UKRAINE

NATIONAL REPORT

On Compliance with Obligations under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management

KYIV 2020

FOREWORD

Ukraine signed the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (hereinafter the Joint Convention) on 29 September 1997 and was one of the first countries to ratify it by the Law of Ukraine of 20 April 2000.

Since 1997, Ukraine has been an active participant of all processes and events under the Joint Convention in order to fulfill its tasks. The First, Second, Third, Fourth, Fifth and Sixth National Reports of Ukraine were presented to the Contracting Parties of the Joint Convention at Review Meetings. The comments and recommendations of the review processes have been incorporated in national action plans concerning the improvement of spent fuel and radioactive waste management system.

The Seventh National Report has been developed by the State Nuclear Regulatory Inspectorate of Ukraine in full compliance with requirements of the Joint Convention and Guidelines Regarding the Form and Structure of National Reports INFCIRC/604/Rev.3 and with due regard to the Summary Report of the Sixth Review Meeting of the Contracting Parties (JC/RM5/04/Rev2).

By submission of the National Reports, Ukraine fulfills its obligations according to Article 32 of the Joint Convention.

This Report, as well as the previous ones, is based on legislative and regulatory documents in force in Ukraine and official reports of state executive bodies responsible for the national policy in nuclear energy use and radioactive waste management, as well as state enterprises, including operating organizations (operators).

The key objective of the Report is to provide objective information to the Contracting Parties of the Joint Convention and to the public of Ukraine regarding the safety of spent fuel management and the safety of radioactive waste management and actions taken to protect personnel, the public and the environment against hazardous effects of ionizing radiation. The Report highlights the changes and progress in the legislative and regulatory framework since the Sixth Review Meeting and identifies prospects and plans for further development and issues to be resolved.

Based on this Report and pursuant to the powers entrusted by the Cabinet of Ministers of Ukraine, the Chairman of the State Nuclear Regulatory Inspectorate of Ukraine declares the following:

Ukraine adheres to the principle of priority to safety of people and the environment at all stages of spent fuel and radioactive waste management in the field of nuclear energy and radiation safety.

In this regard, *Ukraine completely fulfills its obligations under the Joint Convention,* which is proved by:

- establishment and development of the legislative and regulatory framework for safety in the use of nuclear energy;
- functioning of the state nuclear regulatory body that has relevant competences and establishes safety requirements and criteria, develops and approves regulations and rules on nuclear and radiation safety, conducts licensing and state oversight and applies legislative enforcement measures in case of incompliance;

– independence of the state nuclear regulatory body from other state bodies, establishments, enterprises and officials that deal with nuclear energy and independence from local governments and public associations;

– safety assessments and reviews of existing and new spent fuel and radioactive waste management facilities and measures to improve safety and security;

– development of the emergency preparedness and response system;

– full responsibility of the licensee for safety and measures intended to protect people and the environment;

– development of safety culture and implementation of safety self-assessment practices.

The actual data in this Report, except for those specially stated, are provided as of 1 July 2020. The changes to take place by May 2021 will be additionally reported by the Ukrainian Delegation at the Seventh Review Meeting.

Kyiv, September 2020

Hryhorii Plachkov
Chairman – Chief State Inspector on
Nuclear and Radiation Safety of Ukraine
State Nuclear Regulatory Inspectorate of Ukraine

List of Abbreviations

Baryer	State Enterprise *Baryer*
CCMEZ	State Specialized Enterprise for Capital Construction Management of the Exclusion Zone
ChNPP	State Specialized Enterprise *Chornobyl Nuclear Power Plant*
CLTSF	Centralized Long-Term Storage Facility for Radiation Sources
CPS	Central Production Site of RADON ASSOCIATION
CRME	State Specialized Enterprise *Centralized Radioactive Waste Management Enterprise*
CSFSF	Centralized Spent Fuel Storage Facility for RNPP, KhNPP, SUNPP
DIA	Dnipro Interregional Affiliate of RADON ASSOCIATION
DRS	Disused Radiation Sources
DSFSF	Dry Spent Fuel Storage Facility at ZNPP
EBRD	European Bank for Reconstruction and Development
EC	European Commission
EIA	Environmental Impact Assessment
Energoatom	National Nuclear Energy Generating Company *Energoatom*
ENSDF	Engineered Near-Surface Disposal Facility for Solid Radioactive Waste on *Vektor* Site
FCSE	Final Closure and Safe Enclosure
HLW	High-Level Waste
IAEA	International Atomic Energy Agency
ICSRM	Industrial Complex for Solid Radioactive Waste Management at ChNPP
INSC	European Commission Instrument for Nuclear Safety Cooperation
IRRS	Integrated Regulatory Review Service
ISF	Interim Spent Fuel Storage Facility
KhIA	Kharkiv Interregional Affiliate of RADON ASSOCIATION
KhNPP	Khmelnitsky Nuclear Power Plant
LIA	Dnipro Interregional Affiliate of RADON ASSOCIATION
LRSF	Liquid Radioactive Waste Storage Facility
LRTP	Liquid Radioactive Waste Treatment Plant at ChNPP
LRW	Liquid Radioactive Waste
LSRSF	Liquid and Solid Radioactive Waste Storage Facility
NPP	Nuclear Power Plant
NRI	Nuclear Research Institute, National Academy of Sciences of Ukraine
NRU	National Report of Ukraine (on Compliance with Obligations under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management)
NSC	Shelter New Safe Confinement
OIA	Odesa Interregional Affiliate of RADON ASSOCIATION
PChP	Industrial Association *Prydniprovsk Chemical Plant*

