovna Rada of Ukraine on 23 January 2017 under No. 5703, the SNRIU developed the draft Law of Ukraine "On Amendment of the Law of Ukraine on Licensing Activity in Nuclear Energy". The draft Law was registered in the Verkhovna Rada on 14 May 2018 under No. 8348.

To fulfil instructions of the Prime Minister of Ukraine in compliance with the appeal of the G7 Ambassadors in Ukraine and upon the meeting of the Prime Minister of Ukraine with the Ambassadors, the draft Law of Ukraine "On Amendment of Some

Laws of Ukraine in the Area of Nuclear Energy" was developed by SNRIU, agreed with authorities concerned, approved by the Cabinet of Ministers of Ukraine and submitted to the Verkhovna Rada of Ukraine.

This draft Law is intended to prevent the weakening of state regulation of nuclear energy safety in compliance with the goal of such regulation, which is to ensure nuclear and radiation safety in the country.

The system of nuclear legislation includes regulatory acts of the Cabinet of Ministers that establish a mechanism for implementing laws and conducting nuclear energy activities (without technical aspects).

Nuclear and radiation safety regulations and rules are an important part of the nuclear safety legislation. These documents establish criteria, requirements and conditions for safe use of nuclear energy in all associated areas (safety of nuclear installations, particularly NPPs, safety of radioactive waste management facilities, safety of radiation sources, physical protection, safety of radioactive material transport etc.).

The SNRIU regulations are registered in the Ministry of Justice of Ukraine in compliance with the established procedure and officially published and are binding for entities to which these regulations apply.

Basic legislative and regulatory acts in the field of nuclear energy that came into force in 2015–2019 are listed in Annex 4.

In connection with the signature of the Association Agreement between Ukraine, of the one side, and the European Union, European Atomic Energy Community and their member states, of the other side, and its ratification by the Verkhovna Rada of Ukraine and the European Parliament on 16 September 2014, the SNRIU activated the adaptation of Ukrainian legislation to EU nuclear safety laws.

The issues related to cooperation of Ukraine and European Union in the field of nuclear safety are envisaged by the Agreement in Article 342 and Annex XXVII (nuclear energy section).

Annex XXVII to the Association Agreement between Ukraine and the European Union was amended by Association Council resolution. These amendments were approved by the Verkhovna Rada of Ukraine on 6 June 2019. These amendments are aimed at updating the EU acquis to be implemented. It should be noted that adaptation of the EU legislation in the area of nuclear safety actually complies with amended Annex XXVII. The SNRIU started appropriate efforts in 2015 pursuant to the decisions made by the Verkhovna Rada of Ukraine and continued them in 2015-2017. The implementation plan approved by Cabinet Resolution No. 1106 of 25 October 2017 was enforced in March 2018.

The SNRIU developed the draft Law "On Amendment of Some Laws of Ukraine in the Area of Nuclear Energy" to implement Council Directive 2013/59/Euratom laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation. The draft Law was supported by the Government and submitted to the Verkhovna Rada of Ukraine (reg. number 5550 of 16 December 2016). The SNRIU followed the review of draft Law No. 5550-d registered on 21 May 2018 in the Verkhovna Rada of Ukraine, which results from revision of draft Law No. 5550. The decision to revise the draft Law was made by the Verkhovna Rada of Ukraine upon its review at the plenary meeting held 17 April 2018.

The draft Law was adopted in the first reading at the Verkhovna Rada meeting on 14 May 2019. The SNRIU currently monitors the preparation of the draft Law for adoption by the Verkhovna Rada as a whole. The draft Law provides for harmonisation of Ukrainian legislation with European and international safety standards regarding the

requirements for occupational and medical exposure, safety of uranium ore processing and radiation protection of the public in existing exposure situations.

The draft Law fully implements one of the basic principles of state policy: protection of people and the environmental against the dangers arising from ionizing radiation and corresponds to the current system of radiation protection in European Union countries. In particular, it is planned to reduce the levels of exposure to radon and its decay products and minimise long-term risks of radon spread in residential and non-residential buildings and workplaces. The document is also aimed at strengthening the radiation protection of the public in medical exposure and improving the quality of diagnostics and treatment of oncological diseases by terminating the import and production of poor-quality medical radiological equipment in Ukraine.

The adoption of draft Law No. 5550 by the Verkhovna Rada of Ukraine will be a significant step towards ensuring compliance of human protection standards in Ukraine with European safety standards.

The SNRIU is working on the development of other regulations envisaged in the implementation plan and adapts provisions of the Directives in the elaboration of radiation safety rules and standards.

The SNRIU also cooperates with the Ministry of Health in joint measures to implement Council Directive 2013/59/Euratom.

To implement Council Directive 2006/117/Euratom on the supervision and control over shipments of radioactive waste and spent fuel, a draft Cabinet Resolution "On Amendments of the Procedure for Issuing Permits for International Transport of Radioactive Materials" was developed. The objective of the draft Resolution is to define the procedure for agreement of radioactive waste and spent fuel transport between Ukraine and European Union member states. The draft Resolution was agreed with central executive bodies concerned and has been submitted to the Cabinet of Ministers of Ukraine for review.

SNRIU also works on the implementation of Council Directive 2014/87/Euratom dated 8 July 2014, which amends the Community framework for nuclear safety of nuclear installations (more detailed information on the implementation of this Directive is provided in other sections).

7.2.2 Nuclear installation licensing system and prohibition of nuclear installation operation without a licence

At the legislative level, the nuclear installation licensing system is governed by the Law of Ukraine "On Nuclear Energy Use and Radiation Safety" and the Law "On Licensing Activity in Nuclear Energy".

Article 26 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety" prohibits legal entities or individuals to conduct any activity related to the use of nuclear installations or radiation sources without an appropriate licence.

Pursuant to the Law of Ukraine "On Licensing Activity in Nuclear Energy", the operators have licences covering all necessary life stages of their nuclear installations.

7.2.3 System of the regulatory inspection and assessment of nuclear installations to ascertain compliance with applicable regulations and licensing conditions

In compliance with the Convention on Nuclear Safety, a state system for NRS regulation was established and is maintained in Ukraine.

The legislative principles underlying the system of regulatory oversight and safety assessment of nuclear installations remained unchanged over the reporting period.

Under Article 5 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety", oversight activity is considered to be among the fundamental cornerstones of the national policy in nuclear energy use and radiation protection.

In accordance with Articles 22, 24 and 25 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety", state regulation of nuclear energy use provides for supervision over compliance with regulatory requirements and terms of authorisations granted to organisations, enterprises and entities using nuclear installations, including enforcement measures (oversight).

Under Article 15 of the Law of Ukraine "On Licensing Activity in Nuclear Energy", the nuclear regulatory body supervise compliance with licence conditions by conducting regulatory inspections and nuclear safety reviews of reporting documents submitted by the operator.

7.2.4 Enforcement of applicable regulations and licensing conditions, including suspension, modification or revocation

Under Article 24 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety", the state nuclear regulatory body is empowered to supervise compliance with regulations and standards on nuclear and radiation safety as well as licensing conditions. In case of incompliance, the regulatory body may apply administrative sanctions to personnel and officials of enterprises, institutions and organisations. Article 25 of the Law determines the rights of inspectors regarding their responsibilities and application of enforcement measures towards individuals who fail to comply with legislation, regulations and standards on nuclear and radiation safety and licensing conditions. Article 81 of the Law determines the types of violations for which personnel and officials dealing with nuclear installations and radiation sources, personnel and officials of enterprises, institutions and organisations dealing with any other nuclear energy activity, as well as citizens, are brought to disciplinary, civil (except for civil liability for nuclear damage), criminal and administrative responsibility. Article 17-1 of the Law of Ukraine "On Licensing Activity in Nuclear Energy" sets penalties that may be imposed on entities engaged in nuclear energy activities if they fail to fulfil completely or partially conditions of the licences and other permits and if they conduct activities without a licence. The Code of Ukraine on Administrative Violations defines penalties that may be applied to officials and personnel that do not comply with nuclear and radiation safety law.

Article 16 of the Law of Ukraine "On Licensing Activity in Nuclear Energy" considers incompliance with licensing conditions to be a reason for suspension and cancellation of the operator’s licence, depending on the life stage of a nuclear installation.

Oversight of nuclear and radiation safety directly at NPP sites is conducted by the on-site Nuclear Safety Inspectorates.

In the reporting period:

- development of the national nuclear legislation was in progress;
- Ukraine paid significant attention to and took important decisions on the state nuclear energy policy, in particular, with regard to enhancing the safety of nuclear installations, ensuring state safety regulation and developing the national nuclear power sector.

Therefore, Ukraine complies with the provisions of Convention Article 7.

ARTICLE 8 Regulatory Body

8.1 Establishment of the regulatory body

Each Contracting Party shall establish or designate a regulatory body for nuclear safety entrusted with the implementation of the legislative and regulatory framework and provided with adequate authority, competence and financial and human resources to fulfil its assigned responsibilities.

The main functions of the nuclear regulatory body as determined by the Convention on Nuclear Safety and the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management are entrusted to the State Nuclear Regulatory Inspectorate of Ukraine, which acts in compliance with the "Statute of the State Nuclear Regulatory Inspectorate of Ukraine" approved by Cabinet Resolution No. 363 of 20 August 2014.

The SNRIU Board is working on a permanent basis to develop recommendations on significant issues and most essential areas of NRS regulation.

To address issues related to NRS regulation, nuclear security and accounting and control of nuclear materials and prepare proposals for resolving these issues, a State Regulatory Control Commission was established in the SNRIU as a collegial advisory body.

To prepare proposals for making decisions to issue, refuse to issue, amend, renew, refuse to amend or renew, terminate, revoke and resume licences in the field of nuclear energy, a Licensing Commission was established in the SNRIU.

Advisory and consultative functions in the SNRIU decision-making process in nuclear energy are exercised also by the Radiation Protection Council, Reactor Safety Council and Public Council.

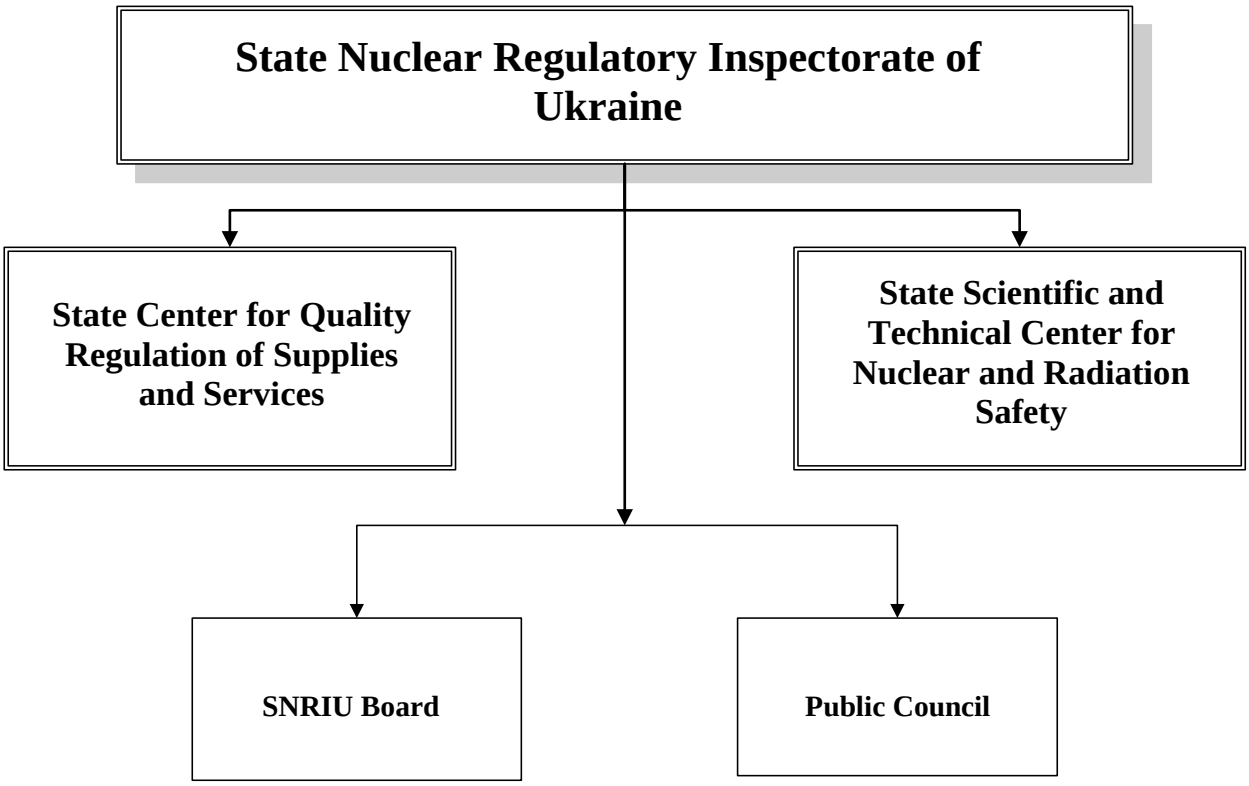
The Public Council was established to ensure that the public is involved in administration of state affairs, exercise public supervision of the SNRIU activities and promote effective interaction of the SNRIU with the public, taking into consideration public opinion in the formulation and implementation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

- promote conditions for citizens to exercise their constitutional right for participation in the administration of state affairs;
- conduct public supervision over SNRIU activities;
- assist the SNRIU in considering the public opinion in the formulation and implementation of state policy.

Within the SNRIU system, there are two state technical safety organisations:

1. SSTC NRS, providing analytical, scientific, expert, technical, engineering, informational, advisory and methodological support to the state nuclear regulatory body;
2. State Centre for Quality Regulation of Supplies and Services (*DerzhTsentrYakosti*), providing technical support to the SNRIU as well as methodological and advisory support in updating regulatory requirements for quality assurance of equipment and services for nuclear power facilities.

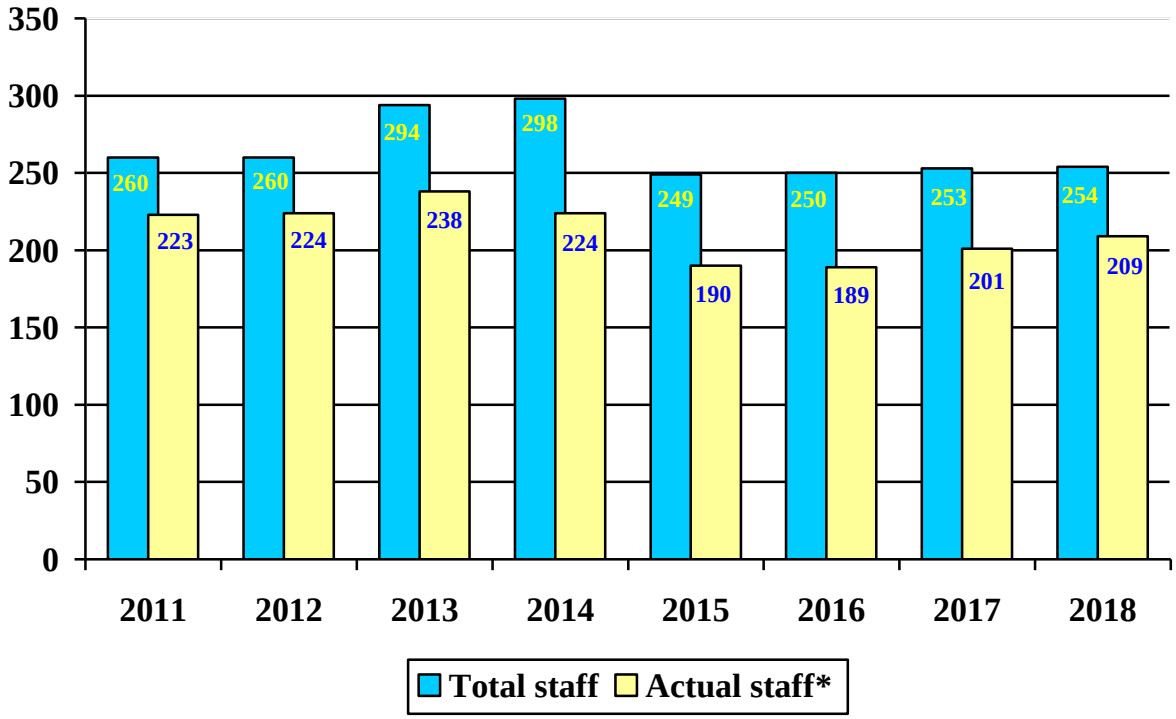
The SNRIU general organisational structure is shown below.



Annually, the SNRIU issues a report on nuclear and radiation safety in Ukraine. This document highlights implementation of the national policy in peaceful use of nuclear energy and compliance with NRS requirements in Ukraine. The annual report is published in Ukrainian and English and posted at the SNRIU official website www.snrc.gov.ua.

To implement one of the fundamental safety principles in nuclear industry, such as safety culture, the regulatory body adopted the "Statement on the SNRIU Policy in Nuclear Energy Safety and Safety Culture Development", which can be found on the SNRIU website www.snrc.gov.ua.

To fulfil decisions of Protocol No. 13 of the Government Committee for Economic Development and European Integration dated 27 April 2015 and obligations of the Government envisaged by the Memorandum on Economic and Financial Policy with regard to reducing the number of workers in executive authorities, other state authorities and local authorities, and Letter of the Ministry of Finances of Ukraine No. 31-08040-13-5/15207 dated 6 May 2015, the maximum number of SNRIU staff was reduced.



* as of 31 December

Distribution of the actual and total staff (including vacancies) of the Ukrainian regulatory body in 2011-2018

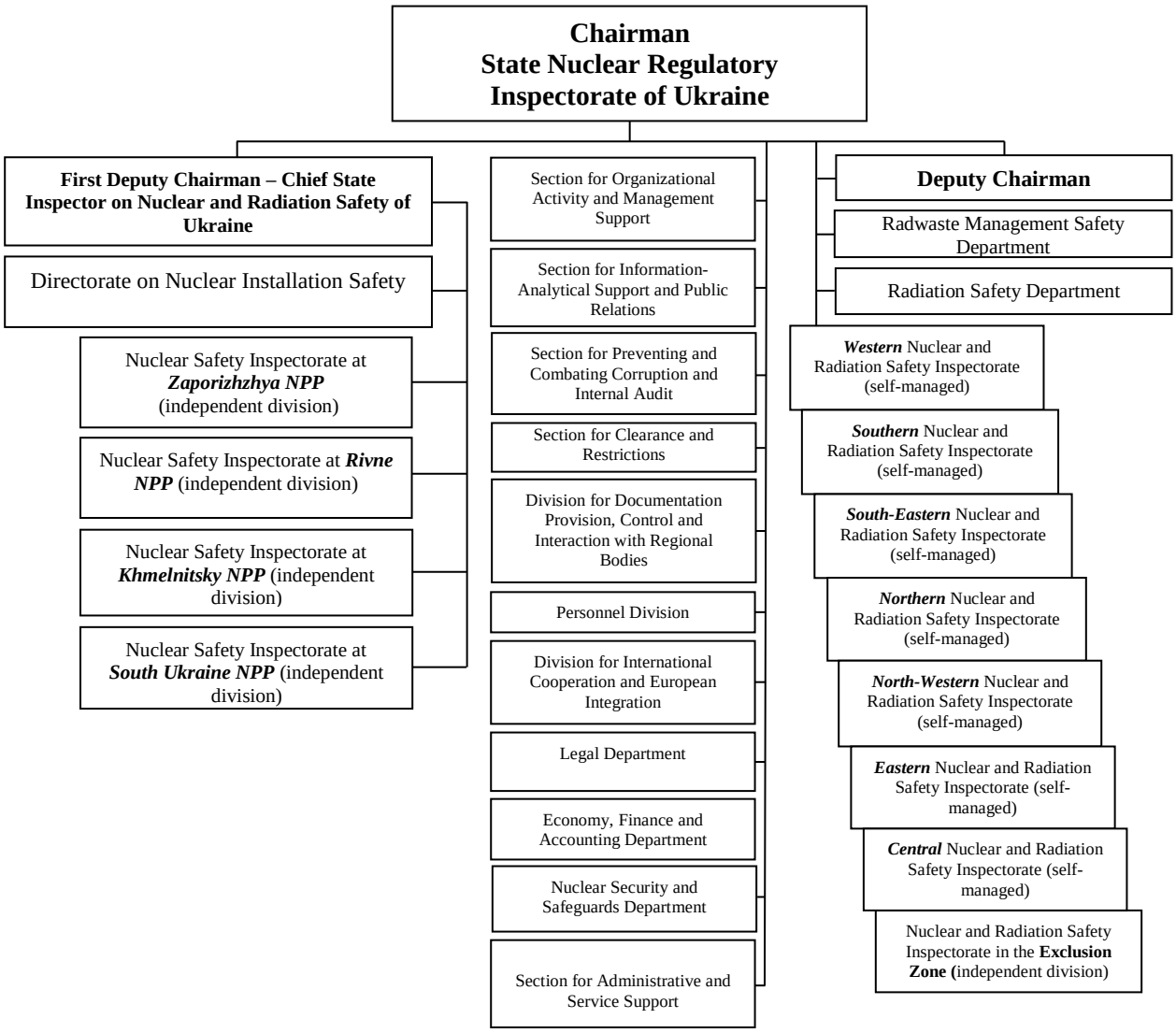
Since 2008, the activity management system certified for compliance with ISO 9001:2008 has been in operation at the State Nuclear Regulatory Inspectorate of Ukraine.

Within the certification procedures, annual internal and external audits are conducted in all areas of activities, working parameters are monitored on a permanent basis and measures are taken to improve the results at the SNRIU.

On 11 July 2018, an annual supervisory audit was conducted at the SNRIU by the International Management Systems Certification Body, a TÜV NORD CERT business partner, for compliance with the quality management system in the new version of standard ISO 9001:2015.

Upon the SNRIU audit by TÜV NORD CERT, the certificate confirming compliance of the quality management system with ISO 9001: 2015 requirements, regarding regulatory services in the field of nuclear energy, was extended.