PSAR	Preliminary Safety Analysis Report
RADON	State Specialized Enterprise *RADON ASSOCIATION*
Radwaste	Radioactive Waste
RBMK	Light-Water Graphite-Moderated Channel-Type Reactor
RICS	Radioactive Waste Interim Confinement Site in the Exclusion Zone
RL	Reference Level
RNPP	Rivne Nuclear Power Plant
RWDS	Radioactive Waste Disposal (Storage) Site
RWTP	Radwaste Treatment Plants at NPPs
SAR	Safety Analysis Report
SAUEZM	State Agency of Ukraine on Exclusion Zone Management
SFA	Spent Fuel Assembly
SFP	Spent Fuel Pool
SIP	Shelter Implementation Plan
SISP	State Interregional Specialized Plants for Radioactive Waste Management of RADON ASSOCIATION
SkhidGZK	State Enterprise *Eastern Ore Mining and Processing Plant*
SNRIU	State Nuclear Regulatory Inspectorate of Ukraine
SRRF	Solid Radwaste Retrieval Facility
SRSF	Solid Radioactive Waste Storage Facility
SRTP	Solid Radioactive Waste Treatment Plant within ChNPP ICSRM
SRW	Solid Radioactive Waste
SRW-1, SRW-2	Near-Surface Radioactive Waste Disposal Facilities on *Vektor* Site
SSR	Storage Site for Radwaste Resulting from Decontamination and Sanitary Treatment of Vehicles
SUNPP	South Ukraine Nuclear Power Plant
TSO	Technical Support Organization
URTC	Ukrainian Radiological Training Center
USCPS	Unified State Civil Protection System
Vektor	Industrial *Vektor* Site for Decontamination, Transport, Treatment and Disposal of Radioactive Waste in Chornobyl Exclusion Zone
VTS	Vehicle Sanitary Treatment Site
VVER	Water-Cooled Water-Moderated Power Reactor
ZNPP	Zaporizhzhya Nuclear Power Plant

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Section A

A.1 Introduction

The safe management of spent fuel and radioactive waste is one of the most important factors in sustainable development of nuclear energy in the State according to the Energy Strategy of Ukraine, including application of radiation and nuclear technologies in medicine, science and industry.

Ukraine, as one of the Contracting Parties to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (Joint Convention), ensures implementation of provisions under the Joint Convention and IAEA safety fundamentals.

The existing practice to ensure the safety of spent fuel and radioactive waste management, national strategies, plans and programs for further development of the system for spent fuel and radioactive waste management and major events and changes that took place after the Sixth Meeting of the Contracting Parties to the Joint Convention are highlighted in the relevant sections of this Report.

The Report includes information on the improvement of the legislative and regulatory system of spent fuel and radioactive waste management, system for administration of spent fuel and radioactive waste management, emergency preparedness, personnel training, financial resources, quality assurance, decommissioning, international cooperation and improvement of safety in spent fuel and radioactive waste management.

Annexes to the Report also present:

- list of existing spent fuel and radioactive waste management facilities, and nuclear facilities being decommissioned;
- inventories of spent fuel and radioactive waste subject to the Joint Convention;
- dynamics of radiation safety indicators;
- list of regulations approved in the reporting period;
- information on Shelter safety and implementation of measures to transform the Shelter into an environmentally safe system, including construction of the New Safe Confinement;
- data on waste from uranium mining and milling industry.

A.2. Basic Conclusions from the Sixth Review Meeting

During the Sixth Review Meeting, the Contracting Parties noted the progress of Ukraine for the time since the Fifth Review Meeting. In particular, implementation of the following measures was referred to the areas of good performance:

– recertification of the SNRIU management system to comply with requirements of ISO 9001:2015 international standard;

– implementation of radioactive waste classification system harmonized with IAEA GSG-1 Guide requirements;

– implementation of the regulatory framework on radioactive waste management;

– significant progress in completion of the dry spent fuel storage facility ISF-2 on Chornobyl NPP site;

– design, construction and commissioning of the systems for solid radioactive waste treatment at RNPP and ZNPP to produce radwaste packages acceptable for disposal;

– comprehensive safety assessment of radioactive waste management facilities, facilities in the exclusion zone;

– progress on the completion of ChNPP NSC construction;

– diversification of management options for spent fuel of VVER-1000 and VVER-440 through the construction of the Centralized Storage Facility for Spent Fuel of RNPP, KhNPP, SUNPP;

– operation of the plant for production of metal drums and reinforced concrete containers for radioactive waste storage and disposal;

– collection, retrieval and placement of disused radiation sources from bankrupt enterprises, orphan radiation sources, radiation sources detected in illicit trafficking for safe and secure storage.

The following challenges were defined for Ukraine:

1. Construction of radioactive waste and spent fuel management facilities in the exclusion zone and on Chornobyl NPP site, including:

– construction and commissioning of CSFSF;

– construction and commissioning of the long-term storage facility for vitrified HLW resulting from VVER-440 of Rivne NPP that will be returned from the Russian Federation;

– design and construction of the Process Building for Treatment of Radioactive Waste on Vektor site;

– design and construction of additional facilities for management of ChNPP radioactive waste.

2. Legislative recognition of a special status of the special industrial use zone in the exclusion zone for its efficient use in economic and nuclear areas and protection of future generations.

3. Intensification of efforts on establishing a geological repository for radwaste disposal, including:

– develop an operating organization (operator) for a geological repository;

– develop an action plan on establishing a geological repository for radwaste disposal;

– start siting for a geological repository.

Information on the reached progress in the implementation of Challenges and recommendations is presented in Subsection K.1. of this Report.

Besides, the preparation of NRU-2020 took into account issues joint for the parties defined in the Final Summary Report of the Sixth Review Meeting (JC/RM6/04/Rev.2), in particular:

– implementation of national radwaste and spent fuel management strategies;

– impact of long-term management of spent fuel and HLW on safety;

– mutual agreement of stages of radwaste management and long-term storage of disused radiation sources and their disposal;

– remediation of legacy sites and facilities.

Section B. POLICIES AND PRACTICES (Article 32, Para. 1)

In accordance with the provisions of Article 30, each Contracting Party shall submit a national report to each review meeting of Contracting Parties. This report shall address the measures taken to implement each of the obligations of the Convention.
For each Contracting Party the report shall also address its:
i) spent fuel management policy;
ii) spent fuel management practices;
iii) radioactive waste management policy;
iv) radioactive waste management practices;
v) criteria used to define and categorize radioactive waste.

B.1. Spent Fuel Management Policy

The principles of state policy for spent fuel management are set forth in Article 5 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety" (outlined in Subsection B.1 of NRU-2003).

The Energy Strategy of Ukraine until 2035 [39] (Energy Strategy of Ukraine) defined the need to complete construction of storage facilities for spent fuel and HLW from its reprocessing. Therefore, it envisages implementation of the so-called deferred decision, that is long-term (50 years and more) storage of spent fuel with subsequent definition and approval of the final decision on fuel reprocessing or disposal.

In 2019, the Concept of the State Economic Program for Management of Spent Nuclear Fuel from National Nuclear Power Plants until 2024 was adopted, which defines that the priority of the state policy of Ukraine is the construction and commissioning of an own centralized storage facility for spent fuel of VVER reactors of national nuclear power plants.

The principles of the state spent fuel management policy envisage the following:

1) for VVER reactors:

– process storage of spent fuel in near reactor spent fuel pools (wet storage) to reach the level of residual heat removal approved for further transport;

– temporary storage of Zaporizhzhya NPP spent fuel during the design period (50 years);

– transport of spent fuel from Rivne NPP, Khmelnitsky NPP and South Ukraine NPP for process storage and reprocessing to specialized foreign enterprises before commissioning of CSFSF;

– development of the Concept for Management of Spent Fuel of National NPPs (with the definition of strategic areas of spent fuel management until 2035 and in the future);

– approval of the State Economic Program for Management of Spent Nuclear Fuel from National Nuclear Power Plants until 2025, which will define objectives, strategy and scenarios for spent fuel management, formulate key provisions of scientific and technical policy and implementation phases of the main stages of spent fuel management.

2) for RBMK reactors:

– completion of construction, commissioning and safe operation of ISF-2 for storage of all amounts of ChNPP spent fuel;

– implementation of measures to upgrade and improve safety of the existing wet interim spent fuel storage facility, ISF-1.

Spent fuel at VVR-M research nuclear reactor of the Institute for Nuclear Research of the National Academy of Sciences is temporary stored in compliance with requirements of current legislation and regulations of Ukraine. In future, it is envisaged to send spent fuel for reprocessing to the fuel producing country (Russian Federation).

Spent Fuel Treatment Facility before Storage, ISF-2

Spent Fuel Storage Area at ISF-2

Figure 4. Spent Fuel Storage Facility 2 (ISF-2) at ChNPP

B.2. Spent Fuel Management Practices

Spent fuel is managed in Ukraine at the facilities listed in Annex 1 to this Report. The inventory of spent fuel is presented in Annex 2 of this Report.

B.2.1. Spent Fuel Management at Operating NPPs

Management of VVER-440 spent fuel (RNPP-1,2)

After unloading from the core, spent fuel is placed in near reactor spent fuel pool in order to remove residual heat and radioactivity to ensure the possibility for safe placement and transport in packaging.

The period for spent fuel storage in SFP is from 3 to 7 years depending on the period of fuel assembly operation as a part of fuel loading.

After storage in SFP, spent fuel of VVER-440 is transported to RT-1 of the Industrial Association *Mayak* (Russian Federation) for further temporary storage and reprocessing with further return to Ukraine of spent fuel reprocessing products in the form of vitrified HLW according to the valid agreement and contract between *Energoatom* and *Mayak*.

Placement of vitrified HLW after VVER-440 spent fuel reprocessing is envisaged in the storage facility, which is planned to be built on Vektor site.

Management of VVER-1000 spent fuel

After unloading from the core, spent fuel is placed in near reactor spent fuel pool in order to remove residual heat and radioactivity to ensure the possibility for safe placement and transport in packaging. The period for spent fuel storage in SFP is from 3 to 7 years depending on the period of fuel assembly operation as a part of fuel loading.

Starting from 2001, ZNPP spent fuel is send for long-term storage to the dry spent fuel storage facility (DSFSF) located on ZNPP site.

After storage in the spent fuel pool, spent fuel of SUNPP, RNPP and KhNPP is transported to the Mining and Chemical Combine (Russian Federation) for further temporary storage and reprocessing with further return to Ukraine of spent fuel reprocessing products in the form of vitrified HLW and intermediate-level radwaste according to the valid agreement and contract.

VVER-1000 spent fuel reprocessing is not performed at present. From 2016-2020, the design volume for shipment is not more than 300 VVER-1000 SFA annually.

Placement of vitrified HLW after VVER-1000 spent fuel reprocessing is envisaged in the storage facility, which is planned to be built on Vektor site.

ZNPP Dry Spent Fuel Storage Facility (DSFSF)

DSFSF is designed for long-term safe storage of ZNPP spent fuel.

The storage facility is an open site, where ventilated storage containers designed for spent fuel storage are placed at intervals of 4.5 m from each other. The container consists of a metal basket with spent fuel placed inside a concrete structure. The loading of baskets with SFAs is performed in the central halls of reactor compartments, including welding, sealing and checking of welds. In the process of preparing the basket for storage, a refueling container is used for biological protection of personnel. The installation of the basket with SFAs ready for storage in the container is performed in transport corridors of unit reactor compartments. Delivery of containers with SFAs from reactor compartments and installation into the place for storage on storage site are carried out by a caterpillar conveyor.

The trial and commercial operation started on 24 August 2001 (License EO No. 000014 dated 16 July 2001).

The commercial operation started on 10 August 2004 (License EO No. 000196 dated 10 August 2004).

DSFSF total capacity is 9120 SFAs.

The design number of containers is 380 pcs (first stage of 100 pcs and second stage of 280 pcs).

First stage filling date – 30 January 2012.

Second stage filling started on 02 February 2012 (based on OD No. 000196/43 dated 29 December 2011).

Quantity of SFAs in the container is up to 24 pcs.

The design storage period for spent fuel is 50 years.