Organisational Structure of the State Nuclear Regulatory Inspectorate of Ukraine

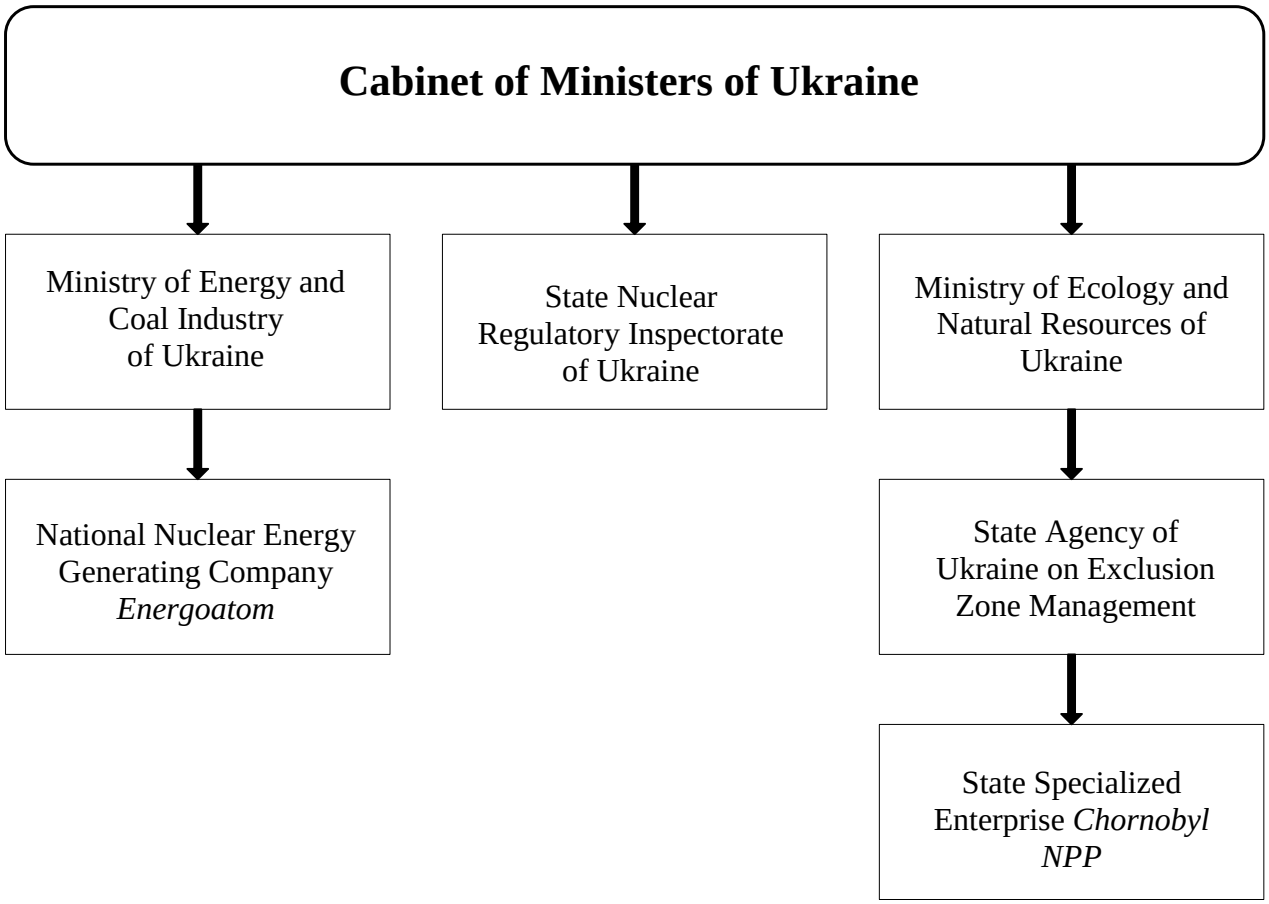


8.2 Status of the regulatory body

Each Contracting Party shall take the appropriate steps to ensure an effective separation between the functions of the regulatory body and those of any other body or organisation concerned with the promotion or use of nuclear energy.

The national legislation of Ukraine clearly specifies and distinguishes functions of the regulatory body and functions of any other agencies or institutions dealing with nuclear energy use. At the legislative level, this is governed by Articles 21, 23 and 24 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety". At the sub-legislative level, this is governed by appropriate statutes that determine the powers of these bodies and are approved by the Cabinet of Ministers of Ukraine.

The Law of Ukraine "On Licensing Activity in Nuclear Energy" states that any bodies, officers, officials, members of the public and their associations shall not be allowed to interfere with resolution of the issues that fall within the SNRIU authorities unless otherwise provided by law.



Therefore, Ukraine complies with the provisions of Convention Article 8.

ARTICLE 9 Responsibility of the Licence Holder

Each Contracting Party shall ensure that prime responsibility for the safety of a nuclear installation rests with the holder of the relevant licence and shall take the appropriate steps to ensure that such licence holder meets its responsibility.

Laws of Ukraine establish a legally binding framework, allocating responsibilities for the safety of nuclear installations.

Under Article 26 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety", the use of nuclear installations in Ukraine shall be subject to licensing. The operating organisation (operator) shall obtain licences for activities at individual life stages of its nuclear installations. Article 32 of the Law states that the licensee is fully responsible for radiation protection and safety of the nuclear installation. Article 33 of this Law determines specific obligations of the operator.

There are two operators in the nuclear power sector of Ukraine, namely: National Nuclear Energy Generating Company *Energoatom* and State Specialised Enterprise *Chornobyl NPP*.

Energoatom has licences granted by the SNRIU for operation of South Ukraine NPP Units 1–3; Rivne NPP Units 1–4; Khmelnitsky NPP Units 1 and 2, and Zaporizhzhya NPP Units 1–6 (including operation of DSFSF on the ZNPP site). A licence was also obtained on 29 June 2017 for construction and commissioning of the nuclear installation (centralised spent fuel storage facility for WWER spent fuel from national NPPs (CSFSF)).

Under the licences for operation of NPP units, ZNPP DSFSF and construction and commissioning of CSFSF, *Energoatom* obtains individual permits for activities and operations identified in the licences, in particular: start-up of power units after refuelling outages, first reactor start-up after long-term operation measures, commissioning of new infrastructure facilities included in the technological system, testing of the power unit, facilities, systems and components important to safety that are not envisaged by technical specifications and operating procedures for the reactor and its systems and components etc.

The SSE *Chornobyl NPP* has licences granted by the SNRIU for:

- decommissioning of the Chornobyl NPP;
- operation of the Shelter;
- operation of the interim spent fuel storage facility (ISF-1);
- construction and commissioning of the interim spent fuel storage facility (ISF-2).

According to the licence for Chornobyl NPP decommissioning, the SSE *Chornobyl NPP* shall obtain individual permits to proceed with the next decommissioning stage of an individual nuclear installation and to conduct specific activities or operations at the decommissioning stages, which involve design, construction, commissioning and operation of radioactive waste management facilities as well as measures to remove spent and fresh fuel, solid and liquid operational radioactive waste of ChNPP from the existing facilities (detailed information is presented in Annex 8).

As licence holders, *Energoatom* and SSE *Chornobyl NPP* are fully responsible for the safety of nuclear installations.

According to the obligations imposed by Ukrainian legislation on operators, *Energoatom* and SSE *Chornobyl NPP* shall:

- ensure nuclear and radiation safety (ARTICLE 6 and ARTICLE 14 Sections);
- develop and implement measures to improve the safety of nuclear installations (ARTICLE 6 Section);

- inform about operational events at nuclear installations in a timely and comprehensive manner, investigate and implement corrective actions (para. 16.2);
- secure financial coverage of liability for nuclear damage as required by Ukrainian legislation (ARTICLE 11 Section);
- establish requirements for staff qualification depending on responsibilities for safety of the nuclear installation and provide for staff training (ARTICLE 11 Section);
- ensure radiation protection of personnel, the public and the environment (ARTICLE 15 Section).

Starting with review of the licence application and throughout the licensee's operations, the SNRIU monitors and verifies the licensee for compliance with the established requirements. In particular, the regulatory body verifies whether the nuclear installation complies with safety requirements, whether financial, material and other resources are available and the organisational structure is in place and whether the system for staff training and retraining is available. These requirements, which are mandatory preconditions for licensing, are included in the operator's licence for a certain life stage of the nuclear installation and are subject to continuous oversight by the SNRIU.

In the reporting period, the Ukrainian operators fully complied with their obligations to ensure safety of their nuclear energy operations.

In compliance with legislation in force, the operators fully implement and comply with the obligations and licence terms (individual permits) concerning the safety of licensed nuclear energy activities.

Implementation of the obligations and terms of licences (individual permits) concerning the safety of licensed activities is under continuous regulatory oversight.

Therefore, Ukraine complies with the provisions of Convention Article 9.

ARTICLE 10 Priority to Safety

Each Contracting Party shall take appropriate steps to ensure that all organisations engaged in activities directly related to nuclear installations shall establish policies that give due priority to nuclear safety.

The priority to safety in design and operation of nuclear installations, which is established in the Law of Ukraine "On Nuclear Energy Use and Radiation Safety", is the basic principle of the state nuclear energy policy.

In the reporting period, all legal nuclear entities adhered, within their authorities, to legislative policy principles set forth in Ukrainian laws. This and previous Reports of Ukraine describe the implementation of national policy principles regulating the issues covered by the Convention on Nuclear Safety.

In December 1997, the Verkhovna Rada of Ukraine ratified the Convention on Nuclear Safety. The Law on ratification explicitly reads that "… Confirming its adherence to the principles of nuclear safety culture and promoting their implementation, the Verkhovna Rada of Ukraine has approved a responsible decision on ratifying the Convention on Nuclear Safety".

In 2003, the Law on Principles of National Security of Ukraine came into force. This law determines nuclear and radiation safety as one of the areas and an integral part of Ukraine's national security.

Assurance of safety safeguards, reliability of nuclear power and implementation of relevant international commitments of Ukraine are priorities for the executive authorities. The state of nuclear and radiation safety was regularly reviewed by the Cabinet of Ministers and the National Security and Defence Council of Ukraine at their meetings. NPP safety issues are addressed at the meetings of the SNRIU Boards and Boards of the Ministries concerned, and at the interdepartmental commissions' meetings.

In the reporting period, SNRIU reports on nuclear and radiation safety in Ukraine were regularly developed according to the established procedure for the Verkhovna Rada, President and Cabinet of Ministers of Ukraine.

In particular, in accordance with NP 306.1.190-2012 "General Requirements for the Management System for Activities in the Use of Nuclear Energy", the operator's policy, objectives and management system shall ensure that priority is given to compliance with safety requirements over economic, technical, scientific and other objectives and that constant and systematic monitoring of compliance with safety requirements is conducted.

According to the approved and published Energoatom Nuclear Safety Policy Statement, safety assurance has priority over economic, technical, scientific and other objectives. The operator's highest priority is to improve and maintain the achieved safety level of operating NPPs. The principle according to which the operator's personnel are responsible for safety and quality of their activities is adhered to at all levels.

Since 2002, International Conferences *Safety Culture at Ukrainian NPPs* have been regularly conducted by *Energoatom* every two years.

Safety Days are regularly held at NPPs at two levels (departments and plant as a whole) to introduce the safety culture principles, reveal operational occurrences and deviations from the requirements of applicable standards and regulations, technical specifications, operating procedures and operational documentation. NPP Safety Days are held according to the annual schedule, which is an integral part of the annual schedule for human resource development.

The Safety Day agenda can be adjusted, if necessary, to take account of the supervisory recommendations and events that occurred at NPP.

The Safety Days contribute to implementing the safety culture principles, enhancing nuclear and radiation safety, strengthening the control exercised by subdivision managers and plant administration over fulfilment of the requirements.

The management's statements were developed and brought to the attention of NPP staff, determining the priorities assigned to NPP activities on safety and quality assurance.

Programmes on production culture assurance and improvement as well as occupational safety and fire safety programmes were elaborated and introduced at NPPs; long-term planning of safety culture-related activities is also envisaged.

Job descriptions of all-level managers responsible for nuclear and radiation safety determine the obligations related to fostering the safety culture of their subordinated staff.

Production Culture Days are held across all *Energoatom* NPPs.

The Safety Culture course is a compulsory element of the position-specific training and retraining programmes for all NPP industrial and operational personnel. Training covers all safety culture aspects for operational personnel of all categories.

Energoatom developed complete packages of training courses covering the following topics:

- Fundamentals and Basic Characteristics of Safety Culture;
- Role of Human Factor in Safety Culture;
- Quality Assurance;
- Safety Management.

Safety culture elements were incorporated into the training courses conducted at full-scope simulators, laboratories and workshops.

For implementing the principles of transparency and accessibility of information on nuclear energy use, specific public relations departments and information centres were established at all NPPs and *Energoatom* Headquarters to provide the public with explicit information on the environmental radiation situation. NPPs and their information centres organise guided tours for citizens to get them acquainted with NPP operation. Each NPP issues a plant newspaper and has radio broadcasting and telecasting offices and its website.

NPPs prepare annual reports on the assessment of operational safety and technical condition of power units and reports on radiation safety and radiation protection at NPPs. *Energoatom* summarises the NPP reports to develop the final report on assessment of operational safety and technical condition and the report on radiation safety and radiation protection at NPPs, which are submitted to the regulatory and governing state bodies of Ukraine.

The priority of nuclear and radiation safety established by Ukrainian law and requirements for observing this priority promote adherence to safety as a lifestyle.

Therefore, Ukraine complies with the provisions of Convention Article 10.

ARTICLE 11 Financial and Human Resources

11.1 Financial resources

Each Contracting Party shall take appropriate steps to ensure that adequate financial resources are available to support the safety of each nuclear installation throughout its life.

According to Article 32 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety", the licence holder shall have financial, material and other resources and an appropriate organisational structure and personnel to maintain the level of safety defined by safety regulations, rules and standards and licensing requirements. The licence holder shall have financial capabilities to indemnify damages caused by accidents that may occur in the use of nuclear energy through its own funds or funds of insurance companies (organisations).

The payments for the supplied electricity versus its cost were 97.57% in 2017, 100% in 2018 and 98.48% in 2019. The slight fluctuations in the payments in 2017 and 2019 are associated with decrease in the level of payments in the Wholesale Electricity Market of Ukraine for the final consumers.

A fixed tariff is used for the electricity that *Energoatom* NPPs deliver to the *Energorynok* (Energy Market). Decisions on the tariff amount, as well as breakdown of costs for electricity production, are approved by NEURC.

For improving nuclear safety, ensuring effective and reliable operation of power industry and enhancing the safety of Ukrainian NPPs to the level that meets recognised international standards of nuclear safety and environmental protection, *Energoatom* is implementing C(I)SIP. The estimated cost of C(I)SIP implementation currently approximates 1,740 mln EUR, including 1,140 mln EUR provided by *Energoatom*.

Under the Memorandum of Understanding on Cooperation in the Field of Energy between the European Union and Ukraine, the EBRD/Euratom, on the one side, and the Ministry of Fuel and Energy of Ukraine and *Energoatom*, on the other side, made a decision on funding the Programme from the EBRD/Euratom Loan.

Law of Ukraine No. 1868-IV "On Settlement of Nuclear Safety Issues" dated 24 June 2004 and Cabinet Resolution No. 594 dated 27 April 2006 provided for establishing, accumulating and using a financial reserve for nuclear installation decommissioning. Ukraine is a Contracting Party to the Vienna Convention on Civil Liability for Nuclear Damage dated 1963 (as prescribed by the Law of Ukraine "On Accession of Ukraine to the Vienna Convention on Civil Liability for Nuclear Damage" dated 12 July 1996).

The insurance coverage of *Energoatom* civil liability for nuclear damage has been provided since 2004. Annually, *Energoatom* enters into an agreement with an insurance company that is duly authorised by member companies of the Nuclear Insurance Pool of Ukraine.

11.2 Human resources

Each Contracting Party shall take the appropriate steps to ensure that sufficient numbers of qualified staff with appropriate education, training and retraining are available for all safety-related activities in or for each nuclear installation, throughout its life.

In the reporting period, the national system for nuclear industry personnel training and skill improvement, as described in para. 5.2.2 of the Seventh National Report, was further improved.

The NPP personnel training system is in place and fully operates in Ukraine. This system is based on the IAEA-recommended systematic approach to training and experience acquired by leading IAEA member states in staff training.

The staff training system operates in interaction with research organisations, enterprises, state administrative and regulatory bodies and other educational systems to provide each staff member with high-standard training, retraining and skill improvement, which are aimed at acquiring and maintaining the knowledge and sustaining skills and qualifications necessary for safe operation of NPPs.

The SNRIU licenses the training of NPP staff according to regulation "Rules for Licensing the Training of Staff for Operation of Nuclear Installations" NP 306.2.104-2004. The SNRIU also licenses officials according to "Conditions and Procedure for Licensing the Activities of Operating Organisation Officials" NP 306.1.180-2012 and operational personnel in accordance with "Rules for Licensing of Personnel for Direct Control of NPP Reactors" NP 306.2.103-2004.

Energoatom developed and introduced "Provisions for Staff Development Activities of the National Nuclear Energy Generating Company *Energoatom*" PL-K.0.07.005-13, incorporating state-of-the-art international experience in the area of NPP staff training. The document also declares principles based on which the safety culture of the staff is developed through systematic staff management to maintain the required proficiency level and keep the staff continuously ready to fulfil their professional duties, which is crucial for nuclear and radiation safety of NPPs and especially for protection and integrity of defence-in-depth barriers.

The effectiveness of the staff training system is clearly demonstrated by a steady trend towards improving the staff availability factor.

Energoatom has training centres in place at all nuclear power plants and at the *AtomRemontServis* Enterprise. All centres have appropriate licences and permits issued by state regulatory bodies to train staff of different categories.

Forming a basis for the training system, the training centres of NPPs continue developing. The structure and staff list for the training centres were developed taking account of NPP-specific features. The NPP training centres are staffed with skilled and knowledgeable instructors. The technical training materials are continuously improved.

At present, the NPP training centres use eight full-scale simulators, namely: full-scale simulators for WWER-1000 units at KhNPP-1, ZNPP-1, 3 and 5, RNPP-3 and SUNPP-1 and 3 and a full-scale simulator for WWER-440 unit at RNPP-2, along with simulators for emergency control rooms at KhNPP-1, ZNPP-3 and 5, SUNPP-1 and 3 and RNPP-2 and 3. The full-scale simulators are upgraded on a regular basis to maintain configuration in compliance with prototype power units, to extend the scope and accuracy in modelling of processes and systems and develop modules of beyond design-basis and severe accidents. Besides, the training of staff involves multifunctional and local simulators and computer training systems.

Significant attention is paid to training and professional development of maintenance staff. The training centre for *Energoatom* maintenance staff was established on the premises of the ZNPP training centre with participation of the European Commission. The centre has full-scale equipment of one WWER-1000 loop, including the reactor, steam generator, reactor coolant pump, pressurizer, main coolant piping, etc. Besides, the centre has a reloading machine, main handling equipment, internals inspection cavities, and spent fuel pool. There are equipment and systems for reactor assembly/disassembly and fuel reloading and a test bench of control rod drive mechanisms. The centre was commissioned in 2018.

Staff training is based on training methodologies and guidelines developed in accordance with the *Energoatom* standard "Requirements for Training Materials". The development of training materials is a precondition for obtaining a licence for staff training.

The staff to be licensed are trained using individual training programmes based on standard programmes agreed by the SNRIU.

Annex 6 shows dynamics in the number of licensed plant experts and information on NPP staff training.

In the reporting period, the Ukrainian system for training and retraining of nuclear power plant staff was continuously improved, providing occupational training of employees for activities throughout the nuclear installation life.

All Ukrainian NPPs are fully provided with trained and skilled staff.

Therefore, Ukraine complies with the provisions of Convention Article 11.

ARTICLE 12 Human Factor

Each Contracting Party shall take appropriate steps to ensure that the capabilities and limitations of human performance are taken into account throughout the life of a nuclear installation.

In 2012, Ukraine revised regulatory requirements for the management system and human factor. New regulatory requirements are in full compliance with IAEA requirements GS-R-3 "Safety Requirements. Management Systems for Facilities and Activities", comply with recommending documents GS-G-3.x and WENRA reference levels.

State regulation envisages requirements for safety culture, professional training, creation of a training system and examination of knowledge on nuclear and radiation safety. Licences are issued to train certain categories of plant experts and licence personnel who control the nuclear reactor and top managers who make decisions important to nuclear safety. State oversight of compliance with legal requirements and regulatory framework, as well as conditions of issued licences, shall be performed. Special verifications are conducted to check compliance with regulatory requirements with regard to the human factor, and the regulatory body interacts with licensees to eliminate drawbacks and maintain safety culture.

The *Energoatom* staff management policy is set forth in the *Energoatom* Policy Statement and is focused on professional and psychological awareness of personnel recognising safety assurance as a first priority and inherent need of each employee, leading to self-consciousness, responsibility and self-control in all activities that are important for NPP operational safety.

Recognising the role of human factor in NPP safety assurance, the *Energoatom* management declares that priority is to be given not only to search and punishment but also to detection, resolution and prevention of issues and non-conformances related to human factors.

To prevent and avoid any influence of human factors that may cause NPP operational events if psychophysical state or proficiency level of the staff do not meet the safety requirements, *Energoatom* employs the system of operating experience feedback in personnel training at NPP training centres.

With due regard to human factor, the effectiveness of training systems for Ukrainian NPP staff is assessed as follows:

- analysis of reports on events that describe abnormal occurrences related to human errors;
- audits of NPP training centres by SNRIU experts to verify whether licences can be granted for position-specific training of staff;
- analysis of reports on causalities due to drawbacks in training.

To assess the operational personnel's technical proficiency to operate a power unit under different operating modes, the operational personnel availability factor is calculated. Erroneous actions that caused occurrences during transients and wrong actions or omissions of the operational personnel are taken into account.

The licensed personnel (shift supervisors and MCR operators) are certified by NPP commissions headed by NPP chief engineers. The rest of operational personnel are certified by commissions headed by deputy chief engineers or heads of NPP departments. Personnel's knowledge is assessed as prescribed in the relevant regulations.

Upon completion of training, a post-training knowledge test is conducted by NPP training centres. If results of the post-training test are positive, the trainee is sent for further knowledge verification by the commission.

The following additional certification procedures are envisaged for the staff whose training is subject to licensing:

- preparation for knowledge verification by the NPP central commission, during which previously gained knowledge and skills are refreshed, requirements, rules and standards on NPP safety and operation are specified. Based on the results of pre-training tests, trainees gradually and successively refresh the topics of individual programmes through their self-training and by means of interviews and consultations with instructors;
- drills using a full-scale simulator.

Proficiency and skills of the trainees are tested to check their ability to control production process from the main control room in:

- normal operation;
- abnormal operation;
- emergencies.

Teamwork capabilities are checked as well.

Final post-training tests are administered by deputy chief engineers. They verify if the knowledge obtained by trainees is sufficient for self-guided work and if trainees are prepared for knowledge verification.

Test results are incorporated into records and along with other documents are handed over to the central knowledge verification commission.

In case the test results are not satisfactory, extra time is provided for further preparation.

The knowledge level is verified by the commission headed by the NPP chief engineer with a state inspector as a representative of the on-site State Nuclear Safety Inspectorate.

Upon successful knowledge verification, as well as shadow training and exercises, a package of documents for licensing is prepared and sent to the SNRIU for further review. If results of the review are positive, the SNRIU issues a licence for nuclear installation operation with the NPP units being specified.

Personnel are prepared for emergency mitigation, accident management and prevention of event recurrence in NPP operation through:

- emergency exercises in training for individual position-specific training programmes;
- emergency exercises for shift operational personnel;
- full-scale simulator training for operational personnel under skill improvement programme;
- full-scale training on mitigation of beyond design basis accidents.

Symptom-based EOPs and SAMGs are being implemented at power units for all operational states to enhance reliability of human actions in mitigations of emergencies.