According to para. 3.1 of License EO No. 000196 as of 01 July 2020, DSFSF design operation established upon the results of the safety review performed in 2015-2016 was justified up to 19 October 2025.

The next safety review of DSFSF will be carried out in 2025.

Figure 1. ZNPP Dry Spent Fuel Storage Facility (DSFSF)

A remote temperature control system (RTCS) was put into commercial operation for Stage I containers to improve storage safety. RTCS for Stage II containers is installed in accordance with the design.

The results of operation indicate that DSFSF complies with the safety criteria presented in SAR.

After the Fukushima-1 accident in Japan, within the targeted safety review of NPPs using stress tests according to the European Council and WENRA proposal, extraordinary target safety reassessment (stress tests) of Zaporizhzhya DSFSF was carried out. More detailed information is provided in Subsection B.2.1 of NRU-2014.

CSFSF

CSFSF is being constructed in the territory of Chornobyl exclusion zone.

The technology of dry storage of spent fuel developed by Holtec International will be used to ensure spent fuel storage, which envisages:

- use of two-wall MPC intended for storage of 31 SFAs of VVER-1000 or 85 SFAs of VVER-440;
- loading of SFAs in MPC, MPC preparation for transport to CSFSF and further storage in CSFSF in reactor compartments of NPP units;
- transport of MPC with spent fuel to CSFSF in HI-STAR placed on special railway platforms;
- placement of MPC with spent fuel in protective ventilated containers HI-STORM for surface storage;
- modification of existing technology for spent fuel management at Ukrainian NPPs for transport of spent fuel to CSFSF according to Holtec International technology.

CSFSF construction consists of 15 startup packages. The total capacity of CSFSF is 458 HI-STORM containers, which are able to include 16 529 spent fuel assemblies:

- SFAs of VVER-1000 – 12 010 pcs;
- SFAs of VVER-440 – 4 519 pcs.

All the infrastructure necessary for CSFSF functioning will be constructed on CSFSF site with the first startup package, as well as four HI-STORM containers loaded with spent fuel will be installed:

- SFAs of VVER-1000 – 93 pcs;

- SFAs of VVER-440 – 85 pcs.

Commissioning of the first startup package will allow the start of storage facility operation. The supply of special equipment and spent fuel storage systems for CSFSF is performed according to the contract with the technology developer and equipment producer that is Holtec International Company.

Further, storage facility capacity will be increased up to design capacities through the construction and commissioning of startup packages No. 2 – 15 during the required period.

CSFSF design is aimed at storage of spent fuel of Ukrainian NPPs only.

The design period for spent fuel storage is 100 years.

CSFSF operation provides for two main stages: active (45-50 years) during which MPC with SFAs will be transported and CSFSF will be filled up to design indicators and passive (50-55 years) during which the controlled storage of SFAs will be implemented.

Detailed information on the main stages of CSFSF construction and information campaigns on safety issues regarding this facility held with the public was presented in Subsection B.2.1 of NRU-2017.

During the reporting period, a significant amount of activities on CSFSF construction were completed. As of 01 July 2020, equipment for CSFSF first startup package was produced by Holtec International and supplied to Ukraine, individual, functional and comprehensive testing of equipment received for NPPs was carried out. The main construction and installation activities on CSFSF site are in the final stage. The technical readiness of buildings and structures is being checked. The total volume of completed construction and installation activities is 87 %. Activities are underway on modification of spent fuel management systems at NPPs for the possibility to send spent fuel to CSFSF according to Holtec technology.

The construction of a 6.5 km long access road to CSFSF has been completed.

Procedures have been initiated to obtain an acceptance certificate by *Energoatom* for approval of HI-STAR packaging design for the transport of radioactive materials.

Obtaining of a separate permit from the SNRIU for the supply of nuclear materials to CSFSF is expected based on confirmation of the construction readiness of CSFSF and the results of modification of spent fuel management systems at NPPs according to Holtec International technology.

Figure 2. CSFSF Construction Site

B.2.2. Spent Fuel Management at Chornobyl NPP

As of 01 July 2020, all ChNPP nuclear fuel is stored in wet spent fuel storage facility ISF-1.

At present, the construction of dry spent fuel storage facility ISF-2 has been completed and activities are underway for its commissioning. After ISF-2 commissioning, all ChNPP spent fuel will be transferred for long-term storage to ISF-2.

Wet Spent Fuel Storage Facility (ISF-1)

ISF-1 is a wet type storage facility for spent fuel located on ChNPP site and intended for interim storage of RBMK-1000 spent fuel. It has been in operation since September 1986.

As of 01 July 2020, 21 284 SFAs are in storage in the ISF-1 spent fuel pools.

Safety justification for SFA storage in ISF-1 SFP is presented in the Safety Analysis Report for Spent Fuel Storage Facility (ISF-1) dated 24 June 2015. K_{eff} neutron multiplication factor was calculated taking into account fuel burnup and the presence of damaged nuclear fuel in SFP canyon to load ISF-1 SFP.

ISF-1 operation life is justified up to 31 December 2025.

Figure 3. Wet Spent Fuel Storage Facility (ISF-1) of ChNPP

Dry Spent Fuel Storage Facility (ISF-2)

Activities on construction and commissioning of ISF-2 intended for storage of ChNPP RBMK spent fuel are in the final stage.

During the reporting period, significant activities have been performed at ISF-2, in particular:

– construction and installation activities have been completed on 20 December 2019;

– compliance of completed facility (ISF-2) with design documents and its readiness for operation were confirmed on 10 January 2020;

– cold tests were carried out in 2017-2019;

– authorizing activities on providing ChNPP with a permit for ISF-2 operation have been started since February 2020. Hot tests of ISF-2 and spent fuel transfer from ISF-1 are planned in the second half of 2020.

Spent Fuel Treatment Facility before Storage, ISF-2

Spent Fuel Storage Area, ISF-2

Figure 4. Spent Fuel Storage Facility 2 (ISF-2) of ChNPP

ISF-2 design developed according to the Holtec International technology (USA) envisages the following algorithm of spent fuel management:

1. Transport spent fuel from ISF-1 to ISF-2, namely to the facility for spent fuel preparation for storage, where each spent fuel assembly will be cut into two parts (into two FE bundles).
2. Install FE bundle into a special fuel tube.
3. Install 186 fuel tubes with FE bundles into two-wall dry shielded canister (large two-wall sealed stainless steel containers).
4. Dry the two-wall shielded canister (after filling by fuel tubes with FE bundles) at a special gaseous drying facility and filling of the canister with inert gas – helium.
5. Check tightness of the two-wall shielded canister filled with spent fuel and its transport to the spent fuel storage area.
6. Install the two-wall shielded canister with spent fuel into a concrete storage module and its storage during 100 years.

B.2.3. Spent Fuel Management at Research Reactors

Spent fuel management on the NRI site is described in Subsection B.2.3 of NRU-2011.

The system for spent fuel storage in two storage facilities (Annex 1) is implemented at a nuclear research reactor. BV-2 storage facility was constructed in 2009, which allowed increasing the capacity of storage facilities and improve storage safety. The safety of spent fuel management at the reactor is justified in the reactor technical documentation, which is approved by the State Nuclear Regulatory Inspectorate of Ukraine. As of 1 July 2020, there is no spent fuel of VVR-M.

B.3. Radioactive Waste Management Policy

The major principles of state policy for radioactive waste management are defined by Ukrainian legislation and are presented in Subsection B.3 of NRU-2011.

The state policy for radioactive waste management is implemented in compliance with the Strategy for Radioactive Waste Management in Ukraine, National Target Ecological Program for Radioactive Waste Management and National Program for Chornobyl NPP Decommissioning and Shelter Transformation into an Environmentally Safe System.

The Strategy for Radioactive Waste Management in Ukraine identifies major areas and tasks for development of the radioactive waste management system for a 50-year period in Ukraine (described in NRU-2014 in more details).

The implementation of the tasks of the National Target Ecological Program for Radioactive Waste Management, which was envisaged for the period from 2008 to 2017 has not been completed in full due to lack of financing (actual financing of measures was 10.4%).

The main results of the implementation of these measures are presented in NRU-2017.

Activities are ongoing to update the measures of the National Target Ecological Program for Radioactive Waste Management and to extend the term of their implementation for the next period. In 2020, SAUEZM developed the concept for a new National Target Ecological Program for Radioactive Waste Management and measures for its interdepartmental agreement and approval are being implement.

State policy for management of radwaste accumulated and generated in ChNPP decommissioning and Shelter transformation is implemented through tasks and measures identified in the National Program for Chornobyl NPP Decommissioning and Shelter Transformation into an Environmentally Safe System.

These tasks are fulfilled through the implementation of the Radioactive Waste Management Program at Chornobyl NPP. The main objective of this Program is to develop and ensure an integrated optimized procedure for radwaste management at ChNPP taking into account existing radwaste management facilities and those planned to be constructed.

At present, changes have been developed to the National Program for Chornobyl NPP Decommissioning and Shelter Transformation into an Environmentally Safe System for the period from 2021 to 2031.

The main area of technical policy of *Energoatom*, which is the operator of NPPs, in the field of radioactive waste management is the creation of state-of-the-art infrastructure for safe management of radioactive waste from generation and collection to transfer for disposal of radwaste packages, which will comply with acceptance criteria, to relevant radwaste disposal facilities.

The main areas of activities and measures for 2017-2021 are defined in *Energoatom*'s Comprehensive Program for Radioactive Waste Management.

B.4. Radioactive Waste Management Practices

B.4.1. Radioactive Waste Management at Operating NPPs

The on-site management of radioactive waste generated in NPP operation includes collection, transport, treatment and interim storage in NPP design facilities for liquid and solid waste.

A list of facilities designed for radioactive waste management at operating NPPs is provided in Subsection 3.1 of Annex 3 to this Report. Information on radwaste stored in facilities at operating NPP sites is provided in Subsection 4.1 of Annex 4 to this Report.

The system for management of NPP operational radwaste is to be improved to ensure treatment to minimize waste amounts and obtain radwaste packages acceptable for disposal or long-term storage in centralized facilities designed and constructed on Vektor site. The main areas of activities and the list of measures to improve the radwaste management system at operating NPPs was presented in NRU-2017.

Liquid Radwaste Management

Liquid radwaste is stored in relevant storage facilities. Liquid radwaste is collected into stainless steel tanks equipped with a system for automated liquid waste level monitoring and alarm in case of leaks. To avoid emergency leakage of liquid radwaste, all tanks are located in concrete rooms lined with stainless steel sheets. The designs of the liquid radwaste storages provide for a redundant empty tank to be used in case of damage and repair of other tanks.

Figure 5. On-site Storage of Liquid Radwaste at NPPs

To minimize waste volumes, evaporation bottoms are additionally evaporated to the state of salt fusion cake (except for South Ukraine NPP). The salt fusion cake is stored in 200-liter KRO-200 containers placed into special compartments in SRSF.

Centrifugation facilities are in operation at RNPP and KhNPP for purification of drain water from solid fraction (sludge). At KhNPP, treatment of spent filtering materials at centrifugation facilities is possible in addition to sludge dewatering. Dewatered sludge or dewatered filtering materials are temporarily stored in KT-0.2 containers in solid radioactive waste storage facilities.

Spent filtering materials and sludge are collected and stored under a layer of water in SRSF tanks. Taking into account significant amount of accumulated spent filters, the priority task is to develop procedures to immobilize the spent sorbents and sludge for the possibility of their treatment. Measure 2.3 of the *Energoatom's* Comprehensive Program for Radioactive Waste Management PM-D.0.18.174-16 "Develop formulations for immobilization of spent filters and sludge of NPPs and immobilize a trial batch of filters and sludge of NPPs (ZNPP)" is currently under implementation for this purpose.