To minimise effects of the human factor, the following administrative arrangements are implemented, namely:

- individuals are permitted to work at a nuclear installation and with nuclear materials only following special examination and training;
- psychophysical state of the operational personnel is checked annually;
- all staff's health is monitored annually and operational personnel are subject to mandatory medical examination before shifts;

- staffing, staff training and safety culture improvement are controlled at the interdepartmental level;
- as prescribed in the staff development schedule, general-plant and unit emergency response and fire protection exercises are held annually for operational personnel, including individual training with administrative and technical staff.

Therefore, Ukraine complies with the provisions of Convention Article 12.

ARTICLE 13 Quality Assurance

Each Contracting Party shall take appropriate steps to ensure that quality assurance programmes are established and implemented with a view to providing confidence that specified requirements for all activities important to nuclear safety are satisfied throughout the life of a nuclear installation.

The management system combines (integrates) regulatory requirements for nuclear safety, environmental protection, occupational safety, etc. needed to achieve objectives of the organisation. The management system covers: management of equipment, operation of equipment for the production of electric and thermal power and modification, maintenance, repairs, reconstruction and modernisation of NPP equipment, development, design and production of special instrumentation, devices and special means, engineering and technical support, management of human resources, safety management (nuclear safety, radiation safety, occupational safety, fire safety, environmental protection, physical protection) and actions in accidents and emergencies, engineering support and major construction, management of material and technical resources, management of finances, economy, purchase and sale of electricity in the electricity market.

Energoatom's Integrated Management System (IMS) also complies with the ISO 9001 requirements (for quality control system) and ISO 14001 requirements (for environmental management system) and OHSAS 18001, which has been ascertained by certificates issued by TÜV NORD CERT.

In order to identify the areas for improvement and ascertain the actual status of compliance with the above requirements, *Energoatom* conducts internal audits of IMS processes. Audits are conducted in the areas such as NPP equipment operation support, management of maintenance and repairs, safety assurance, upgrading, modernisation, and long-term operation, acceptance and incoming inspection, equipment and material procurement management, management of emergencies, emergency preparedness, environmental management, etc.

In addition, *Energoatom* performs scheduled internal inspections of compliance with rules, regulations and standards on nuclear safety, fire safety and occupational safety. The inspections also cover measuring laboratories and metrological services, as well as emergency preparedness, plant physical protection, financial and economic activities.

In order to make sure that vendors/manufacturers can ensure that their products conform to the prescribed requirements, the operator carries out audits of the vendors that provide products for NPP systems important to safety.

Great attention is paid to providing NPPs with highly-skilled personnel to ensure a high safety level during nuclear installation operation. Personnel are trained and retrained on a regular basis. Training is based on a graded approach reasoning from the roles and functions of employees: managerial staff, quality assurance officers and other specialists.

Therefore, Ukraine complies with the provisions of Convention Article 13.

ARTICLE 14 Assessment and Verification of Safety

14.1 Assessment of safety

Each Contracting Party shall take appropriate steps to ensure that comprehensive and systematic safety assessments are carried out before the construction and commissioning of a nuclear installation and throughout its life. Such assessments shall be well documented, subsequently updated in the light of operating experience and significant new safety information and reviewed under the authority of the regulatory body.

Operation of nuclear installations envisages their detailed and comprehensive safety analysis taking into account design features and operating practices. Ukrainian laws, regulations and standards require safety assessments and safety review.

The operator's safety assessment of operating power units is aimed at developing and keeping updated the main safety justification document, Safety Analysis Report, which presents both comprehensive safety assessment and technical and organizational measures to ensure safety.

Safety assessment and verification represent a continuous process and require the safety analysis to be detailed and the safety assessment procedures to be improved continuously in order to take account of the best world practices and actual events that occurred or might occur at nuclear installations.

Safety analysis efforts, which comply with the then effective legal nuclear and radiation safety framework and IAEA's recommendations, were started in Ukraine in the 1990s and included development of SARs initially for pilot units (RNPP-1, SUNPP-1, ZNPP-5) and afterwards for the other power units. Safety analysis for NPPs was a subject of great attention of the international organisations (IAEA, STUK, GRS, IRSN, etc.) under international projects.

At present, SARs have been developed for all Ukrainian NPPs, and include both deterministic and probabilistic safety assessments.

Results of safety analysis confirm that safety of Ukrainian NPP units meets requirements of regulations, rules and standards of nuclear and radiation safety of Ukraine.

Currently, *Energoatom's* activities on SAR are generally intended to keep the Reports updated and eliminate some limitations of previous safety analyses.

In particular, according to the regulation "Requirements for Safety Assessment of Nuclear Power Plants" that became effective in October 2010, the operator continues development of the probabilistic safety assessment of levels 1 and 2 including a full range of initiating events for all normal states of the reactor and spent fuel pool. These efforts are under way to cover all operating NPPs under the C(I)SIP. Nowadays, PSAs have been developed for ZNPP-1-4 and all units of RNPP, KhNPP and SUNPP; activities are ongoing for ZNPP-5,6.

The implementation of living PSA procedure at NPP units was started in 2010 to keep updated the probabilistic models of NPP units developed within SARs with the purpose of applying risk-informed approaches. Such efforts were also planned under the C(I)SIP. To date, living PSA has been implemented at all power units of Ukrainian NPPs. In 2017, the operator developed and the regulatory body agreed a branch standard, which was then implemented. The branch standard is a methodological guideline on the development, implementation and update of living PSA. According to this standard, Ukrainian NPPs are already carrying out activities on current and full update of PSA.

In 2014, SAMGs for the reactor and spent fuel pool were implemented at pilot units SUNPP-1, ZNPP-1 and RNPP-1. In 2015-2016, SAMGs for reactor shutdown state and SFP were implemented for pilot units SUNPP-1, ZNPP-1 and RNPP-1.

Within C(I)SIP, measures have been implemented on the development of emergency operating procedures for accidents occurring in low power and shutdown states. Severe accident management guidelines for full power and shutdown states have been developed and implemented for all NPP units.

The developed SAMGs take into account upgrades focused on the severe accident management strategies involving mobile power supply sources and pumping units.

Adaptation of SAMGs to all other units of Ukrainian NPPs was completed in 2017.

The Programme for Analysing Phenomena of Severe Accidents was implemented in 2016. It defines further organisational and technical measures on:

- validation and improvement of computer models for severe accident analysis (including purchase of new codes);
- analysis of defined emergency phenomena of severe accidents with high level of uncertainties and assumptions made in the development of SAMGs.

In 2017, *Energoatom* purchased the ANSYS computer code and conducted training of personnel. In 2018, the first stage of negotiations with NRC took place for the participation in the CSARP program and receipt of the MELCOR 2.x computer code. Currently, efforts are ongoing to analyse the potential for criticality in the process of severe accident progression and in-vessel and ex-vessel phenomena of severe accidents using the MELCOR 1.8.5 computer code for further development of recommendations on modelling the phenomena of interest.

As prescribed by nuclear law and national safety requirements and regulations, the operator shall periodically, at least every 10 years, perform periodic safety review for NPP units and report its results to the regulatory body.

In the framework of NPP long-term operation measures, the operator developed PSRRs for RNPP-1-3, ZNPP-1-4 and SUNPP-1,2. Besides, a scheduled periodic safety review not related to long-term operation was performed for RNPP-4 and KhNPP-2 and PSRR was developed upon its results. Within activities on long-term operation, PSRR for KhNPP-1 has been completed. PSRRs for ZNPP-5 and SUNPP-3 are in the final stage. The development of PSRRs has been started for RNPP-1,2 within their scheduled safety review (design-basis life of these power units expires in 2030 and 2031, respectively).

In 2017, a new regulatory document "Requirements for Periodic Safety Review for Nuclear Power Plants" was put into force. The regulation was developed taking into account IAEA SSG-25 "Periodic Safety Review for Nuclear Power Plants" and national experience in periodic safety review of NPP units. Under agreement with the regulatory body, the operator determined the pilot power unit (ZNPP-6). The scheduled safety review will be performed according to provisions and requirements of the new regulation. At present, the operator’s standard "Requirements for the Structure and Contents of Periodic Safety Review Report for Nuclear Power Plants. Methodological Guideline" is under development. This document will specify requirements for the procedure of PSRR development and PSRR structure and contents.

14.2 Verification of safety

Verification by analyses, surveillance, testing and inspection is carried out to ensure that the physical state and the operation of a nuclear installation continue to be in accordance with its design, applicable national safety requirements, and operational limits and conditions.

Since the previous Report, the nuclear installations have been verified for compliance with requirements, standards and rules of nuclear and radiation safety.

Regulatory oversight is carried out by on-site State Nuclear Safety Inspectorates and state inspectors of the SNRIU Headquarters. Inspectors' activities are governed by applicable regulations, special programmes and inspection schedules. The experts of relevant divisions of SNRIU and resident State Nuclear Safety Inspectorates are involved in comprehensive inspections.

Pursuant to requirements of the General Safety Provisions for Nuclear Power Plants, NP 306.2.141-2008, the operator ensures that the NPP safety is permanently monitored.

To this end, an institutional control service was established and operates at *Energoatom*.

The mission of the institutional control service is to monitor *Energoatom* departments for compliance with requirements, standards, criteria and rules on nuclear and radiation safety along with requirements for environmental protection, licence terms and operational documents.

Each NPP has an institutional control service whose mission includes regular (daily) control of operating modes, condition of equipment and systems important to safety and their compliance with requirements of operational documentation, regulations and rules of nuclear and radiation safety.

Pursuant to NP 306.2.145-2008 "Nuclear Safety Rules for WWER Nuclear Power Plants", each NPP conducts internal nuclear safety inspections and submits appropriate certificates to the SNRIU.

According to the approved programme, internal inspections are carried out by the operator every two years. Radiation protection and environmental conditions are also inspected on a regular basis.

Based on inspection results, measures are identified to eliminate the revealed shortcomings, as required.

Systems and components important to safety commonly undergo direct and complete inspection for compliance with design specifications during commissioning, after maintenance and repairs, as well as throughout NPP life on a regular basis.

The nuclear installation design provides for diagnostics (testing) of systems and components important to safety. In-service inspection is carried out in compliance with conditions and limits of safe operation as prescribed by safety analysis report and technical specifications.

Specific measures on testing and inspection, their scope and frequency, are determined in technical specifications, ad-hoc programmes and procedures applied at NPPs. As prescribed by the regulations, the operator carries out:

- inspections and testing of equipment and process systems;
- monitoring of design life of major equipment;
- regular non-destructive testing of equipment and piping metal and welds;
- assessment of fuel cladding integrity;
- primary and secondary water chemistry control;
- checks of reactor cooling system integrity;
- monitoring of radioactive releases and discharges and radiation conditions in the NPP control area and observation area,

and other monitoring actions as prescribed by special programmes and procedures.

Upon maintenance and repair, the systems and equipment are checked for operability and compliance with design characteristics, with inspection results being recorded.

To limit degradation of structures, systems and components important to safety (as a result of ageing, wear, corrosion, erosion, fatigue, etc.) and to support their operability and reliability during operation, *Energoatom* developed and fulfils programmes on equipment ageing management, equipment qualification and long-term operation of operating units. The C(I)SIP was developed and implemented along with the *Energoatom* comprehensive integrated programme on NPP operation improvement.

The legislative and regulatory framework was established in Ukraine to allow a comprehensive and systematic safety assessment throughout the life stages of nuclear installations.

Therefore, Ukraine complies with the provisions of Convention Article 14.

ARTICLE 15 Radiation Protection

Each Contracting Party shall take the appropriate measures to ensure that in all operational states the radiation exposure to the personnel and the population caused by a nuclear installation shall be kept as low as reasonably achievable and that no individual shall be exposed to radiation doses which exceed prescribed national dose limits.

The Law of Ukraine "On Human Protection Against Ionising Radiation" aimed to ensure the protection of citizens' life, health and property against negative effects of ionising radiation prescribes practical steps to implement provisions of the basic Law "On Nuclear Energy Use and Radiation Safety" and establishes the main dose limits for personnel and the public. This Law also outlines the scope of authority and obligations of state bodies responsible for radiation protection.

In 2001, 2009 and 2012, the Law of Ukraine "On Human Protection against Ionising Radiation" was amended to bring its provisions of the Law into full compliance with ICRP recommendations.

The regulatory document "Radiation Safety Standards of Ukraine" (NRBU-97) and its annex "Radiological Protection against Potential Radiation Sources" (NRBU-97/D-2000) were developed to specify the main provisions of the Law of Ukraine "On Human Protection against Ionising Radiation". They are based on accumulated international experience, reflect up-to-date approaches towards law-making and radiation protection and take into account recommendations of IAEA and ICRP.

NRBU-97 determines the basic principles of radiation protection applied to practices and intervention situations and establish radiation and health and safety regulations, in particular, effective dose limit for category A (personnel) (20 mSv/year) and category B (2 mSv/year) and for category C (the public) (1 mSv/year), as well as limits for equivalent doses of external exposure for the eye lens, skin, hands and feet that comply with recommendations of ICRP Publication 60.

NRBU-97/D-2000 complements and extends NRBU-97, incorporating potential radiation sources into the system of radiation and health and safety regulation.

The basic principles of radiation protection and the ALARA (optimisation) principle are implemented in Ukraine through development and introduction of regulatory standards and rules as well as through development and introduction of proper operational procedures. A number of organisational and technical measures can be referred to the activities on ALARA principle implementation. These organisational and technical measures are implemented at Ukrainian NPPs with the purpose of reducing individual and collective doses of personnel, minimising releases and advancing the radiological monitoring systems.

In connection with the liquidation of the Health and Epidemiological Service of Ukraine, Cabinet Resolution No. 348 of 29 March 2017 entrusted the State Service of Ukraine on Food Safety and Consumer Protection with the tasks and functions of implementing the state policy in the sphere of health and epidemiological welfare of the public and control (oversight) of compliance with health and safety legislation.

The functions of dose control at workplaces and radiation doses of employees are within the competence of the State Labour Service of Ukraine.

Effectiveness of radiation protection measures is assessed from collective and individual dose rates, as well as dynamics of their changes.

Figure 1 (Annex 7) shows dynamics of collective doses for Ukrainian NPP personnel for a period from 2009 to 2018.

Figure 2 (Annex 7) shows individual doses for personnel of Ukrainian NPPs over a period from 2016 to 2018. The diagram shows that individual doses to the majority of individuals monitored at all Ukrainian NPPs (more than 80% of personnel) are below 1 mSv. In 2016-2018, no individuals were registered at Ukrainian NPPs to have a dose higher than 20 mSv/year.

In 2016-2018, no individuals with exposure dose higher than 20 mSv/year were identified at operating Ukrainian NPPs.

The actual releases recorded by the regular radiation monitoring systems at Ukrainian NPPs are much lower than permissible levels established taking into account appropriate dose limit quotas for individuals from the public.

The total indices (percentage of actual release to permissible one) of gas-aerosol releases to the environment for the main nuclides (inert radioactive gases, iodine radionuclides and long-lived nuclides: ^{137}Cs, ^{134}Cs, ^{60}Co, ^{54}Mn, ^{90}Sr) in 2018 reached 0.85% at ZNPP (including 0.71% for tritium), 0.78% at RNPP (including 0.61% for tritium), 0.18% at SUNPP (including 0.08% for tritium) and 0.11% at KhNPP (including 0.04% for tritium).

Figure 3 (Annex 7) shows dynamics in the total indices of radioactive gas-aerosol releases to the environment at NPPs for a period from 2009 to 2018. Figure 3 (Annex 7) demonstrates that over the recent years, the level of release indices is below 1%. A higher release index at ZNPP and SUNPP in 2018 is connected with the technique introduced at the plants and with measurement and control activities related to tritium releases through ventilation stacks. Releases of tritium have been controlled at RNPP since 2007 and at KhNPP-2 since 2010.

The total indices (ratio of actual discharges to permissible ones) of registered water discharges to the environment in terms of the main nuclides (^{137}Cs, ^{134}Cs, ^{60}Co, ^{54}Mn, ^{90}Sr, ^{3}H) in 2018 reached 2.13% at ZNPP, 0.50% at RNPP, 1.57% at SUNPP and 0.14% at KhNPP and have not significantly changes in recent years.

Figure 4 (Annex 7) shows dynamics in the total indices of radioactive releases to the environment at NPPs for a period from 2009 to 2018.

The environment in the nuclear installation control areas is monitored by regular radiation monitoring systems in accordance with current regulations on radiation monitoring established at each NPP. These regulations prescribe the scope and methods of monitoring.

In 2018, the radioactive content of atmospheric air in the ZNPP location area was 1.1–1.6 μBq/m^3 for ^{137}Cs and < 0.01 μBq/m^3 for ^{90}Sr. At RNPP, the content of ^{137}Cs radionuclide in atmospheric air varied from 3.9 to 7.1 μBq/m^3. At SUNPP, the registered radioactive content of atmospheric air was < 1.4 μBq/m^3 for ^{137}Cs, and varied from 0.2 to 1.3 μBq/m^3 for ^{90}Sr. At KhNPP, the content of radioactive materials in atmospheric air varied from 1.9 to 11.9 μBq/m^3 for ^{137}Cs and from 0.2 to 3.0 μBq/m^3 for ^{90}Sr.

For all NPPs, the concentrations of radionuclides in surface air are essentially lower than the permitted values for these radionuclides and are at zero background level.

Therefore, Ukraine complies with the provisions of Convention Article 15.

ARTICLE 16 Emergency Preparedness

16.1 Emergency plans and programmes

Each Contracting Party shall take the appropriate steps to ensure that there are on-site and off-site emergency plans that are routinely tested for nuclear installations and cover the activities to be carried out in the event of an emergency.

UCPS functional subsystem "Safety of Nuclear Installations" operates at the national, regional and facility levels in Ukraine.

At the facility level, on-site State Nuclear Safety Inspectorates are responsible for operation of the subsystem. State Regional Nuclear and Radiation Safety Inspectorates are responsible for the subsystem at the regional level.

At the national level, SNRIU EIC is the key subsystem component, which involves the most experienced experts of SNRIU structural subdivisions and subordinate organisations.

According to the Provisions on the UCPS Functional Subsystem "Safety of Nuclear Installations" approved by SNRIU Order No. 16 dated 20 January 2009, the SNRIU shall ensure 24-hour shift, maintain communication with Ukrainian NPPs, analyse and register information on NPP operational events, which is included into a computer database. Information summaries on the Ukrainian power units and messages on operational events at Ukrainian NPPs are placed on the SNRIU website www.snrc.gov.ua.

The actions of the operator and the licensee in case of an accident at NPPs are established by the Standard Emergency Plan for Ukrainian NPPs, Emergency Response Plan of *Energoatom* Headquarters and emergency plans of each NPP.

The emergency plans of *Energoatom* Headquarters and NPPs are based on IAEA practical recommendations concerning emergency planning set forth in the following documents:

- Preparedness and Response for a Nuclear or Radiological Emergency. General Safety Requirements. IAEA Safety Series No. GSR Part 7, Vienna, 2015;
- Method for the Development of Emergency Response Preparedness for Nuclear or Radiological Accidents, IAEA, Vienna, 1998, IAEA-TECDOC-953/R;
- Method for Developing Arrangements for Response to a Nuclear or Radiological Situation, IAEA, Vienna, 2009, Modifying IAEA-TECDOC-953/R.

The development of emergency plans also considered experience of other IAEA member states, in particular France and USA (among others, requirements of the U.S. Nuclear Regulatory Commission for emergency planning presented in Section 10 of the Code of Federal Regulations, Part 50.47, for allocation of responsibilities on emergency response).

NPP emergency plans by their purpose are institutional documents. Managers and licensed personnel of NPPs and the operating organisation with relevant qualification shall be familiarised and aware of how to apply their provisions.

The Standard Emergency Plan for Ukrainian NPPs and associated emergency plans of operating NPPs were checked many times during the missions of IAEA, OSART, WANO and SESU (Ministry of Emergencies) commissions of different levels. Besides, there were no principal comments on the structure and contents of plans, conceptual emergency response, classification of accidents, emergency organisational structure of NPPs, functions and tasks of emergency personnel.

In addition, each NPP developed and introduced a number of regulating documents (Radiation Safety Procedure, Procedure for Personnel Actions in Case of Radiological

Emergencies, Procedure for Plant Shift Supervisor after Notification of Hazardous Natural and Hydrological Phenomena etc.) that specify actions of plant operating personnel in the event of emergencies.

The General Provisions for *Energoatom* System of Preparedness for and Response to Accidents and Emergencies at Nuclear Power Plants of Ukraine, being the main document that establishes the principles of emergency preparedness and response, identifies its goals, objectives, structure and performance, and allocates duties and responsibilities to *Energoatom* subdivisions and officials on emergency planning, preparedness and response, and interaction with external bodies, companies and organisations, were revised in 2015 (as scheduled) to incorporate IAEA recommendations and resolutions and carefully analyse WANO proposals after the Fukushima Daiichi accident (Japan, 2011).

The Emergency Response Plan of *Energoatom* Headquarters and Standard Emergency Plan for NPPs were revised according to the same criteria.

Upon the revisions, relevant changes and additions were made into the documents on emergency preparedness (emergency plans) at NPP level and considered within established timeframes.

The efficiency and agreement of emergency plans of *Energoatom* Headquarters and NPPs are systematically verified during emergency training of different levels, and during scheduled annual comprehensive inspection of NPPs and separated entities, which shall ensure and implement emergency measures in case of a threat and/or occurrence of radiation and nuclear accidents, man-made and natural emergencies.

Comprehensive inspections are conducted by *Energoatom* Headquarters according to a specially developed programme within timeframes established by relevant annual order. According to the conclusions of each inspection, the commission develops a report with conclusions on compliance of emergency preparedness and response, civil protection and safety of separated entities with requirements of legal and other regulatory documents, and presents comments with the deadlines for implementation. *Energoatom* management approves the report and monitor incorporation of its comments.

The following types of emergency exercises are performed to train staff of NPP emergency groups and teams for accidents, as well as improve staff knowledge and skills on mitigation of accident consequences or emergencies:

Location	Training type	Training periodicity
Energoatom Headquarters, NPP. NPP control area, observation area	General plant emergency training involving *Energoatom* top management (GPET)	Every three years for each NPP
NPP	General plant emergency training	Once a year for staff of each NPP
NPP. MCR, CCR	Unit emergency training	Once a year with each shift
NPP. NPP shop	Shop emergency training	Twice a year
NPP. Industrial site, workplace	Training of emergency teams	Twice a year

Location	Training type	Training periodicity
NPP. Workplace	Individual emergency training	For individuals who are going to occupy a specific position or to be transferred to another position or missed scheduled training

The operator performs full-scale GPET every three years at each NPP in accordance with the "Schedule of General Plant Emergency Training together with *Energoatom* Headquarters Involving Representatives of Ministries and Institutions, and Representatives of Local Executive Authorities". On 4-5 October 2017, representatives of the nuclear regulatory bodies of Poland, Norway and Belarus supervised the general plant emergency training at RNPP.

Pursuant to this schedule, the operator participates in state-level emergency exercises every five years, which are conducted by SESU in accordance with NP-306.5.01/3.083-2004 Radiological Accident Response Plan.