The purpose of these activities is to implement a set of measures to develop the optimal formulation for immobilization of filters and sludge, testing of samples of radwaste form received according to this optimal formulation and treatment of a trial batch of filters and sludge from tanks of liquid radwaste storage facility SK-1,2 of ZNPP" (approximately from 6000 to 12000 liters) to obtain packages with radwaste in the form of 200 l barrels (not less than 50 pcs). As a treatment technology, the method of fixing radwaste in a geopolymer matrix or matrix similar in properties using a mobile installation will be used. The treatment technology shall allow obtaining the necessary characteristics of solidified radwaste acceptable for its safe storage on NPP sites and final disposal in CRME disposal facilities. Characterization of NPP spent filters and sludge samples is also planned within task implementation.

In order to solve the issue on liquid radwaste accumulation, the activities on developing formulations and technology to immobilize evaporation bottoms by direct cementation were performed. The studies and tests of samples (forms) of evaporation

bottoms immobilized according to the developed formulations proved compliance of the developed formulations with the requirements of regulatory documentation for the end product of treatment. The advisability of implementing this technology will be determined by the results of the feasibility study on the optimization of liquid radwaste management procedure.

Within implementation of EU international project U4.01/14A “Specification of Waste Forms to Allow Safe Treatment, Storage and Disposal of Problematic Radioactive Waste Held at Ukrainian Nuclear Energy Facilities”, it is envisaged to provide recommendations on the selection of technology for treatment of specific flows of NPP radioactive waste, in particular, evaporator bottoms, salt deposits (SUNPP), filters and sludge.

The results of this project, as well as activities “Develop formulations for immobilization of spent filters and sludge of NPPs and immobilize a trial batch of filters and sludge of NPPs (ZNPP)”, which are currently underway, will be the basis for the development of a feasibility study and approval of decisions on the selection and implementation of liquid radwaste treatment technologies.

Within implementation of Task 3 “Characterization of Selected Problematic Radwaste Flows” of U4.01/14A project, it is planned to analyze physical and chemical peculiarities and radiochemical analysis of samples for three selected flows of problematic radwaste, justify representativeness of samples and calculate radionuclide vectors for these radwaste flows. The following problematic radwaste flows have been defined at present: salt fusion cake (ZNPP, RNPP, KhNPP) and solid salt deposits (SUNPP), spent filters and sludge (all NPPs). The estimated time of task completion is 2020.

Solid Radwaste Management

Solid waste is collected in situ, sorted into groups (by gamma dose rate) and transported for interim storage to SRSF.

The on-site SRSF represent reinforced concrete structures including individual compartments for radwaste depending on activity. The compartments are equipped with a fire alarm system, automated fire-extinguishing system and exhaust ventilation with air purification. Some SRSF compartments are additionally equipped with a moisture detection and removal system.

In 2019, commissioning of the following solid radwaste treatment facilities has been completed:

- at ZNPP (incineration facility, release monitoring system, facilities for fragmentation, supercompaction, radwaste retrieval from storages and activity measurement);
- at RNPP (facilities for solid radwaste retrieval, sorting and fragmentation facility, supercompaction and activity measurement for characterization of radwaste packages; cementing facility, metal decontamination facility, oil purification facility).

Figure 6. Solid Radwaste Fragmentation Facility, ZNPP

Figure 7. Solid Radwaste Supercompaction Facility, RNPP

Due to the commissioning of the Radioactive Waste Treatment Plant (RWTP), the majority of low-level radioactive waste generated at ZNPP and RNPP in 2019 has been treated. In addition, solid radwaste was retrieved in 2019 with its further treatment at compaction and incineration facilities, as well as KTRO-200 containers (temporarily stored in rooms of ZNPP solid radwaste storage facilities) at the supercompaction facility were treated, due to which supply of low-level waste to storage facilities decreased a lot.

RWTP commissioning made it possible to treat solid radwaste accumulated on NPP sites to state acceptable for disposal and free capacities of existing on-site radwaste storage facilities taking into account plans for long-term operation of NPPs.

Figure 8. ZNPP and RNPP Radwaste Treatment Plants

Radioactive waste treatment facility at KhNPP is under construction. The construction design was approved, agreements for the supply of main equipment of KhNPP radwaste treatment facility were signed and are implemented. Preparation for construction activities is underway. *Energoatom's* Comprehensive Program for Radioactive Waste Management envisages KhNPP radwaste treatment system development to 2021 and SUNPP radwaste treatment system development to 2023.

All systems will be provided with facilities for radiation monitoring and characterization of radwaste packages.

For interim storage of conditioned radioactive waste in universal protective reinforced concrete containers for the transfer to Vektor site, design and engineering documents on the light storage facility on ZNPP site have been developed.

The Technical Decision for Salt and Bitumen Compound Processing Procedure with Further Disposal was developed and approved by the SNRIU to prepare RNPP salt and bitumen compound for disposal. According to this Technical Decision, characterization of salt and bitumen compound samples was performed to define the content of alpha-, beta-, gamma- emitting nuclides for calculation of radionuclide vectors, calculation of scaling coefficients with justification materials, as well as additional physical and chemical characterization was performed. The report on physical and chemical characterization of salt and bitumen compound was approved by the SNRIU. It is recommended to be used for safety justification at the stages of transport, storage, preparation for disposal and disposal.

According to the Agreement between the Government of Ukraine and the Government of the Russian Federation on Scientific, Technical and Economic Cooperation in the Field of Nuclear Energy of 14 January 1993 and the contractual obligations of *Energoatom* Company, radioactive waste received after spent fuel reprocessing shall be returned to Ukraine.

The amount of vitrified HLW that will be returned to Ukraine shall be calculated according to the document "Methodology for Calculating the Amount of High-Level Waste Returned to Ukraine after Process Storage and Reprocessing of a VVER-440 SFA Batch" agreed by the regulatory authorities of Ukraine and Russia.

In 2019, the parties agreed the Technical Conditions for vitrified HLW from reprocessing spent fuel of Rivne NPP VVER-440 reactors to be returned to Ukraine, Certification Procedure and Program of Quality Assurance in Spent Fuel Reprocessing.

Construction of the facility on Vektor site for interim long-term (100 years) storage of vitrified HLW from the reprocessing of VVER-440 spent fuel is envisaged by the National Target Environmental Program for Radioactive Waste Management.

Information on the storage facility design is presented in Section H of this Report.

Within preparation to acceptance of the first batch of HLW from reprocessing of VVER-440 spent fuel, *Energoatom* in cooperation with Industrial Association *Mayak* plan to perform audit of HLW vitrification technology.

The report of *Energoatom* on radioactive waste management during NPP operation as of 31 December 2019 is presented on website http://www.energoatom.com.ua.

B.4.2. Radioactive Waste Management at Chornobyl NPP

At present, within the license to perform ChNPP decommissioning activities and within an individual permit to perform activities at the stage of final closure of ChNPP-1, 2, 3, ChNPP provides activities on management of liquid and solid radioactive waste (generated and to be generated) according to the Radioactive Waste Management Program at Chornobyl NPP Site approved by the SNRIU.

Detailed information on the existing radwaste management system at ChNPP is presented in Subsection B.4.2 of NRU-2008.

A list of facilities for ChNPP radwaste management is provided in Subsection 3.2 of Annex 3 to this Report.

Information on radwaste stored in facilities on the ChNPP site is presented in Subsection 4.2 of Annex 4 to this Report.

Detailed information on the Shelter activities and NSC construction is presented in Annex 9 to this Report.

According to the National Program for Chornobyl NPP Decommissioning and Shelter Transformation into an Environmentally Safe System, the priority measures in the development of the system for treatment of ChNPP radwaste generated during operation and decommissioning of ChNPP units and activities at the Shelter include commissioning of ICSRM and LRTP operation.

Detailed information on interim radwaste storage facilities, ICSRM and LRTP is presented in NRU-2017.

According to conditions of an individual permit issued by the SNRIU, activities on the second stage of hot tests are completed at ICSRM.

Figure 9. Solid Radioactive Waste Treatment Plant at ChNPP

Activities are underway to prepare to carry out the third stage of hot tests at ICSRM. The Action Plan on Commissioning of ICSRM SRRF and SRTP and the Methodology for Sampling of Light Compartments of Solid Radwaste Storage Facility (Building 85) were developed in December 2019 for ICSRM commissioning.

Within the second stage of hot tests at SRRF and SRTP, measures were provided to implement technologies for incineration of solid and liquid combustible low-level short-lived radioactive waste in order to minimize accumulated ChNPP radwaste from operation. In particular, a Technical Decision and an Action Plan for treatment of this radwaste by incineration were developed in 2018.

Within the extended program of the second stage of hot tests at ICSRM, activities are underway on repacking of HLW from interim storage facility for solid HLW at SRTP with further placement for temporary storage into interim storage facility for HLW and low- and intermediate-level long-lived waste. As of 01 July 2020, 38 packages with HLW and 11 packages with long-lived waste are placed for temporary storage into compartments of the interim storage facility for HLW and low- and intermediate-level long-lived waste.

Within preparation and conduct of the third stage of hot tests and further operation of ICSRM, the following activities were completed in 2018:

- development of the Decision on Implementation of Radionuclide Vector Method for Characterization of Radionuclide Composition of SRTP Radwaste Packages and its approval by the SNRIU;
- research and development efforts on the Development of Methodologies for Characterization of SRW and Radwaste Packages of SRTP;

- development of methodological documents on the establishment of radionuclide vectors and activity measurement of radwaste packages;

ChNPP initiated activities on reconstruction of certain ICSRM systems, in particular, the ventilation and notification system reconstruction to put the state of fire safety equipment of SRRF and SRTP in compliance with Ukrainian legislation on fire safety of industrial facilities.

Based on an individual permit of the SNRIU for LRTP commissioning issued in 2014 and certificate of the State Architecture and Construction Inspectorate of Ukraine on construction completion issued in 2018, ChNPP implements the stage of LRTP operation with regard to technological process of vat residue processing from the tank 4A-201/3.

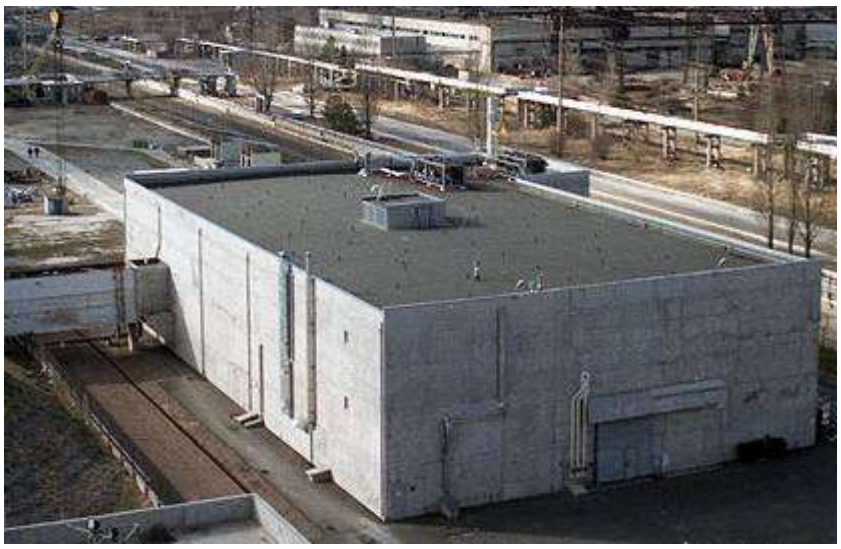


Figure 10. Liquid Radwaste Treatment Plant on ChNPP Site

As of 01 July 2020, taking into account comprehensive testing of LRTP on an active product, 171 625 m^3 LRW was treated, 1986 radwaste packages (200-l drums) were received and 1795 of such drums were transferred for disposal to ENSDF.