In particular, in September 2017, SESU in cooperation with the Defence Threat Reduction Agency of the United States Department of Defence and the Federal Emergency Management Agency of the USA with the participation of other ministries and institutions conducted a state-level emergency response exercise related to a conditional radiation accident at *Energoatom* ZNPP. One of the main tasks of this training was to improve preparedness and skills for the management of nuclear and radiological emergencies and improve existing plans and procedures to coordinate emergency response and protect the public against natural, man-made, social and military threats.

Within the Comprehensive Training and Exercise on Response Force Preparedness, under logistical support of the U.S. Department of Defence, joint command and tactical exercises were conducted in 2018 to check the effectiveness of the facility plan of interaction in the event of sabotage and anti-terrorism security.

SESU also uses GPET as initiating events for annual training and trainings to check efficiency of plans for protection of the public in case of radiological accidents at NPPs with a threat of radiation release.

The arrangement and implementation of emergency radiation protection measures in the event of radiological accidents are governed by the Radiological Accident Response Plan and Exemplary Radiological Accident Response Plan for Territorial Subsystems of the Unified Civil Protection System Whose Territory Belongs Fully or Partially to the NPP Observation Area, approved by Ordinance No. 339 of the Ministry of Health of Ukraine on 6 May 2008.

Energoatom, NPPs and other separated entities ensure full compliance with nuclear legislation and civil protection legislation regarding their obligations and responsibilities to develop and implement measures on emergency preparedness and response.

See details on the emergency preparedness and response system at the link on the *Energoatom* official website^

http://archive.energoatom.kiev.ua/files/file/ag_04122018.pdf

http://archive.energoatom.kiev.ua/ua/actvts/security_activities/emergency_preparedness_response

Within the Ukraine-NATO Annual National Programme for 2019, an updated National Plan of Response to Nuclear and Radiological Emergencies, including those that may occur in other countries and have transboundary effect on the territory of Ukraine or

on safety of its public, is under development and approval, taking into account the participation in international exercises, practical experience and recommendations of NATO member states and IAEA safety standards.

16.2 Information of the public and neighbouring states

Each Contracting Party shall use the appropriate steps to ensure that its own population and competent authorities of the States in the vicinity of the nuclear installation are provided with appropriate information for the emergency planning and response.

Cabinet Resolution No. 733 of 27 September 2017 approved Provisions on the Notification of a Threat or Occurrence of Emergencies and Communications in Civil Protection Field.

According to para. 12 of these Provisions, special notification systems shall be installed and operated at nuclear power plants.

Cabinet Resolution No. 1570 of 2 October 2003 determined the national competent authorities and contact points in accordance with the Convention on Early Notification of a Nuclear Accident and Convention on Assistance in Case of a Nuclear Accident or Radiological Emergency:

- SESU is the competent national body authorised to send and receive requests for assistance in the event of a nuclear accident or radiological emergency and to accept offers of assistance;
- SNRIU is the competent national body authorised to send emergency notification and information in the case of a nuclear accident or radiological emergency in Ukraine and receive emergency notification and information in case of a nuclear accident or radiological emergency in another state and is the only competent national authority responsible for the round-the-clock duty to ensure that emergency notifications and information, as well as requests for assistance, are received at all times;

As the competent national body and contact point within the IAEA Conventions, the SNRIU ensures:

- 24/7 duty to receive and transfer emergency notification of an event or assistance from the IAEA or other countries under international agreements;
- information exchange and communication with the IAEA Incident and Emergency Center and competent authorities of other countries within international agreements (Ukraine concluded 13 such agreements: with Sweden, Turkey, Belarus, Slovakia, Hungary, Finland, Norway, Poland, Germany, Austria, Bulgaria, Latvia, Romania, Russia (not in force)).

The SNRIU Emergency Information Center uses the following automated assessment and forecasting systems:

- InterRass for conservative assessment at close distances;
- JRODOS for realistic assessment at close and far distances;
- Hot Spot for rapid assessment of incidents such as release, explosion (including nuclear) and fire.

On-line monitoring data come from the system for transfer of process and radiation parameters of Ukrainian NPPs, including from the posts of the automated radiation monitoring systems in the 30-km plant control areas.

The SNRIU Emergency Information Centre and *Energoatom* main and backup emergency centres maintain communication with all Ukrainian NPPs, analyse and register information on NPP events and on nuclear and radiation safety. They are

combined in one information system by redundant communication channels – surface and satellite.

Signals and notifications at NPP sites and in industrial areas, as well as in the settlements around the plants are transmitted from the workplace of the plant shift supervisor. Direct telephone communication is established between the plant shift supervisor and on-duty services of territorial authorities in the field of civil protection.

Within 30 minutes from the moment of accident classification, NPP submits recommendations to the management of territorial subsystem of the UCPS regarding iodine treatment and evacuation of working personnel from control area, and regarding protective measures for the public living in the observation area of emergency NPP. Management of the territorial subsystem shall make a decision on radiation protection measures (iodine treatment, shelter and evacuation) and ensure notification of the public on protective measures.

To inform local and central authorities about expected doses to the public and provide forecasts and recommendations on public protection, *Energoatom* uses facility-level decision support systems (DSS) in case of emergencies designed for the 30-km plant area using data of weather stations and ARMS control points.

The atmospheric transport models of the KADO software designed by the Institute of Radiation Protection of the Academy of Technical Sciences of Ukraine allow doses for the public to be calculated in the 30-km plant observation area.

For state-level emergencies or events related to transboundary transfer of radionuclides, an interagency RODOS-Ukraine DSS was created based on the European RODOS system within the programme of cooperation with the European Commission under the Instrument for Nuclear Safety Cooperation (INSC).

RODOS DSS was put into commercial operation at *Energoatom* by Order No. 87 of 26 January 2017.

RODOS DSS uses models of atmospheric transport at significant distances and uses input meteorological data of mesoscale meteorological model (weather research and forecasting model, WRF).

The system is managed by the SESU Ukrainian Hydrometeorological Center, whose structure includes the Centre for Prediction of Radiological Accident Consequences (CPRAC) established within this project to support decisions on radiation protection of personnel and the public in the NPP responsibility area and beyond its boundaries on the territory of Ukraine, and the SESU control and duty service (system remote workplaces).

The CPRAC is intended to perform continuous monitoring of system operability and solve test problems with all its components.

The client part of the system is installed at the *Energoatom* Headquarters Emergency Center in Kyiv and Emergency Centers of ZNPP, RNPP, KhNPP (system remote workplaces) and SUNPP and SNRIU EIC (system user workplaces).

The Ukrainian Hydrometeorological Center ensures, on a voluntary basis, the interaction and transmission of data from the observation network to the European Radiological Data Exchange Platform (EURDEP) that is administrated by the Director General for Energy of the European Union.

Regulatory document NP 306.2.100-2004 "Provisions on the Procedure for Investigation and Accounting of Operational Events at Nuclear Power Plants" (Provisions) establishes the procedure for informing the regulatory body about NPP operational events.

The Action Plan for Educational Measures for the Population Living in the Observation Areas of Nuclear Power Plants was approved by Cabinet Resolution

No. 58-r dated 1 February 2012. Pursuant to this plan, the Ministry of Energy and Coal Industry, SNRIU and *Energoatom* are responsible for informing the public by coverage of the operator's activities, nuclear energy and plant operation in mass media, as well as prompt response to unreliable information based on analysis of relevant publications in printed media, information meetings with target audiences and target groups, etc.

In its day-to-day activities, the operator takes systematic actions to inform the public living in the vicinity of NPPs about radiological risks associated with NPP operation. These actions include:

- dissemination of relevant information material and publications for executive authorities of different levels, mass-media and public institutions, as well as use of official websites and printed media of Ukrainian NPPs;
- response to inquiries of the public, mass-media, executive authorities of various levels, etc.;
- lectures for the public, including schoolchildren, with visits to nuclear installations;
- broadcasting of topical television and radio programmes, appearances of NPP managers and experts, and development and dissemination of special printed and information material (placards, booklets, leaflets, etc.) among the public in the observation areas.

Therefore, Ukraine complies with the provisions of Convention Article 16.

ARTICLE 17 Siting

Each Contracting Party shall take the appropriate steps to ensure that appropriate procedures are established and implemented

17.1 Evaluating all relevant site-related factors likely to affect the safety of a nuclear installation for its projected lifetime.

The siting requirements are established by Ukrainian legal and regulatory documents. The decision-making procedure and requirements for documents justifying the construction of a nuclear installation are determined by Article 37 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety" and Law of Ukraine "On Decision-Making Procedure for Siting, Design and Construction of Nuclear Installations and Radioactive Waste Management Facilities of National Importance". In particular, the submittals shall describe:

- characteristics of the environment in the area of a potential site for an installation;
- EIA report, planned activities on nuclear installation construction and decommissioning;
- design-basis measures to prevent and mitigate adverse environmental impacts.

Criteria for evaluating factors that can affect safety of nuclear installations are determined by NRS regulations and state civil engineering standards. These documents identify performance indicators that characterise natural, economic and demographic conditions in the site area, data of pre-operational monitoring of the environment and meteorological, climatic, geological, seismic, hydrological, hydrogeological, engineering-geological and geochemical characteristics.

In 2008, the SNRIU approved the regulatory document "Safety Requirements for Siting of Nuclear Power Plants" (NP 306.2.144-2008) that establishes safety requirements for NPP siting and takes into account IAEA recommendations.

Cabinet Resolution No. 605-r dated 18 August 2017 approved the Energy Strategy of Ukraine for the Period until 2035 "Safety, Energy Efficiency, Competitiveness" (the Strategy). Ukraine considers nuclear energy as one of the most cost-effective low-carbon energy sources. The Strategy proposes nuclear energy development through the elaboration and approval of the long-term Nuclear Energy Development Programme for Ukraine to be completed at the first implementation stage.

A draft site cadastre specifying the priority sites that comply with the requirements of the regulations on NPP operation and environmental impact was developed and is currently updated to identify candidate sites for new NPP units.

The compliance of NPP sites with NRS standards and regulations is verified during the periodic safety review of operating NPPs.

17.2. Evaluating the likely safety impact of the proposed nuclear installation on individuals, society and the environment.

The legal and regulatory documents of Ukraine regulate the evaluation of the proposed potential impact of the nuclear installation on individual categories of the public, society and the environment in view of safety.

According to Ukrainian legislation, the potential impact of a nuclear installation on the environment is evaluated through EIA. Article 2 of the Law of Ukraine "On Environmental Impact Assessment" provides, in particular, for the development of EIA report by the respective entity, the arrangement and conduct of public discussion of the

EIA report by the authorised central body of the Ministry of Ecology and Natural Resources of Ukraine, the submission of a well-grounded conclusion on EIA by the authorised body and consideration of this conclusion in decision making by the state body on implementation of the planned activity.

Pursuant to Article 36 of the Law of Ukraine "On Environmental Impact Assessment", EIA for planned or ongoing activity shall justify its feasibility and ways of implementation, possible alternatives, characteristics of the environment, types and levels of environmental impact in normal and extreme conditions, possible changes in its qualitative state, ecological and economic consequences and measures to reduce ecological risks and meet ecological safety requirements, etc.

In December 2017, in furtherance of the Law of Ukraine "On Environmental Impact Assessment", the Cabinet of Ministers of Ukraine adopted resolutions to establish the procedure for public hearings in the EIA process (No. 989 dated 13 December 2017), the criteria for determining planned activities that are not subject to EIA (No. 1010 dated 13 December 2017) and the procedure for submission of EIA conclusions, EIA funding, and procedure for keeping the unified environmental impact assessment register (No. 1026 dated 13 December 2017).

The RNPP EIA procedure was started in accordance with the Law of Ukraine "On Environmental Impact Assessment" in 2017. The Environmental Impact Assessment Report and Announcement on Public Discussion of the Environmental Impact Assessment Report are registered in the Unified Environmental Impact Assessment Register (http://eia.menr.gov.ua/places/view/76). In March 2019 (19 March 2019), RNPP concluded an agreement with the Ministry of Ecology and Natural Resources of Ukraine on the arrangement and conduct of public discussions during EIA. The estimated deadline for the implementation of activities under the environmental impact assessment procedure with EIA positive conclusions is the end of 2019.

The EIA Report and Announcement on Public Discussion of EIA Report for the Construction of KhNPP Units 3 and 4 were entered into the Unified Environmental Impact Assessment Register (http://eia.menr.gov.ua/places/view/2231, case No. 201811232231 dated 26 November 2018) after the Law "On Environmental Impact Assessment" was put in force at the end of 2018. An agreement was concluded with the Ministry of Ecology and Natural Resources of Ukraine on the arrangement and conduct of public discussions at the end of 2018 (8 October 2018). Public hearings were held in Ukraine in eight regions and in Kyiv from 11 to 21 February 2019.

17.3. Re-evaluating as necessary all the above relevant factors to ensure the continued safety acceptability of a nuclear installation.

Article 33 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety" states that the operating organisation (operator) shall periodically re-evaluate safety of a nuclear installation or a radioactive waste disposal facility according to the nuclear and radiation safety standards, rules and regulations and shall report on its results to the SNRIU.

Safety reassessment is also performed upon request of the state nuclear regulatory body in case of substantial changes in the design of a nuclear installation or storage facility and if operating experience revealed deficiencies of the previous evaluation.

In order to maintain the safety level and implement corrective actions (if necessary) in a timely manner, re-evaluation of specific factors and nuclear installation site characteristics can be requested. Such re-evaluation may be necessary in the following cases:

- a decision is made to place a new nuclear installation at the site (in Ukraine such re-evaluations were part of the state environmental review at ZNPP in connection with DSFSF construction as well as at KhNPP and RNPP in connection with the construction of KhNPP-2 and RNPP-4, respectively);
- safety improvement programmes are planned (environmental review was performed within the C(I)SIP as a part of feasibility studies. The review resulted in positive findings. The main conclusion was that safety would be improved after implementation of the C(I)SIP at Ukrainian NPPs in full scope, which in due course would reduce the risk of incidents and accidents that can potentially affect the health of personnel and the public);
- new scientific findings that indicate the need to revise the design data on natural factors are obtained (corresponding studies were carried out at RNPP to predict potential development of internal erosion and karst processes; additional seismic studies were carried out at ChNPP and SUNPP, detailed information is provided in para. 5.1.3 of the Fourth National Report of Ukraine);
- negative trends of monitoring data (hydrogeological, engineering-geological, etc.) are revealed: for example, subsidence or sloping of buildings.

Environmental audits were performed at all NPPs in 2018. The audits involved experts who had certificates of environmental auditors issued by the Ministry of Ecology and Natural Resources of Ukraine. The following conclusions were made:

- no significant negative impact on the environment of the region was revealed during NPP operation;
- NPP activity fully complies with requirements of current legislation of Ukraine on environmental protection;
- measures taken at the facilities for environmental protection can be found efficient, comprehensive and justified, and nature protection activity of NPP is efficient and sufficient to a considerable extent;
- environment management system at the facilities under environmental audit is rather efficient and complies with requirements of ISO 14001:2015.

17.4 Consulting Contracting Parties in the vicinity of a proposed nuclear installation, insofar as they are likely to be affected by that installation and, upon request providing the necessary information to such Contracting Parties, in order to enable them to evaluate and make their own assessment of the likely safety impact on their own territory of the nuclear installation.

According to State Construction Standards of Ukraine, if planned activity may affect neighbouring states, transboundary EIA shall be developed in compliance with the Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention) ratified by Ukraine on 19 March 1999.

Under Law of Ukraine No. 2861-IV dated 08 September 2005 "On Decision-Making Procedure for Siting, Design and Construction of Nuclear Installations and Radioactive Waste Management Facilities of National Importance", reports on measures aimed at notification of neighbouring states of a potential transboundary impact shall be developed for new nuclear installations and radwaste management facilities of national importance.

In 2008, the mass media published the Declaration of Intentions to build Khmelnitsky NPP Units 3 and 4.

In 2009-2011, feasibility studies were conducted for the construction of KhNPP Units 3 and 4, including EIA for consequences of transboundary releases under normal operation and in emergencies.

The comprehensive state review of the feasibility study for the construction of KhNPP Units 3 and 4 was conducted by the State Specialised Expert Review Organisation (Central Service for Ukrainian State Civil Engineering Review) and resulted in positive conclusions.

According to the Espoo Convention, *Energoatom* developed "Notification of Planned Activities…", which was submitted by the Ministry of Ecology and Natural Resources of Ukraine, national coordinator under the Convention, to the neighbouring states that are considered potentially affected by the planned activities.

The notified countries confirmed their interest and intention to participate in the procedures of transboundary EIA.

Informational and Analytical Overview of the Feasibility Study for the Construction of KhNPP Units 3 and 4 was prepared to provide adequate information according to the Espoo Convention to the neighbouring states, including environmental and engineering data and assessment of transboundary transfer consequences in normal operation and emergencies.

Transboundary consultations were conducted from 2011 to 2013. All questions, remarks and comments of representatives from neighbouring countries (Poland, Belarus, Hungary, Moldova, Romania, Slovakia, and Austria) were responded with justifications.

In August-September 2013, three expert consultations were held with representatives of state organisations from Poland, Austria and Hungary on the implementation of Article 5 of the Espoo Convention related to the construction of Khmelnitsky NPP Units 3 and 4. Consultations with the Republic of Moldova, Slovakia, Romania and Belarus were conducted by correspondence.

The Cabinet of Ministers of Ukraine approved the feasibility study for the construction of KhNPP Units 3 and 4 by Resolution No. 498-r dated 4 July 2012. Law of Ukraine "On Siting, Design and Construction of Khmelnitsky Nuclear Power Plant Units 3 and 4" No. 5217-VI dated 6 September 2012 became effective on 4 October 2012.

Since the Russian party did not fulfil obligations under the Intergovernmental Agreement, which makes it impossible to construct power units in accordance with the proposed design and which is not acceptable for further review and implementation of the design, and taking into account armed aggression of the Russian Federation against Ukraine, the Verkhovna Rada of Ukraine adopted Law of Ukraine No. 697-VIII in 2015 "On Invalidation of the Law of Ukraine *On Siting, Design and Construction of Khmelnitsky Nuclear Power Plant Units 3 and 4*" and Law of Ukraine No. 696-VIII "On Cancellation of the Agreement between the Cabinet of Ministers of Ukraine and the Government of the Russian Federation on Cooperation in Construction of Khmelnitsky NPP Units 3 and 4".

The Ukrainian party decided to continue the project "Construction of Khmelnitsky NPP Units 3 and 4" with replacement of the reactor supplier. In 2016, the feasibility study for the construction of Khmelnitsky NPP Units 3 and 4 was revised and further approved by the Cabinet of Ministers of Ukraine by Resolution No. 579 of 26 July 2018.

At the same time, a decision was made at the meeting of the Interdepartmental Coordination Council (ICC) on the implementation of the Espoo Convention in Ukraine on 15 December 2016 to continue the transboundary consultations to complete KhNPP Units 3 and 4, which were initiated in accordance with the procedure established in the Espoo Convention. The interested parties of the Convention were informed about this

decision by letter of the Ministry of Ecology and Natural Resources in April 2017. Poland, Austria, and the Republic of Belarus decided to continue transboundary consultations. *Energoatom* prepared updated information on the environmental impact assessment and submitted it to the Ministry of Ecology and Natural Resources of Ukraine in July 2017. During 2017-2018, these countries repeatedly submitted their requests, which received professional responses.

The EIA report for the planned construction of KhNPP Units 3 and 4, containing a section on transboundary impact (in English) was developed to complete the transboundary consultations, in compliance with the Law of Ukraine "On Environmental Impact Assessment". The Report was sent to Poland, Austria and the Republic of Belarus in accordance with the established procedure.

Consultations with the public took place in the Republic of Belarus and the Republic of Poland on the construction of Khmelnitsky NPP Units 3 and 4. Expert consultations and public hearings were held in Austria on 13 June 2019.

Besides, to meet the decision of the Sixth Review Meeting of the Parties to the Espoo Convention, Ukraine implements the EIA procedure, including that in a transboundary context, at the RNPP site and plans to complete it by 2020.

The procedure was started pursuant to Decision VI/2 of the Sixth Review Meeting of the Parties to the Convention and the minutes of meeting of the Interdepartmental Coordination Council on the implementation of the Espoo Convention in Ukraine on 15 December 2016, according to which *Energoatom* submitted an official notification on the intention to perform a safety review at RNPP Units 1 and 2 by 2020 and information on the timeframes for environmental impact assessment of four RNPP units to the Ministry of Ecology and Natural Resources of Ukraine in January 2018.

The EIA procedure for RNPP was started in accordance with Law of Ukraine "On Environmental Impact Assessment" No. 2059-VIII dated 23 May 2017 and in particular with requirements of the Espoo Convention.

In 2008, a report was prepared concerning measures aimed at notification of neighbouring states of a potential transboundary impact from CSFSF, and corresponding consultations were held with the Republic of Belarus as the Party that could be potentially affected by the storage facility operation.

In 2009, the Cabinet of Ministers of Ukraine approved the feasibility study of investments into CSFSF construction, and the Verkhovna Rada of Ukraine adopted the Law of Ukraine on the CSFSF Siting, Design and Construction on 9 February 2012. In June 2017, *Energoatom* obtained SNRIU licence for the construction and commissioning of the centralised spent fuel storage facility for national WWER NPPs. The licence defines the exclusion zone of the Chornobyl nuclear power plant as the construction site in accordance with Cabinet Resolution No. 721-r dated 5 October 2016. CSFSF acceptance into commercial operation is planned for 2020-2022.

Ukraine also developed necessary legislative and regulatory basis to ensure compliance with the justification principle of all radiation-related activities. Extraordinary safety evaluations and re-evaluations of natural and man-made factors are carried out on a regular basis in accordance with the established procedure.

In siting and construction of new nuclear installations, legally imposed measures shall be taken to inform neighbouring states of any potential impact in the transboundary context.

Therefore, Ukraine complies with the provisions of Convention Article 17.

ARTICLE 18 Design and Construction

Each Contracting Party shall take the appropriate steps to ensure that:

18.1. The design and construction of a nuclear installation provide for several reliable levels and methods of protection (defence in depth) against the release of radioactive materials, with a view to preventing the occurrence of accidents and to mitigating their radiological consequences should they occur

In 2008, SNRIU approved the regulatory document "General Safety Provisions for Nuclear Power Plants" NP 306.2.141-2008, which takes into account IAEA recommendations specified in the Basic Safety Principles for Nuclear Power Plants (INSAG-12). Regulatory document NP 306.2.141-2008 identifies safety criteria, fundamentals, and general organisational and engineering safety requirements with defence-in-depth strategy based on five levels relying on:

- successive physical barriers to the spread of radiation and radioactive substances to the environment;
- engineering and organisational measures aimed at protection of physical barriers and maintaining their efficiency.

After the adoption of this and other safety regulations, the designs of operating NPPs in Ukraine were revised for compliance with the established requirements. Corrective actions were developed and implemented for the identified deficiencies. NPP upgrading and reconstruction projects are being developed in accordance with the new safety regulations.

The technical and organisational measures incorporated in the design are intended to prevent any damage of physical safety barriers, strengthen defence-in-depth levels, prevent limits and conditions of safe operation and design-basis accidents from being violated, mitigate their consequences and ensure safety in case of any design-basis initiating events.

The power units considering all implemented safety improvement measures are regarded as the NPP current design.

Based on the results of the Joint EC-IAEA-Ukraine Project on comprehensive design safety assessment of NPPs, the team of international experts confirmed that no inconsistencies with IAEA requirements were found at Ukrainian NPPs.

18.2 The technologies incorporated in the design and construction of a nuclear installation are proven by experience or qualified by testing or analysis

Pursuant to the regulatory document "General Safety Provisions for Nuclear Power Plants" (NP 306.2.141-2008), technical and organisational decisions made to upgrade and improve the safety level also incorporate scientific and technical achievements and are implemented in accordance with the established requirements, namely: they shall be proven by experience or trial operation. The requirements for upgrading are defined by the SNRIU regulation "Requirements for Modifications of Nuclear Installations and Their Safety Assessment Procedure" NP 306.2.106-2005.

According to NRS regulations and standards, the licensing procedure provides for introduction of a technology first at a "pilot" unit and then, after favourable results of trial operation, for its adaptation to other units. This procedure fully complies with international experience and permits implementation of measures based on operating experience and proven practices.

Following the IAEA full-scope Integrated Regulatory Review Service (IRRS) mission, international experts identified a good practice: "application of the "pilot

approach concept" to obtain permission for similar modifications at several plants is efficient if appropriate attention is given to plant differences".

18.3 The design of a nuclear installation allows for reliable, stable and easy manageable operation, with specific consideration of human factors and the man-machine interface

According to new safety regulations, the NPP modification and upgrading projects are developed with account of human factor and introduction of systems and hardware for diagnostics of operational modes and conditions, including self-diagnostics of hardware and software.

The design envisages informational support system of the operator, as a part of NPP instrumentation and control system, including also a system displaying integrated information on the current safety status of the reactor and plant unit in general.

The I&C incorporated in the design and implemented at the units ensure the most favourable conditions for the operators to make correct decisions on NPP control, minimise erroneous decisions, as well as to ensure collection, processing, documentation and storage of appropriate data sufficient for prompt and reliable identification of initiating, their evolution, determination of the actual operation mode of safety systems and components important to safety (especially those of safety classes 1 and 2) and deviations from standard algorithms of personnel actions. Measures are under way to preserve this information in beyond design basis accident conditions.

Therefore, Ukraine complies with the provisions of Convention Article 18.

ARTICLE 19 Operation

19.1 Each Contracting Party shall take the appropriate steps to ensure that the initial authorisation to operate a nuclear installation is based upon an appropriate safety analysis and a commissioning programme demonstrating that the installation, as constructed, is consistent with design and safety requirements

The legal grounds for granting the initial licence for operation of a nuclear installation at a specific life stage are determined in the Laws of Ukraine "On Nuclear Energy Use and Radiation Safety" and "On Licensing Activity in Nuclear Energy" and are specified in the regulation "General Safety Provisions for Nuclear Power Plants" (NP 306.2.141-2008).

The licence granted to the operator for a specific life stage determines activities or operations that may be conducted during construction, commissioning and operation only under a written permit issued by the SNRIU. The terms and procedure for issuing such permits are determined by the SNRIU and specified in safety regulations and standards.

19.2 Operational limits and conditions derived from the safety analysis, tests and operational experience are defined and revised as necessary for identifying safe boundaries for operation

The main document defining safe operation of NPP units is technical specifications for safe operation, which defines the limits and conditions of safe operation as well as requirements, methods and general procedure for operations associated with NPP safety.

The technical specifications for safe operation are based on the plant design, SAR, and technical documentation for equipment.

The limits and conditions of safe operation are continuously monitored and specified through operating experience analysis, evaluation of the current safety level and new scientific and technical information, as well as in case of equipment modifications and introduction of new systems, in accordance with regulatory requirements.

The technical specifications for safe operation and other operational documents are amended when necessary, on a permanent basis. Operational documentation is subject to revision every three years.

19.3 Operation, maintenance, inspection and testing of a nuclear installation are conducted in accordance with approved procedures

Operation, maintenance, inspection and testing of a nuclear installation are conducted in accordance with the approved technical specifications for safe operation, operating and inspection procedures.

To ensure compliance of safety-related systems with the design requirements, regular maintenance and inspection activities are carried out. These activities are arranged according to the procedures, programmes and schedules and are carefully documented. Conditions for maintenance, repair and inspection of safety systems are established in the SAR and respective specifications. Administrative and technical measures are determined to prevent possible unauthorised changes in circuits, instrumentation and algorithms of the control safety systems. After maintenance, the systems and equipment are verified for operability and compliance with the design characteristics, the results being recorded.

Operability of safety systems, safety-related systems, monitoring and control systems and condition of the base metal and welds of safety-related systems and components are inspected prior to NPP start-up after refuelling outage and periodically

according to the technical specifications for safe operation and operating procedures. The frequency and scope of periodic inspections are determined in the design and established by NPP schedules. Unscheduled inspections can be conducted upon request of the regulatory body.

In the reporting period, corporate WANO peer review of *Energoatom* was performed. The SNRIU conducted planned regulatory inspections.

Besides, *Energoatom* conducts internal inspections according to the approved programmes such as standard programme for NPP nuclear safety verification, programme for safety culture review, etc. Following internal inspections, corrective actions are developed and implemented to eliminate the deficiencies in operational safety.

Energoatom submits the results of internal operational safety inspections and periodic safety review reports to the regulatory body. The frequency and requirements for the reports are defined by regulatory documents.

19.4 Procedures are established for responding to anticipated operational occurrences and to accidents

Currently, the following *Energoatom* documents define emergency response actions for events and accidents that may occur in NPP operation:

- procedures for mitigation of reactor abnormal operation;
- reactor emergency operating procedures (EOP);
- SAMG;
- emergency response plan of *Energoatom* Headquarters;
- standard emergency response plan for Ukrainian NPPs and NPP response plans based on the standard plan.

Peer reviews of all *Energoatom* NPPs were performed to familiarise with and generalise operating experience, exchange information of solving challenging issues, familiarise, check and assess efficiency of organisational and technical measures performed by NPPs regarding EOPs during their support from 2010. The reports with peer review results were submitted to NPPs to be used in operation. Results of peer reviews confirmed their efficiency, so they are planned for the future as well.

According to SNRIU Board Resolution No. 13 dated 24-25 November 2011 "On Results of Targeted Safety Reassessment of Operating NPPs and ZNPP Dry Spent Fuel Storage Facility in the Light of the Fukushima Daiichi Accident", the operator already took measures within the C(I)SIP to develop EOPs for low power and shutdown states and developed SAMGs for full power and shutdown for all NPP units.

SAMGs for reactor operation at full power and SFP were implemented for pilot units SUNPP-1, ZNPP-1 and RNPP-1 in 2014. In 2015-2016, SAMGs for reactor shutdown state and SFP were implemented for pilot units SUNPP-1, ZNPP-1, and RNPP-1.

SAMG development and implementation for all other Ukrainian NPPs was completed in 2017.

"Provisions on the Use of a Package of Severe Accident Management Guidelines" VL-D.0.41.630-16 and other documents governing the application and maintenance of emergency documents were additionally developed.

19.5 Necessary engineering and technical support in all safety-related fields is available throughout the lifetime of a nuclear installation

Engineering support of nuclear installations is provided by the corresponding *Energoatom* departments, Ukrainian and foreign institutes and expert organisations.

Engineering support activities are performed by Ukrainian design institutes, scientific organisations and establishments of the Academy of Sciences of Ukraine and other countries (including those involved in NPP des).

Engineering support within *Energoatom* is provided by the corresponding engineering departments established at each NPP; industry-level tasks are performed by *Energoatom* departments and the Scientific and Technical Centre.

Responsibilities and activities are distributed according to the administrative documents that identify responsibilities, interactions, and organisation of the activities.

Engineering support covers the following areas:

- NPP safety analysis,
- implementation of new technologies,
- ageing management,
- equipment qualification,
- radiological materials science,
- strength and resistance of systems, structures, and components,
- reactor core operation,
- radwaste and spent fuel management.

19.6 Incidents significant to safety are reported in a timely manner by the holder of the relevant licence to the regulatory body

According to the national requirements and recommendations related to the investigation and recording of NPP operational events, the operator :

- developed a system for accumulation, analysis and feedback of operating experience;
- is responsible for the adequacy and quality of investigations, reliability and timely submission of the investigation results for NPP operational events to the SNRIU;
- takes measures to prevent safety-significant events, in particular failures of equipment and human errors and improve the operating procedures, methods and means for diagnostics of equipment, systems and components important to safety.

In turn, the SNRIU verifies compliance with the safety rules and regulations during the investigation and analysis of NPP operational events and planning and inspections based on the experience gained from investigation of operational events, in compliance with national NRS standards, provisions of 2014/87/Euratom Council Directive, respective reference levels of the Western European Nuclear Regulators Association (WENRA) and IAEA recommendations (in particular, SSG-50 Operating Experience Feedback for Nuclear Installations). The SNRIU pays special attention to the following issues in the investigation of NPP operational events by the operator:

- arrangements for operational event investigation and adequate recording of investigation results;
- correct and timely classification of operational events depending on their features and consequences;
- correct definition of root causes of events and identification of corrective measures to exclude the recurrence of similar faults in the future;

- monitoring over completeness and timeliness of corrective measures identified upon investigation.

22 operational events occurred at Ukrainian nuclear power plants in 2018; this number is higher than in 2017 (16 events) and 2016 (12 events). Seven NPP operational events occurred in early 2019. The number of operational events increased in 2018 as a result of increased failure of normal-operation equipment that is not significant to safety but its failure led to unit disconnection or unloading.

No operational events that led to human exposure or radioactive releases/discharges to the environment above the established limits were recorded at Ukrainian nuclear power plants in 2016-2019. Ukrainian NPPs were operated without violation of safe operation limits. No events occurred that would lead to drop and/or damage of fuel assemblies.

Violation of safe operation conditions that occurred for the first time since 2004 was recorded in 2018, when ZNPP personnel did not check the operability of safety system trains 1 and 3 at Unit 4 after they found that safety system 2 was inoperable during scheduled test. This violation was evaluated as Level 1 on the INES scale, which includes insignificant failures of components important to safety when a major part of the defence in depth remains operable. Other events that occurred in 2016-2019 were classified as below scale/Level 0 (not important to safety).

19.7 Programmes to collect and analyse operating experience are established, the results obtained and the conclusions drawn are acted upon and existing mechanisms are used to share important experience with international bodies and with other operating organisations and regulatory bodies

The operator provides collection, processing, analysis and storage of information on equipment failures and human errors, ensures systematisation and prompt transfer of the information obtained. The information on equipment failures and human errors is included into the annual safety status reports.

Safe operation of NPPs is supported by the information event database being a part of the unified information system of the operator: information system on operational events at Ukrainian NPPs.

Energoatom implemented programmes for operating experience exchange:

- Ukrainian reliability database (for engineering support of the equipment rejection system and determination of reliability characteristics of safety-related systems and components).
- Information system on operational events (for collection, processing, analysis and storage of data on equipment failures and human errors).
- Operational safety and technical assessment system (for development of reports on NPP performance indicators and current safety state of power units).

Operating experience, both internal and external, is thoroughly analysed. There are special divisions dealing with these aspects within the operating organisation.

Notifications on significant events at Ukrainian NPPs are promptly submitted to the IAEA and WANO within the operating experience exchange programmes. Similarly, the Ukrainian operator receives information about significant events at NPPs worldwide from the IAEA and WANO.

Appropriate contacts are maintained with the plant design institutions, research organisations, and equipment manufacturers to bring the operating experience to their knowledge and to receive their recommendations, if necessary.

The Ukrainian operator developed and implemented the company standard SOU NAEK 035:2013 "System for Accumulation, Analysis and Application of Operating Experience" that sets forth general requirements for effective functioning of the Ukrainian and worldwide NPP operating experience feedback system. The standard contains general requirements for implementation of all activities ensuring effective functioning of the system for operating experience accumulation, analysis and application.

According to this standard, the Guidelines on Self-Assessment of Efficiency of the Systems for Accumulation, Analysis and Application of Operating Experience were developed, based on which the operating organisation performs annual self-assessment of the systems for accumulation, analysis and application of operating experience.

IAEA experts conducted PROSPER mission related to NPP operating experience on the initiative of the Ukrainian operator in 2018. IAEA experts noted that the Ukrainian operator sought to improve operational safety through operating experience feedback, as evidenced by the development of culture for considering low-level events and consistent promotion of operating experience feedback in daily operation of nuclear power plants.

In the reporting period, Ukraine actively participated in all meetings and workgroups of the Forum of WWER Regulators and exchanged information on WWER operating experience.

19.8. The generation of radioactive waste resulting from the operation of a nuclear installation is kept to the minimum practicable for the process concerned, both in activity and in volume, and any necessary treatment and storage of spent fuel and waste directly related to the operation and on the same site as that of the nuclear installation take into consideration conditioning and disposal

Each NPP is provided with process systems and facilities for collection and preliminary treatment of solid and liquid radioactive waste on the NPP site. NPP management keeps records of the amounts, transfer, and location of all radioactive materials, including nuclear fuel, dismantled equipment, contaminated tools, clothes, radwaste and other radiation sources.

The *Energoatom* Comprehensive Radioactive Waste Management Programme for 2017–2021 was developed in 2016 and is under implementation to improve the technical policy in radwaste management, determine and allocate funds for implementation of the first-priority radwaste management measures and monitor their implementation.

Technical measures for the construction of complex radioactive waste processing and conditioning lines, implementation of individual radioactive waste management facilities for radwaste retrieval, decontamination of radioactive metal and implementation of advanced technologies for radwaste waste conditioning are planned and are currently implemented under the National Target Environmental Programme for Radioactive Waste Management (for 2008-2017) and the *Energoatom* Comprehensive Radioactive Waste Management Programme.

Particular attention is paid to the construction and commissioning of radioactive waste treatment plants (RWTP) to process radioactive waste to a condition acceptable for disposal, arrange storage of conditioned radioactive waste and reduce the amounts of radioactive waste accumulated and generated in current operation. Projects for the construction of radioactive waste treatment plants at ZNPP and RNPP were implemented with the support of the European Commission TACIS programme in the reporting period. RNPP and ZNPP RWTPs with actual radioactive waste were commissioned in 2018.

Activities aimed at RWTP implementation at KhNPP and SUNPP are currently under performance.

One of the priority areas for radioactive waste management defined in the Comprehensive Programme is to ensure a minimum level of radioactive waste generation in NPP operation. Industry measures and NPP activities to minimise radioactive waste generation are planned and implemented; the most efficient measures are limitation of generation, advanced decontamination technologies, improved work planning in the strict access area and measures determined upon analysis of generation sources and amounts of radioactive media, liquid and solid radwaste, etc.

The strategic task for the management of spent fuel that is currently implemented at *Energoatom* is to fundamentally change the existing spent fuel management approach, which is oriented towards the transport of spent fuel for technological storage and reprocessing to the Russian Federation, through the construction and commissioning of a Ukrainian storage facility for dry spent fuel from RNPP, KhNPP and SUNPP – CSFSF. CSFSF and DSFSF, which has been in operation since 2001 at the ZNPP site, will become a single spent fuel treatment system for the national nuclear power plants. The decision on further management of spent fuel in the long term (reprocessing and disposal of reprocessing waste or disposal of spent fuel in a geological repository) will be made considering international experience after expiation of the period for spent fuel storage in the existing dry storage facility and the one under construction.

The construction of infrastructure for long-term storage of vitrified high-level waste resulting from the reprocessing of WWER-440 spent fuel to be returned to Ukraine from the Russian Federation is envisaged at the Vektor site.

Detailed information on NPP radwaste management is provided in the Sixth National Report of Ukraine under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management that was presented by Ukraine at the Sixth Review Meeting of the Contracting Parties in May 2018 in Vienna (Austria).

Therefore, Ukraine complies with the provisions of Convention Article 19.

ANNEX 1 List of Nuclear Power Plants in Ukraine

1. Power Units in Operation

NPP	Unit No.	Electrical Power, MW	Reactor Type	End of Design-Basis Life/Long-Term Operation
Zaporizhzhya	1	1000	V-320	23.12.2015/23.12.2025
	2	1000	V-320	19.02.2016/19.02.2026
	3	1000	V-320	05.03.2017/05.03.2027
	4	1000	V-320	04.04.2018/04.04.2028
	5	1000	V-320	27.05.2020
	6	1000	V-320	21.10.2026
South Ukraine	1	1000	V-302	02.12.2013/02.12.2023
	2	1000	V-338	12.05.2015/31.12.2025
	3	1000	V-320	10.02.2020
Rivne	1	420	V-213	22.12.2010/22.12.2030
	2	415	V-213	22.12.2011/22.12.2031
	3	1000	V-320	11.12.2017/11.12.2037
	4	1000	V-320	07.06.2035
Khmelnitsky	1	1000	V-320	13.12.2018/long-term operation activities are under way
	2	1000	V-320	07.09.2035

2. Power Units to Be Completed and Commissioned

NPP	Unit No.	Electrical Power, MW	Commissioning Date (as Scheduled)
Khmelnitsky	3	1000	Basic design efforts are under way
	4	1000	

ANNEX 2 List of Safety Improvement Programmes

1. Comprehensive (Integrated) Safety Improvement Programme for Nuclear Power Plants, approved by Cabinet Resolution No. 1270 dated 7 December 2011.

2. Programme on Reconstruction of the Radiation Monitoring Systems at Nuclear Power Plants in Ukraine, PM-D.0.08.428-10.

ANNEX 3 Analysis on Implementation of IAEA Recommendations within Safety Improvement Programmes

SUMMARY ON IMPLEMENTATION OF IAEA RECOMMENDATIONS WITHIN SAFETY IMPROVEMENT PROGRAMMES

4.1 Implementation of IAEA Recommendations Provided in the Reports:

Safety Issues and Their Ranking for WWER-1000 Model 320 Nuclear Power Plants, IAEA-EBP-WWER-05;
Safety Issues and Their Ranking for Small Series WWER 1000 Nuclear Power Plants, IAEA-EBP-WWER-14;
Safety Issues and Their Ranking for WWER-440 Model 213 Nuclear Power Plants, IAEA-EBP-WWER-03.

Most of the safety recommendations identified in the Reports have been implemented. The remaining activities are incorporated into the existing safety improvement programme.

Information on the status of recommendations for rank III safety issues (issues of high safety concern) at NPPs is provided below.

4.1.1 WWER-1000/V-320 Nuclear Power Plants:

Nine of the eleven recommendations have been implemented. The remaining two recommendations are being resolved under the Comprehensive (Integrated) Safety Improvement Programme (C(I)SIP):

Issue No.	Title	Rank	Status	Comments
G2	Equipment qualification	III	Ongoing	The effort is ongoing under C(I)SIP measure 10101. Completed for all units except for ZNPP-5,6 (deadline - 2020).
S9	Qualification of steam generator pilot-operated relief vales and BRU-A (steam dump valve to atmosphere) for water and steam-water discharge	III	Ongoing	Steam generator pilot-operated relief valves have been replaced at all V-320 units. Qualification of steam dump valve drives has been completed under C(I)SIP measure 13302 at all NPP units except for ZNPP-5,6 and RNPP-4. To be completed at V-320 power units: in 2019 for RNPP-4; in 202 for ZNPP-5,6.

4.1.2 WWER-1000/V-320, V-338 Nuclear Power Plants

All 12 recommendations have been implemented. The last recommendation was implemented under the Comprehensive (Integrated) Safety Improvement Programme (C(I)SIP):

Issue No.	Title	Rank	Status	Comments
G2	Equipment qualification	III	Completed	The effort has been completed under C(I)SIP measure 20101.
CI 6	Steam and feedwater piping integrity	III	Completed	Accident scenarios for various points of break on steam line when filled with hot water have been studied within the SAR. C(I)SIP measure 22201 has been completed to prevent consequences from secondary piping rupture outside the containment. The integrity of steam lines and feedwater piping has been justified by calculation for emergency modes (super-pipe concept). LISEGA hydraulic snubbers have been installed on main steam lines and feedwater piping.
S 14	Boron injection system capability	III	Completed	Engineering analysis has been carried out for both units to identify critical components for first-priority qualification for accident conditions. Safety analysis has been carried out for primary pressure control with HPIS. Procedure for HPIS phased disconnection under compensated flow control has been introduced into EOPs. Upgrade has been implemented to ensure coolant flow for operating HPIS from adjacent LPIS tanks. A throttling device has been installed on the HPIS pressure side to ensure HPIS operation in the primary side at P_{1s} <40 kgf/cm^2. A bypass line with a flow control device has been mounted on HPIS pump pressure side. HPIS and LPIS have been upgraded for pressure control in pump operation in the primary side (C(I)SIP

Issue No.	Title	Rank	Status	Comments
				measures 23402 and 23403). The reports on measures are agreed upon with the SNRIU.

4.1.3 WWER-1000/V-213 Nuclear Power Plants

All eight recommendations have been implemented at both RNPP Units 1&2.

4.2 Status of IAEA Recommendations Provided in the Final EC/IAEA/Ukraine Report (Design Safety)

The design safety assessment demonstrates that all Ukrainian NPPs fully comply with most of the 192 safety requirements set forth by the IAEA for plant design.

Five generic areas in which IAEA requirements are partially met are identified. These areas include equipment qualification, consideration of severe accidents, confirmation of seismic margin, completeness of probabilistic safety analysis and complementary safety analyses, instrumentation and control and post-accident monitoring equipment.

Effective work is in progress to eliminate the incompliance at all power units within the Comprehensive (Integrated) Safety Improvement Programme for Nuclear Power Plants.

The status of activities aimed at implementing the IAEA recommendations at NPPs is shown below.

Measure	Title	Status	Deadline
WWER-1000/V-320			
10101	Development of documents and qualification of NPP components	Ongoing	The effort is ongoing under C(I)SIP measure 10101. The measure has been completed for all units except for ZNPP-5, 6. To be completed at ZNPP-5, 6 in 2020.
14101	Instrumentation during and after beyond-design basis accidents	Ongoing	The effort is ongoing under C(I)SIP measure 14101.

Measure	Title	Status	Deadline
			The measure has been completed for ZNPP-1, 2 and RNPP-3, 4. The measure for ZNPP-3,4 is under completion (physical scope completed, reports are being agreed with the SNRIU). The effort is ongoing in 2019 at KhNPP-1, SUNPP-3 and ZNPP-5. To be completed at ZNPP-2 and ZNPP-6 in 2020
16201	Introduction of containment hydrogen control system for beyond-design basic accidents	Ongoing	The effort is ongoing under C(I)SIP measure 16201. The measure has been completed for ZNPP-1-4 and RNPP-3. The measure for KhNPP-1, SUNPP-3, ZNPP-5 and RNPP-4 is ongoing in 2019. To be completed at ZNPP-6 and KhNPP-2 in 2020. Equipment for ZNPP-3-6, SUNPP-3, RNPP-3,4 and KhNPP-1 is/has been purchased from EBRD/EA loan.
18101	Seismic resistance of systems, structures and components important to safety	Ongoing	The effort is ongoing under C(I)SIP measure 18101. The effort is divided into two stages: Stage I – conservatively, without results of seismic monitoring; Stage II – after obtaining seismic monitoring results.

Measure	Title	Status	Deadline
			The measure for SUNPP-3 has been fully completed. The measure for ZNPP-1, 3, 4 and RNPP-3, 4 has been completed in the scope of Stage I. The measure is to be completed in the scope of Stage I for ZNPP-2, KhNPP-1 and KhNPP-2 in 2019 and for ZNPP-5 in 2020. The measure is to be completed considering seismic monitoring results – after obtaining observation results from the seismic monitoring system.
19101	Development of full-scope SAR in compliance with regulatory requirements	Completed	
19202	Development, technical justification, validation and introduction of symptom-oriented EOPs to manage design and beyond-design basis accidents	Completed	
19203	Improvement of emergency operating procedures for low power and shutdown states	Completed	
19204	Severe accident analysis. Development of SAMGs	Completed	The effort is taken under C(I)SIP measure 19204. The effort is divided into two stages: the first for full power operation and the second for shutdown state. SAMGs for full power have been developed for ZNPP-1-6, SUNPP-3. SAMGs have been developed for other

Measure	Title	Status	Deadline
			non-pilot units, the reports/or deliverables are being agreed with the SNRIU. SAMG for shutdown state has been developed for ZNPP-1. For non-pilot units, SAMGs for shutdown state have been developed and are being agreed with the SNRIU or revised to incorporate comments of regulatory review.
WWER-1000/V-302-338			
20101	Development of documents and qualification of NPP components	Completed	The effort has been completed under C(I)SIP measure 20101.
22201	Prevention of consequences induced by secondary piping rupture outside containment	Completed	The effort has been completed under C(I)SIP measure 22201.
24101	Instrumentation during and after beyond-design basis accidents	Ongoing	The effort has been completed at SUNPP-1 in physical scope in 2018 (report is being revised to incorporate SNRIU comments). The effort is to be completed: at SUNPP-1 in 2019
26201	Introduction of containment hydrogen control system for beyond-design basic accidents	Ongoing	The effort has been completed at SUNPP-1 under C(I)SIP measure 26201. The effort is to be completed: at SUNPP-2 in 2019
28101	Seismic resistance of systems, structures and components important to	Completed	The effort has been completed under

Measure	Title	Status	Deadline
	safety		C(I)SIP measure 28101.
29101	Development of full-scope SAR in compliance with regulatory requirements	Completed	The effort has been completed under C(I)SIP measure 29101.
29204	Severe accident analysis. Development of SAMGs	Completed	The effort has been completed under C(I)SIP measure 29204.
WWER-440/B-213			
30101	Development of documents and qualification of NPP components	Completed	
33503	Habitability of main control room and emergency control room in design and beyond-design basis accidents (installation of iodine filters)	Completed	
34101	Instrumentation during and after beyond-design basis accidents	Completed	The effort is taken under C(I)SIP measure 34101. The effort is to be completed: at RNPP-1, 2 in 2020
34408	Introduction of hydrogen control system in steam generator and reactor coolant pump box (A201) and pressurizer compartment (A527/1) (remains to be done at RNPP-1)	Completed	
38101	Seismic resistance of systems, structures and components important to safety	Ongoing	The effort is ongoing under C(I)SIP measure 38101. The effort is to be completed: at RNPP-1, 2 in 2017
39101	Development of full-scope SAR in compliance with regulatory requirements	Completed	
39204	Severe accident analysis. Development of SAMGs	Completed	

ANNEX 4 List of Legislative and Regulatory Documents on Nuclear Energy Use Implemented in 2015-2019

Legislative Acts

1. Law of Ukraine No. 696-VIII "On Cancellation of the Agreement between the Cabinet of Ministers of Ukraine and the Government of the Russian Federation on Cooperation in Construction of Khmelnitsky NPP Units 3 and 4" dated 16 September 2015;
2. Law of Ukraine No. 697-VIII "On Invalidation of the Law of Ukraine *On Siting, Design and Construction of Khmelnitsky Nuclear Power Plant Units 3 and 4*" dated 16 September 2015;
3. Law of Ukraine No. 1339-VIII "On Amendment of the Law of Ukraine *On the Status and Social Protection of Citizens Suffered from the Chornobyl Disaster* to Eliminate Discriminatory Attitudes towards Citizens Who Participated in Mitigation of Other Nuclear Accidents, Nuclear Tests and Military Exercises Using Nuclear Weapons" dated 21 April 2016;
4. Law of Ukraine No. 1542-VIII "On Ratification of the Agreement Between the Government of Ukraine and the European Atomic Energy Community on Scientific and Technological Cooperation and the Associated Participation of Ukraine in the Euratom Research and Training Programme (2014 - 2018)" dated 22 September 2016;
5. Law of Ukraine No. 1638-VIII "On Amendment of Article 265 of the Criminal Code of Ukraine on the Voluntary Handover of Radioactive Material" dated 4 October 2016;
6. Law of Ukraine No. 2059-VIII "On Environmental Impact Assessment" dated 23 May 2017;
7. Law of Ukraine No. 2124-VIII "On Amendment of Article 4 of the Law of Ukraine "On Radioactive Waste Management" to Improve the Funding Mechanism for Radioactive Waste Management" dated 11 July 2017;
8. Law of Ukraine No. 2125-VIII "On Amendment of the Budget Code of Ukraine to Improve the Funding Mechanism for Radioactive Waste Management" dated 11 July 2017;
9. Law of Ukraine No. 2595-VIII "On Amendment of the National Programme for Chornobyl Nuclear Power Plant Decommissioning and Shelter Transformation into an Environmentally Safe System" dated 16 October 2018;

Resolutions of the Cabinet of Ministers of Ukraine

1. Cabinet Resolution No. 83 "On Approval of a List of State-Owned Facilities of Strategic Importance for National Economy and Security" dated 4 March 2015, referring *Energoatom* to such facilities;
2. Cabinet Resolution No. 89 "On Amendment of the Procedure for the Development and Approval of the Standards, Rules and Regulations on Nuclear and Radiation Safety" dated 27 January 2016;

3. Cabinet Resolution No. 358 "On Operation of the Territorial Bodies of the State Nuclear Regulatory Inspectorate of Ukraine" dated 8 June 2016;
4. Cabinet Resolution No. 405 "On Amendment of the Procedure for Using Funds Envisaged in the State Budget for Keeping the State Register of Radiation Sources" dated 01 July 2016;
5. Cabinet Resolution No. 702 "On Amendment of Cabinet Resolutions No. 1471 of 25 December 1997 and No. 625 of 26 April 2003" dated 11 October 2016;
6. Cabinet Resolution No. 39 "Some Issues in Optimising Activities of the Territorial Bodies of the State Nuclear Regulatory Inspectorate of Ukraine" dated 25 January 2017;
7. Cabinet Resolution No. 458 "On Amendment of Cabinet Resolution No. 591 of 1 June 2011" dated 4 July 2017;
8. Cabinet Resolution No. 785 "On Amendment of the Statute on the State Nuclear Regulatory Inspectorate of Ukraine" dated 18 October 2017.
9. Cabinet Resolution No. 1064 "On Amendment of Cabinet Resolutions No. 440 of 6 May 2001 and No. 591 of 1 June 2011" dated 27 December 2017.
10. Cabinet Resolution No. 903 "On Amendment of the Procedure for State Oversight of Compliance with Requirements for Nuclear and Radiation Safety" dated 31 October 2018.
11. Cabinet Resolution No. 884 "On Approval of the Technical Regulation for Packaging for Radioactive Waste Storage and Disposal" dated 17 October 2018.
12. Cabinet Resolution No. 995 "On Amendment of Cabinet Resolution No. 313 of 2 April 2001 and Invalidation of Some Cabinet Resolutions" dated 28 November 2018.

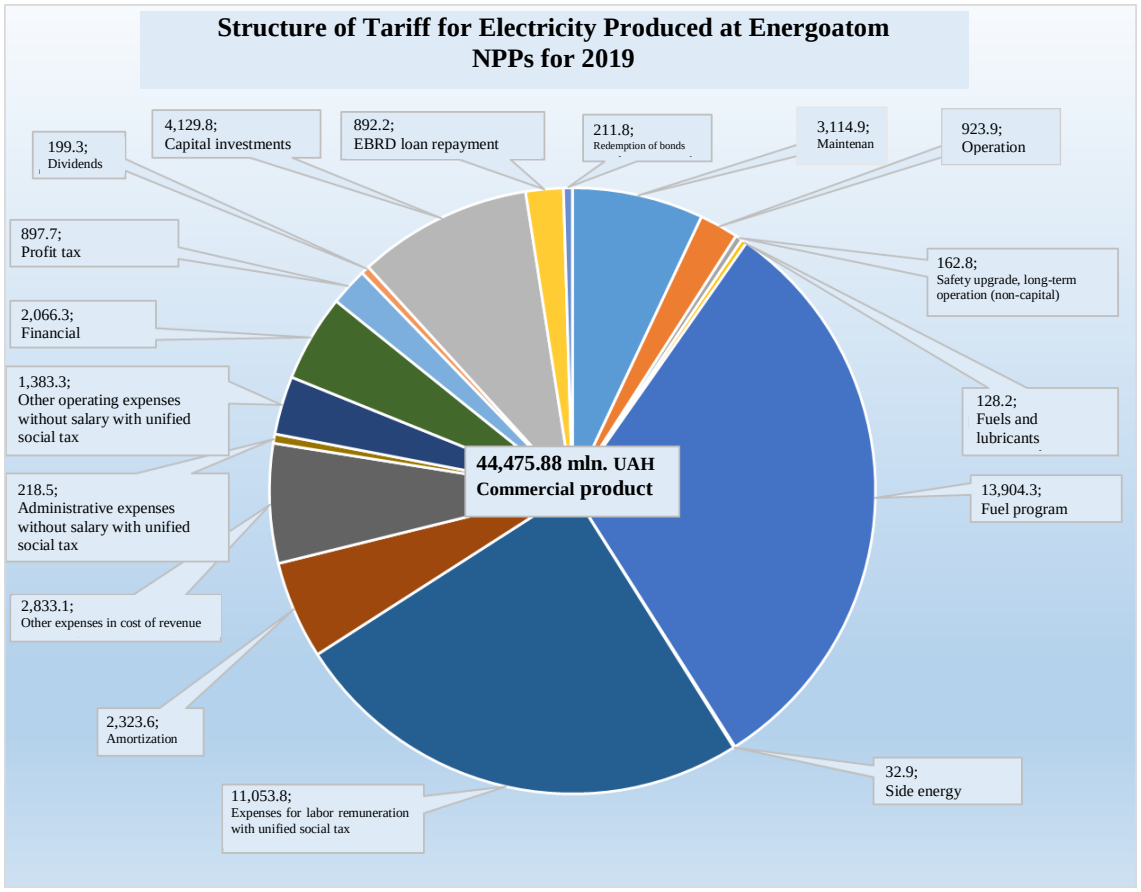
Regulations of the State Nuclear Regulatory Inspectorate of Ukraine

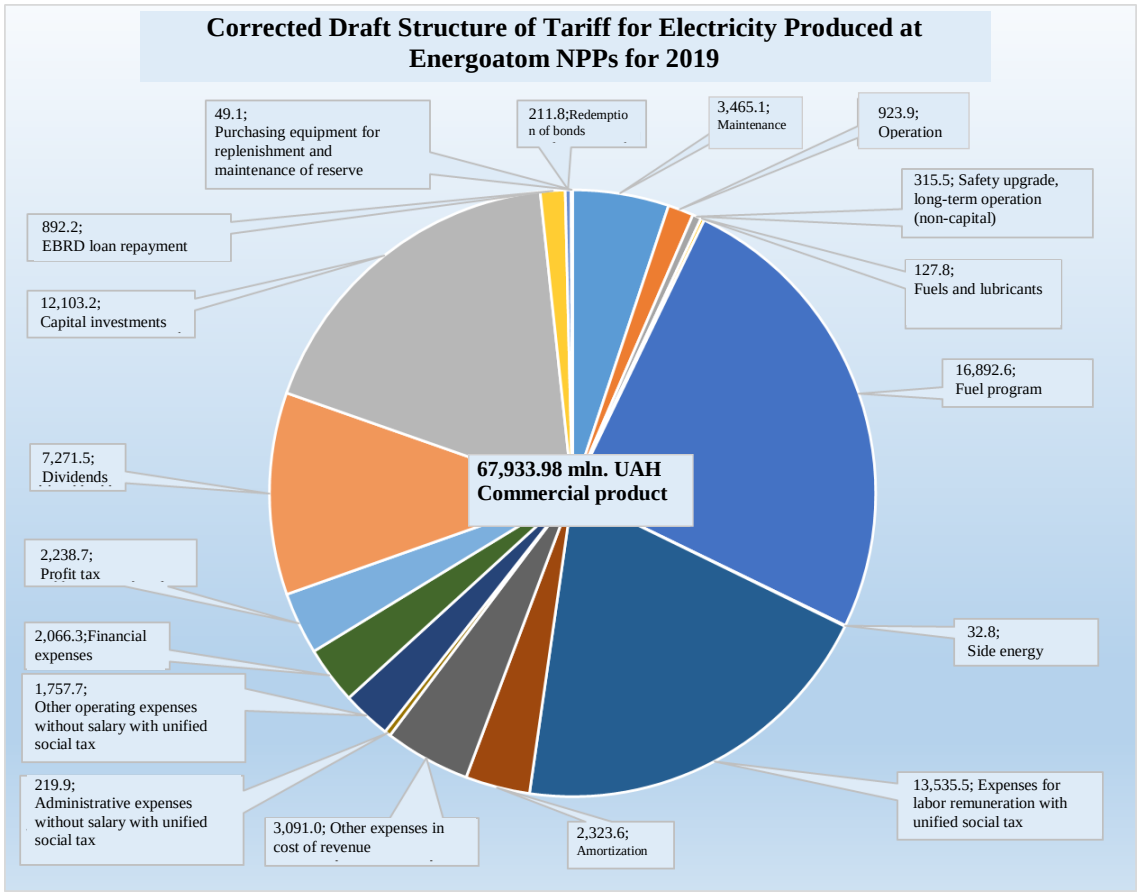
1. SNRIU Order No. 12 "On Approval of a List of Documents Submitted by the Operating Organisation for a Licence for Individual Life Stages of a Nuclear Installation" dated 28 January 2015;
2. SNRIU Order No. 70 "On Approval of the Procedure for Use of the State Register of Radiation Sources" dated 16 April 2015;
3. SNRIU Order No. 69 "On Approval of Registration Cards for Radiation Sources" dated 16 April 2015;
4. SNRIU Order No. 93 "On Approval of Access Control Rules at the State Nuclear Regulatory Inspectorate of Ukraine" dated 20 May 2015;
5. SNRIU Order No. 101 "On Approval of Requirements and Safety Conditions (Licensing Terms) for Uranium Ore Processing" dated 27 May 2015;
6. SNRIU Order No. 140 "On Approval of Nuclear and Radiation Safety Requirements for Instrumentation and Control Systems Important to Safety of Nuclear Power Plants" dated 22 July 2015;
7. SNRIU Order No. 148 "On Approval of Requirements and Safety Conditions (Licensing Terms) for Fabrication of Radiation Sources" dated 13 August 2015;

8. SNRIU Order No. 233 "On Approval of Requirements for Nuclear Fuel Emergency Cooling Systems and Heat Removal to Ultimate Heat Sink" dated 24 December 2015;
9. SNRIU Order No. 234 "On Approval of Requirements for Power Supply Systems Important to Safety of Nuclear Power Plants" dated 24 December 2015;
10. SNRIU Order No. 228 "On Amendment of the Procedure for State Inventory of Radioactive Waste" dated 21 December 2015;
11. SNRIU Order "On Amendment of Requirements for Safety Assessment of Nuclear Power Plants" dated 11 February 2016;
12. SNRIU Order No. 175 "On Approval of Requirements for NPP Seismic Design and Seismic Safety Assessment" dated 17 October 2016;
13. SNRIU Order No. 176 "On Approval of Procedure for the Development, Approval, State Registration and Recording of Nuclear and Radiation Safety Regulations" dated 18 October 2016;
14. SNRIU and Ministry of Health Order No. 724/110 "Instruction on Information Interaction between the State Emergency Service of Ukraine and the State Nuclear Regulatory Inspectorate of Ukraine in the Field of Emergency Prevention and Response" dated 27 July 2016;
15. SNRIU Order No. 39 "Guideline for Keeping Records of Citizens' Requests to the State Nuclear Regulatory Inspectorate of Ukraine" dated 21 March 2016;
16. SNRIU Order No. 201 "On Amendment of Requirements for NPP On-site and Off-site Emergency Centers" dated 9 December 2016;
17. SNRIU Order No. 32 "On Recognition of SNRIU Order No. 142 of 11 October 2011 as invalid" dated 06 February 2017;
18. SNRIU and Ministry of Health Order No. 51/151 "General Safety Rules for Medical Radiation Sources" dated 16 February 2017;
19. SNRIU Order No. 60 "Requirements for Institutional Control of Uranium Sites within Restricted Clearance from Regulatory Control" dated 21 February 2017;
20. SNRIU Order No. 136 "On Improvement of Regulations on Ageing Management for Nuclear Power Plants" dated 13 April 2017;
21. SNRIU Order No. 147 "Conditions, Graded Indicators, Salaries and Bonuses for Managers of State Enterprises Subordinated to the State Nuclear Regulatory Inspectorate of Ukraine" dated 19 April 2017;
22. SNRIU Order No. 279 "General Safety Provisions for Predisposal Management of Radioactive Waste" dated 01 August 2017;
23. SNRIU Order No. 313 "Requirements for Periodic Safety Review of Nuclear Power Plants" dated 30 August 2017;
24. SNRIU and Ministry of Heath Order No. 316/998 "Radiation Safety Rules in Using Radiation Sources in Brachytherapy" dated 31 August 2017;
25. SNRIU Order No. 372 "On Amendment of Some Regulations and Invalidation of the Order on Radioactive Waste Management" dated 12 October 2017;

26. SNRIU Order No. 380 "On Approval of the Procedure for Youth Internship at the State Nuclear Regulatory Inspectorate of Ukraine" dated 17 October 2017;
27. SNRIU Order No. 443 "Requirements for Risk-informed Decision Making for Nuclear Power Plants" dated 1 December 2017;
28. SNRIU Order No. 140 "On Approval of the Rules for Design and Safe Operation of Confining Safety Systems" dated 3 April 2018;
29. SNRIU Order No. 265 "On Amendment of the Requirements for Seismic Design and Seismic Safety Assessment of Nuclear Power Plants" dated 25 June 2018;
30. SNRIU Order No. 331 "On Approval of General Safety Provisions for Disposal of Radioactive Waste" dated 13 August 2018;
31. SNRIU Order No. 391 "On Improvement of Regulations on Uranium Ore Processing" dated 1 October 2018.

ANNEX 5 Structure of Energoatom Electricity Tariff





ANNEX 6 Dynamics in Licensing of NPP Personnel for 2016-2019 (as of 1 April 2019)

Number of NPP experts licensed in 2016–2019				
Entity	**2016**	**2017**	**2018**	**1Q 2019**
ZNPP	166	159	153	152
RNPP	60	61	64	62
SUNPP	110	109	111	112
KhNPP	87	82	77	78
Total	**423**	**411**	**405**	**404**

Three workplaces at each of the 15 power units are staffed with 27 licensed experts working in shifts (2018) on average).

Officials making decisions and dealing with administrative functions associated with nuclear and radiation safety are licensed as well.

There are 92 licences issued by the SNRIU for:

- top-level managers dealing with licensed activities – 21 licences;
- top-level managers dealing with licensed activities only when they act as deputies of the above officials – 23 licences;
- plant shift supervisors – 48 licences.

ANNEX 7 Radiation Safety and Protection Indicators

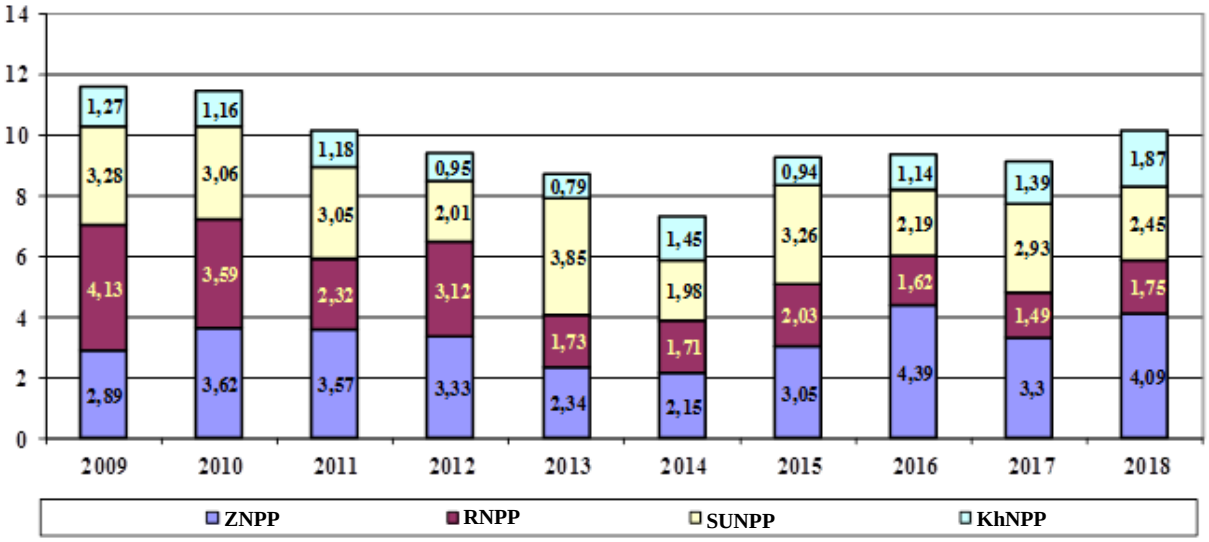


Fig. 1. Collective Doses to WWER NPP Staff (Including Personnel on Assignment) in 2009–2018, person-Sv

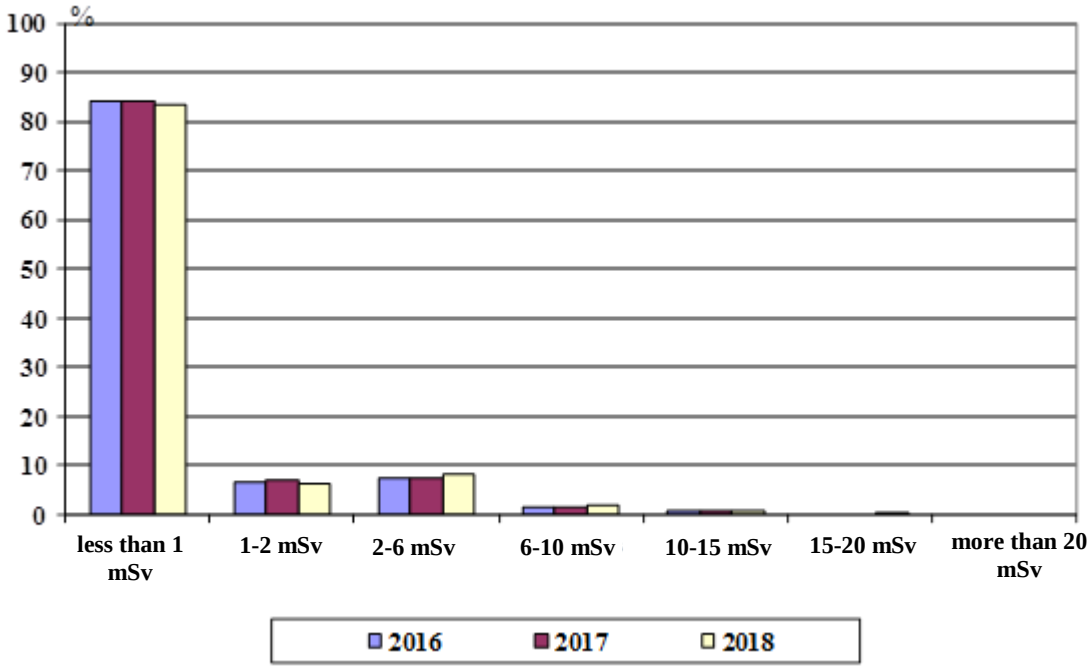


Fig. 2. Percentage of Energoatom NPP Staff Distributed According to Average Individual Doses in 2016-2018

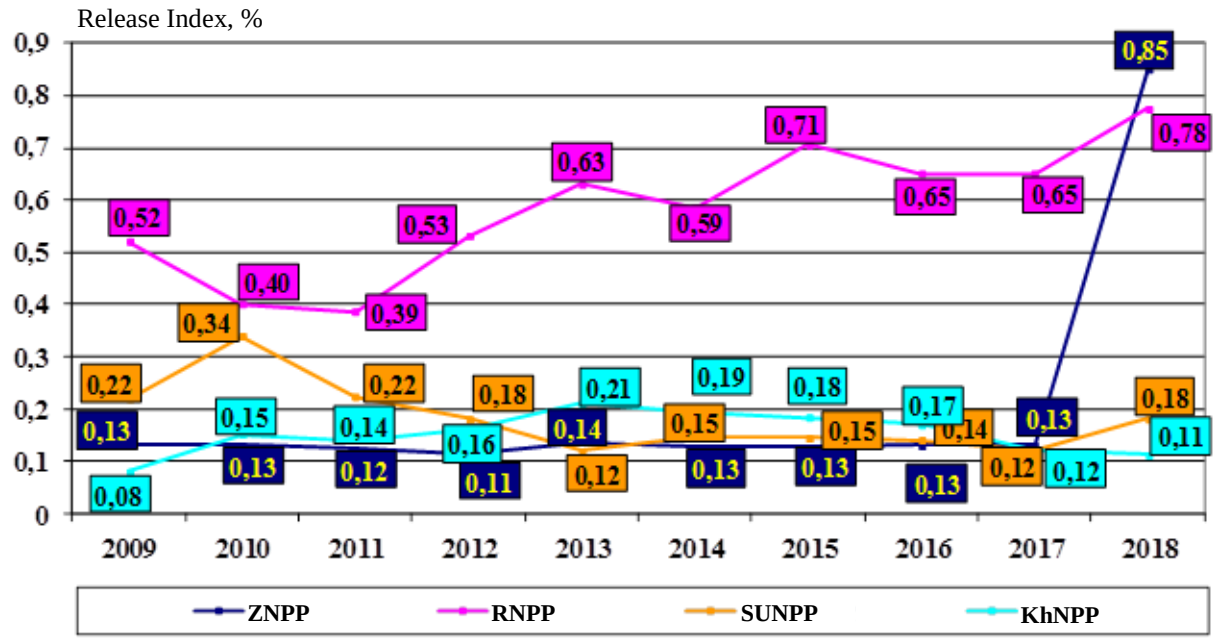


Fig. 3. Dynamics in Total Indices* for Radioactive Airborne Releases to Environment from *Energoatom* NPPs for 2009–2018

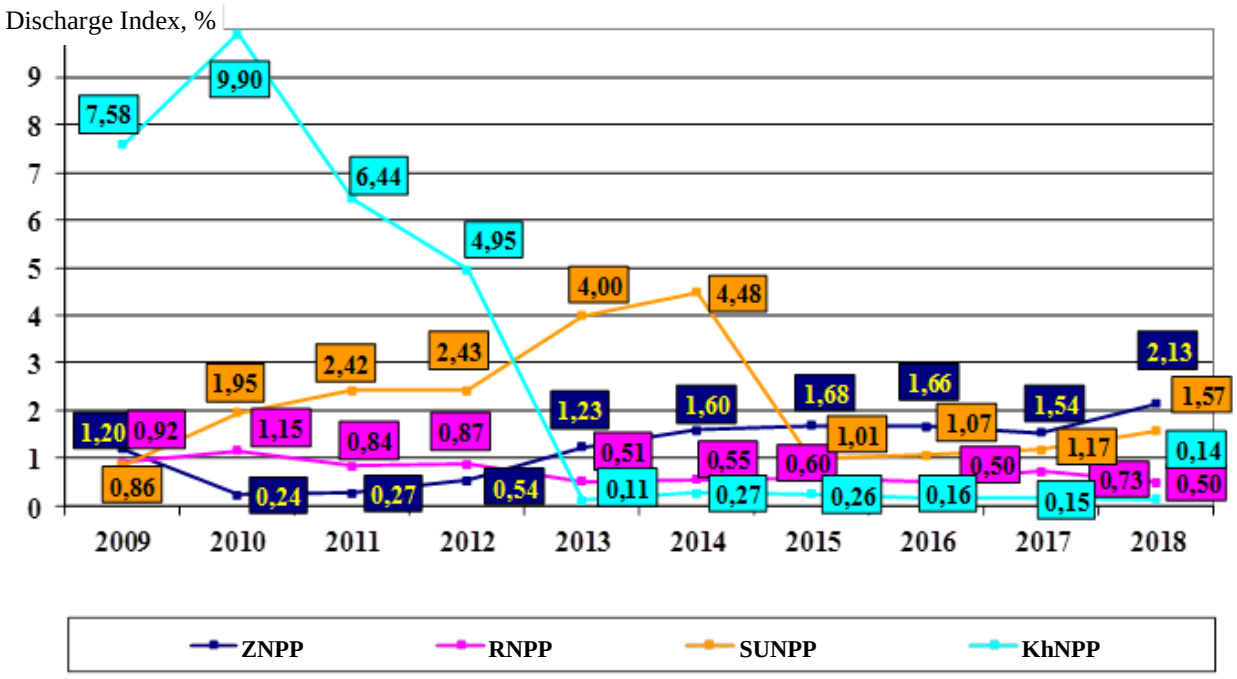


Fig. 4. Dynamics in Total Indices* for Radioactive Discharges from *Energoatom* NPPs for 2009–2018

* index is the ratio of actual release (discharge) to the permissible value calculated with special methodology allowing for contribution of reference radionuclides

ANNEX 8 Information on Chornobyl NPP

ARTICLE 6 Existing Nuclear Installations

All spent fuel, including damaged fuel from Units 1, 2 and 3, has been transported to ISF-1. The next step of the operator was to agree the decision to declare ChNPP Units 1, 2 and 3 as radioactive waste management facilities in the decommissioning process with the SNRIU. Safety justification of damaged spent fuel placement in ISF-1 is provided in ISF-1 SAR, version 3.02. Damaged spent fuel is shown in Figure 8.1.

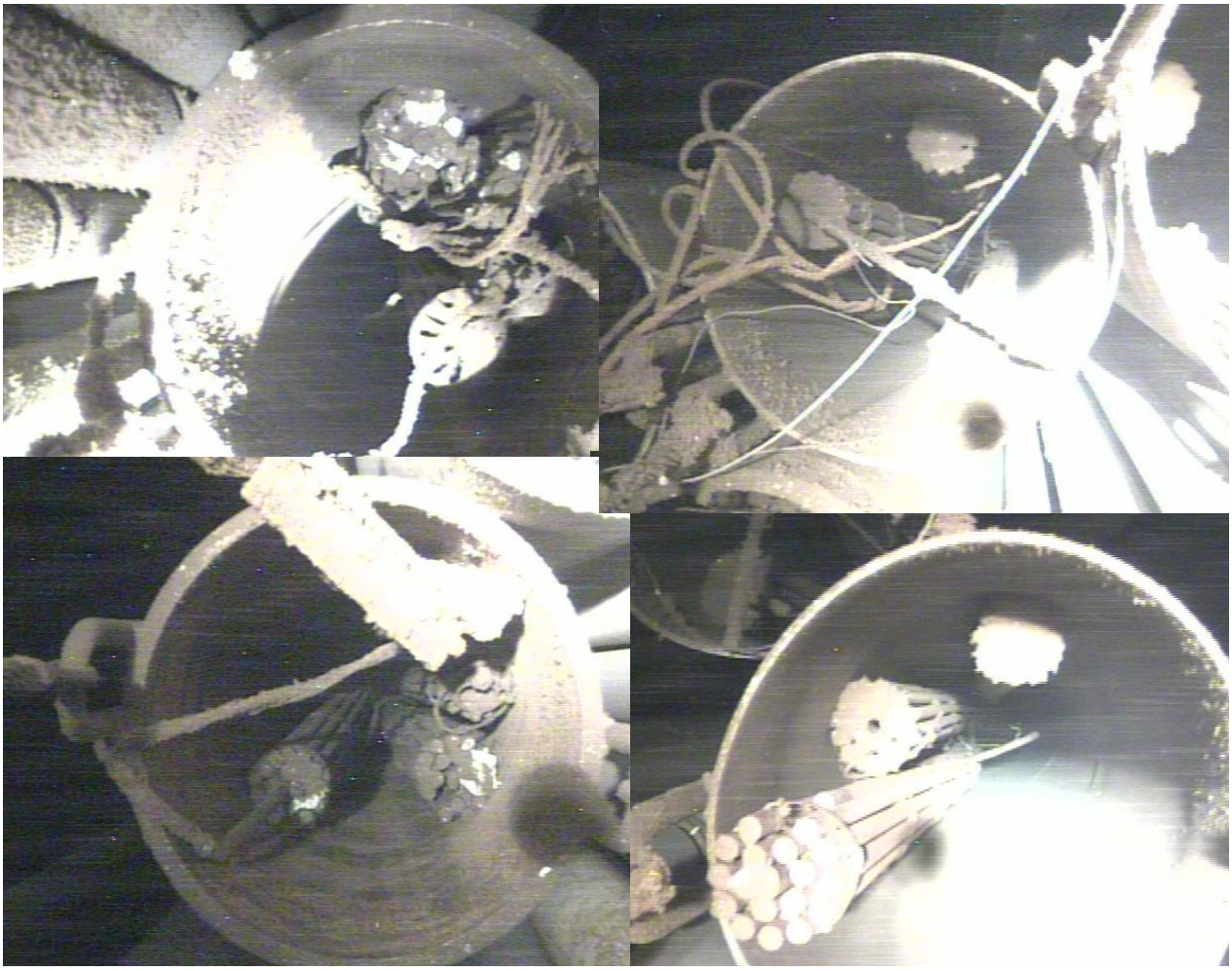


Figure 8.1 – Damaged spent fuel in special canisters

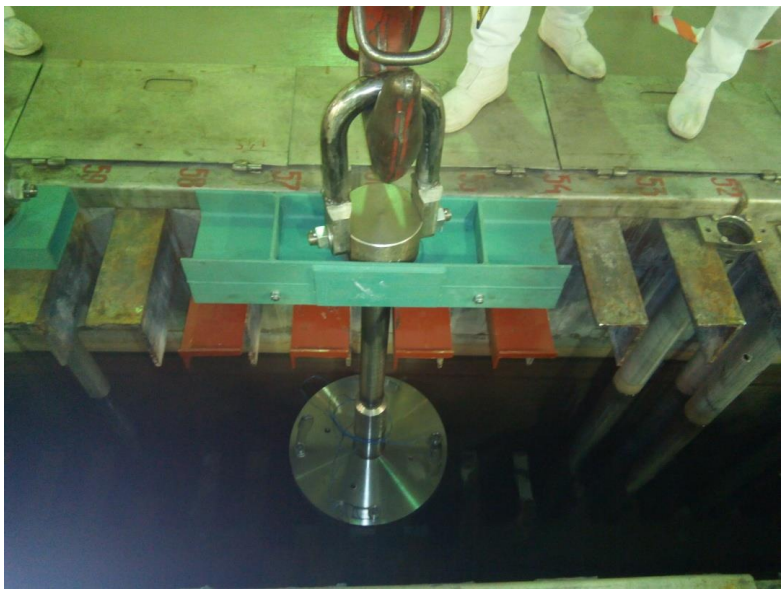


Figure 8.2 – Storage of damaged spent fuel in a unified canister/basket for special canisters in ISF-1 canyon

Interim Spent Fuel Storage Facility (ISF-1)

ISF-1 is a wet spent fuel storage facility and has been in operation since 1986.

In 2016, damaged spent fuel was transported from Units 1 and 2 to ISF-1 under an individual permit issued by the SNRIU for activities and operations on unloading of damaged spent fuel (DSF) from Units 1 and 2 and its placement into ISF-1 for safe storage.

There are currently 21,284 spent fuel assemblies (SFAs) in storage at ISF-1 including:

- 53 damaged SFAs;
- 4 thermometric SFAs;
- 10 measuring SFAs.

The following projects are implemented in compliance with the Plan of ISF-1 Safety Improvement Measures.

"Technical Upgrade of Cable System of Existing Interim Spent Fuel Storage Facility ISF-1":

- Implementation of the working project "Technical Upgrade of Cable System of Existing Interim Spent Fuel Storage Facility ISF-1 at ChNPP" have been started. The activities are to be completed in December 2019.

"Technical Upgrade of ChNPP ISF-1 Lightning Protection System":

- The working project "Technical Upgrade of Lightning Protection System of Existing Chornobyl NPP ISF-1 Building" is ongoing. The deadline is December 2019.

"ISF-1 Technical Upgrade to Replace ChNPP Power Equipment, Lightning and Communication System and I&C":

- The replacement of ISF-1 lights is ongoing. Preparations are under way to replace communications and I&C. The deadline is December 2019.

"Construction of ChNPP ISF-1 Radiation Monitoring System":

- Equipment of ISF-1 with a radiation monitoring system is intended to improve technical characteristics of radiation monitoring instrumentation. The deadline is December 2019.

The delay in ISF-2 commissioning requires the use of ISF-1 as the main spent fuel storage facility at the ChNPP in the next few years.

Interim Spent Fuel Storage Facility (ISF-2)

ISF-2 is the key component in the ChNPP decommissioning process. The ChNPP requires long-term storage for spent fuel currently stored in ISF-1. Considering that ISF-1 is a wet storage facility (spent fuel is stored in water) and that it is not designed for the long-term storage of spent fuel, the construction of ISF-2 will resolve the issue of long-term storage of the ChNPP spent fuel. The activities are financed by EBRD from the Nuclear Safety Account; the Contractor is *Holtec International* (USA).

ISF-2 is designed for acceptance, pre-conditioning and storage of spent fuel assemblies (except for damaged thermometric and measuring SFAs) accumulated at ChNPP. ISF-2 will ensure acceptance for storage, pre-conditioning and storage of 21,217 RBMK-1000 spent fuel assemblies for 100 years.

The following activities have been completed or are ongoing under the contract:

- installation of ISF-2 main and auxiliary systems has been completed;
- comprehensive tests of ISF-2 main and auxiliary systems are ongoing;
- trial operation of physical protection and radiation monitoring systems is ongoing;
- theoretical and practical training of operating personnel is ongoing.

Stages and timeframes for ISF-2 completion:

- completion of construction and installation – second quarter of 2019;
- completion of pre-commissioning operations - second quarter of 2019;
- completion of hot tests and ISF-2 commissioning – fourth quarter of 2019;

ARTICLE 7 Legislative and Regulatory Framework

2. (ii) System of licensing

Pursuant to Article 7 of the Law of Ukraine "On Licensing Activity in Nuclear Energy", individual activities of ChNPP shall be subject to licensing and are implemented under the following licences issued by the SNRIU:

- licence No. OB 000983 of 4 October 2012 for radioactive material transport, renewed until 17 June 2023;
- licence No. OB 010950 (reissued) of 17 July 2015 for use of radiation sources, renewed until 25 April 2024;
- licence No. EO 000946 of 12 January 2011 for training of the State Specialised Enterprise *Chornobyl NPP* personnel at ChNPP the training centre for positions: shift supervisor for spent fuel management department and shift supervisor for radiation safety department, renewed until 12 January 2023.

Pursuant to Article 8 of the Law of Ukraine "On Licensing Activity in Nuclear Energy", individual activities of the operator at specific life stages of a nuclear installation or radioactive waste disposal facility shall be implemented under licences issued by the SNRIU as follows:

- licence No. EO 000033 of 30 December 2001 for operation of Chornobyl NPP Shelter in compliance with Section 1;

The following individual permits were obtained and are in effect under the licence:

- individual permit No. OD 000033/2 of 18 November 2011 for construction and installation of new safe confinement commissioning stage 1 (NSC CS-1) based on licensing package LP-5, including construction of NSC foundations in the

service area and installation of load-bearing components of the steel structure and lining of the main structure;
- individual permit No. OD 000033/3 of 13 July 2012 for operation of the Shelter physical protection system (continuous performance);
- individual permit No. OD 000033/5 of 22 April 2013 for construction and installation of new safe confinement commissioning stage 1 (NSC CS-1) based on licensing package LP-6;
- individual permit No. OD 000033/8 of 25 October 2013 for operation of the new ventilation stack of ChNPP stage 2;
- individual permit No. OD 000033/9 of 4 September 2014 for reinforcement and sealing of existing civil structures of ChNPP stage 2 serving as enclosure of the new safe confinement;
- individual permit No. OD 000033/10 of 4 February 2016 for operation of the Shelter integrated automated monitoring system (IAMS);
- licence No. EO 000040 of 22 March 2002 for Chornobyl NPP decommissioning in compliance with Section 3.

The following individual permits were obtained and are in effect under the licence:
- individual permit No. OD 000040/4 of 10 December 2010 for operation of the interim storage facility for solid waste of group III and low- and intermediate-level long-lived waste of the industrial complex for solid radioactive waste management;
- individual permit No. OD 000040/6 of 23 May 2014 for commissioning of the retrieval facility for solid radioactive waste of all categories and the plant for sorting of solid radioactive waste of all categories and treatment of low- and intermediate-level short-lived solid waste of the industrial complex for solid radioactive waste management;
- individual permit No. OD 000040/7 of 11 December 2014 for operation of the liquid radioactive waste treatment plant;
- individual permit No. OD 000040/8 of 31 March 2015 for final closure and safe enclosure of Chornobyl NPP Units 1, 2 and 3;
- individual permit No. OD 000040/9 of 14 April 2016 for activities and operations on unloading of damaged spent fuel from Units 1 and 2 and its transport to ISF-1 for safe storage.
- licence EO 000859 of 25 June 2008 for operation of the nuclear installation - Interim Spent Fuel Storage Facility (ISF-1)";
- licence EO 001002 of 20 February 2013 for construction and commissioning of the nuclear installation – Interim Spent Fuel Storage Facility (ISF -2).

Pursuant to Article 9 of the Law of Ukraine "On Licensing Activity in Nuclear Energy", activities of the operating organisation’s officials dealing with administrative functions associated with nuclear and radiation safety are subject to licensing and are carried out under the following SNRIU licences:
- licence No. PO 000052 of 29 January 2013 for position: SSE ChNPP General Director;
- licence No. PO 000053 of 29 January 2013 for position: Technical Director (Chief Engineer);
- licence No. PO 000054 of 29 January 2013 for position: First Deputy of General Director (Planning and Decommissioning);
- licence No. PO 000111 of 20 November 2014 for position: Deputy Technical Director (Operation);

- licence No. PO 000111 of 20 November 2014 for position: Deputy Technical Director (Operation);
- licence No. PO 000121 of 24 May 2016 for position: Deputy Technical Director (Radwaste Management).

In compliance with Article 11 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety" and Article 8 of the Law of Ukraine "On Radioactive Waste Management" and in compliance with Cabinet Resolution No. 1122 of 18 July 1998 "On Approval of Procedure for Public Hearings on Aspects of Nuclear Energy Use and Radiation Safety", public hearings on implementation of the Project on Final Closure and Safe Enclosure of ChNPP Units 1, 2, 3 were held in 2013. The approach to design decisions and established design criteria for Units 1, 2 and 3 prior to the safe storage stage proposed by the operating organisation was approved by public representatives and experts involved in discussion.

ARTICLE 10 Priority to Safety

Priority to safety in the construction and operation of nuclear installations is established in the Law of Ukraine "On Nuclear Energy Use and Radiation Safety" and declared by Chornobyl NPP top management in quality and safety policy statements. The statements are an integral part of the enterprise general policy and have been brought to notice of all personnel, published in the mass media and made available on ChNPP website https://chnpp.gov.ua/ua/about/application-guide/zaiavy-kerivnytstva.

ARTICLE 11 Financial and Human Resources

Financial resources

The budget programme for keeping the power units and Shelter in safe state and measures for Chornobyl NPP decommissioning are financed annually from the State Budget of Ukraine.

The Law on State Budget of Ukraine for a specific year envisages an individual line for allocation of funds to prepare the ChNPP units for decommissioning, as well as allocation of funds for Shelter transformation into an environmentally safe system.

The main priority in financial planning is given to measures to prevent decrease in the safety level achieved.

Human resources

A special subdivision, training centre, was established to exercise the SSE *Chornobyl NPP* policy in the field of training, re-training and professional development.

In compliance with regulatory requirements of Ukraine, the training centre performs its functions under the following licences and permits issued for:

- training of operating personnel taking into account peculiarities of each stage of plant decommissioning and related administrative and technical safety measures (under SNRIU licence EO 000946 for personnel training at the training centre);
- training on safe methods for hazardous operations and activities in the framework of the Shelter Implementation Plan (under the certificate of the State Committee of Ukraine for Industrial Safety, Occupational Safety and Mining Supervision);
- vocational training on the most important specialties required for ChNPP on-site activities such as health physicists, radwaste processers, riggers and welders (under the licence of the Ministry for Education and Science of Ukraine);

- psychological support of professional activities of Chornobyl NPP personnel involved into SIP (under the certificate of the National Academy of Education for psychological and psychophysiological diagnostics of personnel).

The contractors' personnel involved into Shelter-related activities are trained in accordance with a specially developed and approved programme covering all safety aspects of activities in conditions of increased radiation and nuclear risks. The contractor's personnel may perform activities only if they have successfully passed examination of their knowledge, as confirmed by respective documents.

ARTICLE 12 Human Factor

In accordance with the Action Plan on Safety Enhancement of Chornobyl NPP Nuclear Installations agreed by the SNRIU in the area of personnel training:

- emergency exercises are conducted over the year for personnel of all shifts, including training of skills in situations associated with numerous failures of regular systems and equipment in extreme natural conditions;
- personnel to be accepted to ChNPP emergency teams undergo psychophysiological examination to select the individuals able to successfully manage and mitigate severe accidents;
- training programmes on psychology of activity in extreme conditions were developed for operating personnel, mid-level managers and emergency personnel to improve their resistance to psychological stresses, self-control, interaction and mutual assistance under mitigation of emergencies and management of accidents.

Operator's self-assessment of administrative and organisational issues

Chornobyl NPP management carries out assessment of administrative and organisational decisions on a permanent basis in compliance with the plant procedures. In particular, when organisational changes are introduced, each change is ranked according to safety impact (category of safety impact is defined) and safety-important organisational changes are analysed depending on their safety category. When administrative decisions are implemented, all measures for risk reduction are taken in compliance with the approved safety impact assessment, full responsibility for compliance with safety requirements and their observation being assumed.

ARTICLE 13 Quality Assurance

In accordance with Ukrainian regulatory requirements and IAEA standards and recommendations, the SSE *Chornobyl NPP* uses the process-oriented management approach. The process-oriented integrated management system promotes management's quality policy for the performance of ChNPP tasks.

The operator's management staff consider the quality policy as their direct obligation, contributing to continuous improvement of the management system, which requires appropriate efforts and resources and is based on assessment of internal and worldwide results. To assure the public that ChNPP activities are carried out in a safe manner, management staff declare their adherence to safety assurance principles and consider all activities to be subject to QMS.

Key components of SSE *Chornobyl* NPP management system are as follows:

- working quality council – collegial body for making managerial decisions on quality assurance;

- 16 high-level processes, including 56 processes of level one and seven processes of level two. Respective monitoring and measuring methods are applied for all processes for their efficient management, including analysis of progress in each process, registration of deviations and adoption of decisions to develop corrective and preventive actions;
- quality programmes developed and introduced first of all for the processes and activities that influence safety, including quality programmes for safety of spent fuel management and radioactive waste management. Requirements of standards and regulations governing management of the operating organisation's activities, licensing terms, etc. are input data for the development of quality programmes. The quality programmes include success criteria and types of monitoring over processes or operations and demonstrate how the existing management system is applied to a specific case, project or contract;
- independent assessment of the management system and its components to define the effectiveness of processes, compliance with safety and quality requirements, capabilities to improve the management system, including audits of ongoing processes and individual aspects;
- audits of the suppliers' QMS, first of all for safety-related systems to confirm the suppliers' ability to ensure compliance of their products with respective requirements.

The SSE ChNPP's objective in the quality area is to comply with legislative requirements in the performance of all tasks and to avoid unacceptable effects on health of the public of Ukraine, as well as other countries, from any activities at ChNPP.

The General Quality Guideline of the SSE *Chornobyl NPP* is the basic document of QMS, identifying SSE ChNPP objectives and tasks and describing the existing management system and interactions between basic SSE ChNPP processes and responsibilities on continuous improvement of the management system. This document is submitted to state regulatory bodies to obtain licences and permits.

The development and implementation of the process-based approach into the existing management system are under way. Further transfer from functional to process-based system involves changes in the structure, allocation of functions and interaction between subdivisions, with a focus on new aspects of managerial activities.

The ChNPP top management realizes its liability towards the society for negative results of ChNPP decommissioning and Shelter transformation into an environmentally safe system.

To reduce the impact of potential risks that, under certain circumstances, can affect production and financial results, social and natural environment and compliance with the DSTU ISO 9001:2015 requirements, the SSE ChNPP introduces the risk and opportunity management system aimed at implementation of strategies and plans and achieving the QMS effectiveness. Implementation of this system shall provide confidence that QMS can achieve planned results and improvements and increase the number of desired effects.

ARTICLE 14 Assessment and Verification of Safety

In compliance with the State Programme for Chornobyl NPP Decommissioning and Shelter Transformation into Environmentally Safe System (approved by Law of Ukraine No. 886-VI of 15 January 2009), in relation to removal of spent fuel from the power units and compliance with schedule for ChNPP decommissioning, SAR for ISF-1 was

completed in 2015. This report justifies the safe placement and storage of special canisters with damaged spent fuel in ISF-1.

The technical design "Equipment and Technology for Stabilisation, Transfer and Storage of Special Canisters with Damaged Spent Fuel" provides for placement of special canisters with damaged spent fuel in the ISF-1 canyon. Removal of damaged spent fuel from Units 1, 2 allowed the ChNPP to become less dependent on ISF-2 implementation in decommissioning activities.

ARTICLE 15 Radiation Protection

The dose limits and reference levels of external exposure (Hd), as well as reference levels of skin exposure (Hskin) and lens exposure (Hlense), established for ChNPP personnel were not exceeded within three years.

The collective and individual doses to SSE ChNPP personnel were as follows in 2016-2018:

Year	Collective, mSv	Average, mSv
2016	4286.19	1.89
2017	2985.68	1.37
2018	2417.55	1.15

The reference level of individual equivalent dose to personnel was 13 mSv in 2016-2018.

In general, there is a tendency to stabilisation of the monitored level of air contamination. In the reporting period, the radioactive airborne activity in the Chornobyl NPP rooms and adjacent territories was within appropriate ranges and did not exceed the reference levels.

Airborne releases of long-live nuclides from all ChNPP sources (Ventilation Stack-1, including Shelter bypass in new ventilation stack, liquid waste storage building, ISF-1, liquid radwaste treatment plant, industrial complex for solid radwaste management) were as follows:

Radionuclide	MAX release, kBq/month		
	2016	2017	2018
^{90}Sr	1.24E+4	1.07E+4	1.79E+4
^{137}Cs	2.94E+4	3.21E+4	4.22E+4
^{60}Co	2.71E+1	1.43E+1	7.63E+0
α-emitting radionuclides	4.48E+2	5.22E+2	1.25E+3

Reference levels are established for each source of airborne releases. Reference levels of airborne radioactive releases to the environment were not exceeded in the reporting period.

Assessments of airborne releases from the Shelter through structural openings (uncontrolled releases) to the space under NSC are carried out by the personnel of the Institute for Safety Problems of Nuclear Power Plants, National Academy of Sciences of Ukraine. Based on respective measurements, the release of a mixture of α-emitting

(^{241}Am, $^{238+239+240}$Pu) and β-emitting (^{137}Cs, ^{90}Sr+^{90}Y, ^{241}Pu) radionuclides through the Shelter roof opening was assessed.

The results of the uncontrolled release of a mixture of β-emitting radionuclides, MBq/year:

Nuclide	2016	2017	2018
α-emitting	2.4	1.26	2.20
β-emitting	151.4	73.0	119.2

The ChNPP radioactive substances are not discharged into natural water reservoirs. Currently, the activity of the industrial sewage system drains discharged into the service water pond results mainly from washing of residual accident-related contamination with storm and melt waters.

Discharge of radioactive substances into SSE ChNPP SWP (service water pond) are as follows:

	Discharge, GBq/year			
	2016	2017	2018	Reference level GBq/year
^{137}Cs	10.4	6.4	4.3	45.5
^{90}Sr	6.4	2.9	8.1	14.0
α- emitting	0.045	0.027	0.022	0.46

ARTICLE 16 Emergency Preparedness

The ChNPP emergency preparedness and response system is an integral part of the emergency preparedness and response system of the SESU.

The SSE ChNPP Response Plan to Accidents and Emergencies is the main guiding document to arrange and implement organisational, engineering and technical, radiation health & safety, evacuation and other measures to reduce the impact of radiation on personnel and the environment in the event of an accident or emergency at the ChNPP.

Exercises and training are periodically conducted at the ChNPP to check operation and preparedness of the system for actions in case of emergencies.

The main ChNPP organisational structures carry out all activities related to emergency planning, emergency preparedness and response in case of an accident or emergency at the ChNPP.

The ChNPP emergency organisational structures include:

- emergency response manager on sites of ChNPP facilities;
- coordination and control body – staff of emergency response manager or ChNPP emergency commission;
- permanent control body – emergency preparedness and response department;
- emergency teams and groups.

The ChNPP site is equipped with two protective buildings to protect personnel. One of the buildings houses the ChNPP on-site emergency centre for mitigation of emergencies.

ARTICLE 17 Siting

i) Evaluation of site-related factors

In 2011, the operator performed the targeted extraordinary safety assessment of ChNPP Units 1, 2, 3 and ISF-1 with regard to external hazards that lead to failure of the main safety functions and, consequently, to severe accidents (beyond design basis accident involving nuclear fuel damage). Based on the main conclusions, extreme natural hazards are ranked as follows:

1) Earthquake and tornado are the most hazardous for ChNPP nuclear installations.

2) Extreme wind, snow, rain and temperature are less hazardous since:

- effect of extreme wind, snow and rain is significantly lower than that of tornado;
- buildings of nuclear installations have high heat retention capability;
- temperature control in rooms is kept, snow is removed and storm water sewage system is in function.

3) External flooding and fire are not hazardous for ChNPP nuclear installations since:

elevations of the ChNPP site (113.7–114.0m) are significantly higher than the extreme water level (111.3m);

the distance from the area of a potential significant fire to nuclear installations is more than 1km, and the nuclear installation sites are provided with hard pavement, concrete enclosures, etc.

ii) Safety impact of nuclear installations on individuals and the environment

In accordance with regulatory requirements, the ChNPP monitors controlled radioactive airborne releases to the atmosphere and radioactive discharges.

Controlled airborne releases to the atmosphere are organised at the ChNPP through:

- ventilation stack of stage 1 and new ventilation stack of stage 2 of the ChNPP main building;
- stacks of liquid radwaste storage building and ISF-1.

Information on radiation monitoring of radioactive releases and discharges into the environment is submitted to the regulatory bodies and mass media on a monthly and quarterly basis, respectively.

iii) Re-evaluation of site-related factors

After removal of spent fuel from Units 1-3 (including damaged fuel at Units 1-2), the nuclear installations in decommissioning will be regarded as radioactive waste management facilities, allowing the operator to intensify decommissioning of Units 1-3 and focus efforts on nuclear safety of ISF-1.

For this purpose, a series of technical decisions have been implemented over the last three years to ensure safe storage of all spent fuel, including damaged fuel, at ISF-1 for normal operation and design-basis accidents caused by extreme natural hazards.

Achievement of these objectives was confirmed by the extraordinary safety reassessment of ISF-1 in 2015. ISF-1 can withstand external hazards, including safe shutdown earthquake of magnitude 6 and F 1.5 tornado and has a safety margin not lower than magnitude 7.6 for pool lining in an earthquake.

In implementation of the safety improvement plan, the SSE *Chornobyl NPP* obtained individual permit No. OD 000040/9 for activities and operations on removal of damaged spent fuel from Units 1 and 2 and its transfer to ISF-1 for safe storage.

ARTICLE 19 Operation

In the reporting period, the ChNPP assessed ISF-1 safety and proved that all conditioned (undamaged) and damaged spent fuel could be safely stored in ISF-1. The safety assessment justified that spent fuel and damaged fuel would not be transferred to ChNPP Units 1 and 2 in case of leakage in a spent fuel pool compartment or ISF-1

canyon. This allows change in the status of Units 1 and 2 from hazardous facilities to radioactive waste management facilities. The unloading of special canisters with damaged spent fuel from Units 1 and 2 accelerated ChNPP decommissioning.

The operational limits and safe operation conditions are monitored by ChNPP operating and engineering personnel.

All personnel involved into safety-related activities shall undergo occupational selection, training and examination of knowledge by examination commissions. The documentation required for these purposes is ensured by the quality system existing at the enterprise. The workplaces of operating personnel are provided with the required documents (regulations, production and emergency procedures) and engineers and technicians have access to the electronic base of these documents.

In order to limit degradation of safety-related structures, systems and components (induced by ageing, wear, corrosion etc.) and to maintain their operability and reliability in operation, equipment ageing management programmes and an action plan to improve safety of the ChNPP nuclear installations were developed, agreed with the SNRIU and implemented at the ChNPP.

Following the Fukushima Daiichi accident and based on WENRA technical specifications and SNRIU recommendations, a targeted safety assessment of spent fuel storages was carried out. The worst scenarios and their combinations were analysed to identify the most probable major safety risks. To increase robustness of ISF-1 in case of external hazards, ensure safety in station blackout conditions and extend accident management and mitigation capabilities:

- ISF-1 was equipped with an independent mobile back-up power source;
- organisational and technical measures were identified and implemented to connect a mobile diesel generator station to the ISF-1 power supply system without changing the existing electrical diagram;

respective changes were introduced to the Guideline for Management of Beyond Design Basis Accidents at Chornobyl NPP Units 1, 2, 3 and ISF-1 (109 P-S).

Engineering and technical support

The ChNPP ensures continuous engineering and technical support through permanent communication with:

- Kyiv Research and Design Institute *Energoproekt* (general designer);
- Institute for Safety Problems of Nuclear Power Plants, National Academy of Sciences of Ukraine (research supervisor).

The SSE *Chornobyl NPP* continues operation of the system for information support to Chornobyl NPP decommissioning. The information support system is being supplemented with data on the state of ChNPP facilities and equipment. The structure of various objects (buildings, structures, rooms, etc.) was developed and the system for information support to Chornobyl NPP decommissioning is in operation at SSE ChNPP. The structure of various objects (buildings, structures, rooms, etc.) was developed for the system and data on 387 process systems and about 20,000 pieces of ChNPP equipment were introduced.

Under cooperation with the Norwegian Institute for Energy Technology (IFE), the ChNPP created a ChNPP decommissioning visualisation centre. The centre’s objective is to introduce virtual reality technologies and technologies for three-dimensional modelling and visualisation to improve effectiveness and safety of ChNPP decommissioning operations.

Notification of incidents

The procedures to inform the regulatory body were developed in compliance with the Provisions on the Procedure for Investigation and Accounting of Operational Events at Nuclear Power Plants (NP 306.2.100-2004) and agreed with the regulatory body.

Analysis of operating experience feedback

The ChNPP ensures collection, processing, analysis and storage of information on equipment failures and human errors, as well as summarises and promptly submits the information obtained. Information on equipment failures and human errors is incorporated into the quarterly safety reports. Operating experience is analysed carefully. The data are used to maintain qualification of operating personnel and plant management and considered in the development of emergency training programmes. Information on significant events is regularly submitted to *Energoatom* and WANO based on bilateral information exchange.

Spent fuel and radwaste management on site

In accordance with Licence EO 000040 for ChNPP Decommissioning issued on 22 March 2002, the operating organisation is allowed to perform activities related to decommissioning of the ChNPP nuclear installations and radioactive waste management facilities.

In the framework of international technical assistance rendered to Ukraine for ChNPP decommissioning, the following projects on construction of ChNPP radioactive waste management facilities are under way: liquid radwaste treatment plant (LRTP), facilities of industrial complex for solid radwaste management (ICSRM), long-length radwaste cutting facility. These facilities shall ensure removal of accumulated radwaste from the facilities existing at the ChNPP, radwaste treatment to the condition acceptable for temporary storage and disposal, and safe disposal of radwaste packages in the near-surface facility and temporary storage of long-lived and high-level radwaste to be disposed of in a geological repository.

In 2018, the LRTP obtained Certificate IU 163180820539 of the State Architectural and Construction Inspectorate of Ukraine that certifies the LRTP compliance with the design and confirms preparedness for operation.

In 2018, 59 radwaste packages produced during active tests were directed to Vector Engineered Near-Surface Disposal Facility for Low- and Intermediate-Level Short-Lived Radioactive Waste (ENSDF) for disposal.

Currently, LRTP is completely prepared for operation; the purchase of binding materials for cement matrix is ongoing.

The ICSRM is at the stage of preparation for the third stage of hot tests. The beginning of the third stage is planned for December 2019.

In compliance with the extended programme for the second stage of ICSRM hot tests and based on the technical decision on processing of solid and liquid combustible low-level short-lived waste by incineration within the second stage of hot tests of the Solid Waste Retrieval Facility (SWRF) and Solid Radwaste Treatment Plant (SRTP) of the Industrial Complex for Solid Radwaste Management (ICSRM), it is planned to incinerate solid and liquid low-level radioactive waste in June 2019.

In compliance with the extended programme for the second stage of ICSRM hot tests and based on the decision on temporary storage of high-level waste (HLW) in the interim storage facility for low- and intermediate-level long-lived waste and high-level waste (LILW and HLW facility), Building 84, SRTP performs the repackaging of HLW

accepted from the interim storage facility for solid high-level waste with subsequent placement for temporary storage in the interim storage facility for low- and intermediate-level long-lived waste and high-level waste (LILW and HLW facility) in Building 84 of the liquid and solid waste storage facility. As of 1 January 2019, 28 packages of HLW, 7 packages of LLW and 4 packages of dummy SRW are in temporary storage in the LILW and HLW facilities.

The Project "Creation of a Facility for Release of Materials from Regulatory Control at ChNPP" (U4.01/11E, this project is continuation of Project U4.01/10E that is also financed by the European Commission) is performed within international technical assistance to implement the procedure for the release of radioactive materials from regulatory control at ChNPP.

The equipment required to create the release facility shall be designed, manufactured and supplied to the ChNPP site. In the framework of the contract, it is envisaged to perform equipment installation. Acceptance tests, certification and licensing and training of NPP personnel involved in operation of the facility are also planned. An up-to-date facility for the release of materials from regulatory control shall be created at ChNPP during Project U4.01/11E. This facility will allow justifying the release of different materials from regulatory control with the help of spectrometric measurements.

The supply of the facility for the release of materials from regulatory control is planned for the second part of 2019.

ANNEX 9 Information on Shelter

The Shelter, a unique facility in the world practice, occupies a special place among the nuclear facilities of Ukraine. It is ChNPP Unit 4 that was destroyed in 1986 in a beyond-design-basis accident and lost all functional characteristics as a power unit. Immediate measures were taken at Unit 4 to mitigate the accident consequences, and activities are under way to ensure monitoring of its condition.

The Shelter was not constructed in compliance with regulations for siting, design, construction, commissioning, operation and decommissioning of nuclear installations. The Shelter current condition does not and cannot comply with nuclear safety regulations or general industrial safety requirements.

The Shelter in its current state is qualified as a place for surface storage of uncontrolled radwaste (temporary storage for uncontrolled radwaste in stabilisation and reconstruction stage). All nuclear and radioactive materials located inside the Shelter are thus regarded as radioactive waste. Activities at the Shelter are regulated in compliance with its qualification specified by NRBU-97/D-2000, based on nuclear and radiation safety regulations in force.

Various modifications of fuel-containing materials amounting to approximately 200 tons (in accordance with conservative estimates) are located in the Shelter. Since there are no technical features to control their criticality, there is a potential risk of a self-sustained chain fission reaction.

Great volumes of the accident-origin radwaste with a total activity of about 5.6E+17 Bq are located inside the Shelter without reliable protective barriers and thus represent unsealed radiation sources.

The installation and sealing of the arch reduced potential danger for the pubic and the environment but the hazard remains significant for personnel involved in Shelter transformation.

In 2001, the SNRIU issued a licence for operation of the ChNPP Shelter. In compliance with the licence terms, the objective of any activity at the Shelter (including Shelter transformation into an environmentally safe system) is to protect personnel, the public and the environment against adverse effects of radioactive materials located inside the Shelter or on its site. Any activity implemented at the Shelter for another purpose is prohibited.

In compliance with the licence terms, based on the experience in Shelter operation and on-line data obtained by the operating organisation and considering comments and recommendations of the state nuclear regulatory bodies, reports on Shelter safety are developed twice a year.

For reference: in compliance with the Memorandum of Understanding between the Government of Ukraine and G7 Governments and European Commission on Chornobyl NPP Closure signed in December 1995, the recommended course of actions was developed and envisaged the following three action phases to transform the Shelter into an environmentally safe system:

Phase 1 - stabilisation and other short-term measures.

Phase 2 - preparation for transformation into an environmentally safe system.

Phase 3 – transformation into an environmentally safe system.

In interaction between the European Commission, USA, Ukraine and international expert team, the Shelter Implementation Plan (SIP) was developed in August 1997 based on the first two phases of the recommended course of actions.

The SIP goal is to construct the New Safe Confinement (NSC), a protective structure including process equipment for removal of fuel-containing materials from destroyed Unit 4 of the ChNPP and radioactive waste management and other systems designed to transform this unit into an environmentally safe system and ensure safety of personnel, the public and the environment and to dismantle unstable structures.

The SIP envisaged implementation of 22 tasks in total and overall project management.

At the moment, 18 out of the 22 tasks have been completed, two tasks are ongoing (one being NSC construction) and two tasks have been postponed to a later period.

First-priority measures to stabilise the Shelter structures were completed in full scope in 2008. The stabilisation measures ensured an appropriate level of Shelter stability (as an intermediate level in gradual Shelter safety improvement), which can be considered acceptable for 15 years (approximately until 2023). The issue of Shelter unstable structures shall be further solved by their dismantling or reinforcement inside the NSC.

The following main infrastructure facilities were commissioned in the framework of SIP: training centre for Shelter personnel, small and large construction sites to implement the NSC project, facility for decontamination of small equipment and tools, changing facility for 1430 persons, airlock at elevation +5.800, off-site utilities for the SIP infrastructural facilities. The modernised dust suppression system and integrated Shelter database were commissioned.

The Shelter fire protection system and physical protection and access control system were commissioned and the new ventilation stack of ChNPP Stage 2 was completed in a period from 2010 to 2012.

In 2016, an individual permit was issued for operation of the integrated automated system for nuclear, radiation, seismic and Shelter structural monitoring (IAMS).

At the beginning of 2019, civil structures that act as NSC enclosure were put into operation in the framework of ChNPP Stage II.

Upon completion of the tender process and in compliance with decisions of the Chornobyl Shelter Fund Donors Assembly and EBRD "non-objection" to sign the contract, the Contract between the SSE *Chornobyl NPP* and tender winner, NOVARKA Joint Venture (France), for new safe confinement (NSC) design and construction was signed on 23 August 2007.

At the beginning of 2013, state review of the project for NSC Commissioning Stage 1 (NSC CS-1) was completed and the SNRIU issued an individual authorisation for NSC CS-1 construction and installation on 22 April 2013.

Currently, pre-commissioning, individual and comprehensive tests of NSC equipment and process systems are ongoing in the framework of the NSC project implementation.

In April 2019, after successful trial operation of almost all equipment and systems within 72 hours, the Contractor (NOVARKA Joint Venture) shall transfer the constructed NSC first commissioning stage (NSC CS-1) to the Customer (SSE ChNPP) as the facility ready for operation.

Within 2019–2020, after NSC CS-1 trial commercial operation, SSE ChNPP shall obtain a licence for operation of the NSC first commissioning stage.

The SIP will be finished with the dismantling of unstable structures. For this purpose, the SSE ChNPP announced a tender in March 2019, with an expected cost of 2,547 billion UAH. Planned deadline is 20 December 2023.

The safe confinement as a multifunctional facility with a service life of 100 years allows the removal of fuel-containing materials and high-level waste from the Shelter in future. Waste conditioning to ensure further safe storage in compliance with legislation in force shall primarily rely on a national decision to create a geological repository in stable geological formations.

The Shelter transformation into an environmentally safe system requires involvement of significant financial and material resources as well as international assistance to solve these comprehensive issues.