Plant for production of metal drums and containers for radwaste is operated at ChNPP to ensure proper management of radioactive waste.

According to the Feasibility Study for Design and Construction of New Additional Facilities for Radioactive Material and Radioactive Waste Management, activities on construction of new radwaste management facilities were underway in the reporting period, in particular:

- facilities for removal of organic compounds and transuranium elements from Shelter liquid radwaste;
- lines for cutting of high-level long-length components from reactor compartments;

Significant amounts of radioactive materials in the form of radioactively contaminated materials and equipment are generated with dismantling activities. Such materials may be further released from regulatory control. ChNPP defined main measures for management of such radioactive materials, in particular, places for their interim storage and further decontamination.

At present, with INSC U3.01/11E project, a facility is under development at ChNPP for release of materials from regulatory control after their decontamination. In addition,

development of standards, methodologies and procedures for release of materials from regulatory control are underway taking into account the best international practice.

Figure 11. Facility for Release of Materials from Regulatory Control

B.4.3. Radioactive Waste Management in Exclusion Zone

Strategic objectives and measures to improve the radioactive waste management system in the exclusion zone are defined by the Strategy for Radioactive Waste Management in Ukraine.

The main activities on radwaste management in the exclusion zone (except ChNPP site) are conducted by CRME appointed as the operating organization for all operating and closure stages of radwaste disposal facilities. The CRME also conducts individual activities on radwaste treatment and long-term storage.

The CRME deals in the exclusion zone with:

- operation of two parallel modules of ENSDF on Vektor site;
- operation of the centralized storage facility for radiation sources on Vektor site regarding comprehensive (hot) tests using radwaste as disused radiation sources of different types;
- operation of near-surface disposal facilities of RWDS *Buryakivka*;
- maintenance, upgrading and safety improvement of RWDS *Pidlisny* and *ChNPP Stage III*;
- maintenance, inspection, monitoring and closure of RICS trenches and pits;
- radwaste transport.

Two near-surface facilities for SRW disposal with a total capacity of 19 200 m3 are in the final stage of construction on Vektor site (acceptance tests of systems and equipment are planned):

- SRW-1 is a facility for disposal of short-lived low- and intermediate- level radwaste in reinforced concrete containers (acceptance capacity is of 9800 m3);
- SRW-2 is a facility for disposal of short-lived low- and intermediate- level large, bulk radwaste, radwaste in drums, craft bags, cargo cages (acceptance capacity of 9400 m3).

Figure 12. SRW-1

Figure 13. SRW-2

A list of facilities for management of radioactive waste located in the exclusion zone (except for ChNPP site) is presented in Subsection 3.3 of Annex 3 to this Report. Data on radwaste disposed of in CRME in the exclusion zone are provided in Subsection 4.4 of Annex 4 to this Report. Data on radwaste stored/confined in the storage facilities of the exclusion zone are presented in Subsection 4.5 of Annex 4 to this Report.

RWDS *Buryakivka*

There are 30 near-surface radwaste disposal facilities (trenches) at RWDS *Buryakivka*. All 30 trenches are fully filled and closed. Detailed description is presented in NRU-2017.

Additional disposal facility (trench) No. 21 A was constructed in 2018 and at present is under operation at RWDS *Buryakivka*, since there was a need to extend production capacities of RWDS *Buryakivka*.

More than 703.7 thousand m3 of radwaste has been accepted to RWDS *Buryakivka* in the process of operation as of 01 July 2020.

RWDS *Buryakivka* Reconstruction project has been approved in 2019 for further extension of RWDS *Buryakivka* capacities. This project envisages the construction of six additional intertrench radwaste disposal facilities in the space between two existing neighboring disposal facilities that are filled and closed.

Figure 14. Aerial Photo of RWDS Buryakivka

ENSDF

ENSDF consists of two parallel section, each with eleven reinforced concrete compartments (modules). SNRIU license allows filling of two symmetrical modules of ENSDF (A1 and D1). Detailed description of ENSDF is presented in NRU-2017.

Figure 15. ENSDF

Figure 16. Loading of Radwaste Package into ENSDF Compartment

Within operation of the disposal facility, measures are taken to monitor civil structures of the module, ensure functioning of the central drainage gallery under the disposal facility, implement up-to-date methodologies for ENSDF safety assessment to increase the number of radwaste suppliers and update radwaste acceptance criteria of this disposal facility.

As of 01 July 2020, during the period of ENSDF operation, vitrified radwaste in the number of 2345 packages with a total radwaste capacity of 835.42 m3 was accepted to A1 and D1 compartments of the disposal facility.

RWDS and RICS

RWDS and RICS in the exclusion zone are elements of the system for managing large amounts of radwaste resulting from the Chornobyl accident. These facilities ensure confinement and isolation of radwaste from the environment. In addition, they require more active measures on maintenance, monitoring, inspection, stabilization, safety improvement, remediation, safety review, etc.

RWDS *Pidlisny* and *ChNPP Stage III* were constructed within priority measures after the Chornobyl accident. Information on safety improvement measures at RWDS *Pidlisny* and *ChNPP Stage III* is presented in NRU-2017.

In 2018-2019, CRME performed additional research of A-1 module of RWDS *Pidlisny* in order to specify data on physical and radiological characteristics of radwaste in this disposal facility (volume and mass of radwaste, radionuclide composition, activity). According to results of performed survey, CRME develops relevant report.

During the reporting period, CRME continued design activities to ensure safety of these facilities.

RICS are territories adjacent to ChNPP with a total area of about 10 hectares, where trenches and pits for radwaste confinement were created within priority measures after Chornobyl accident. Such radwaste consisted of civil structures, household items, upper soil layer contaminated after emergency release. Nine RICS are located in the exclusion zone: Yaniv Station, Naftobaza, Pischane Plato, Stara Budbaza, Nova Budbaza, Prypiat, Kopachi, Chystohalivka, at the territories of which trenches and pits with radioactive waste are located. The estimated number of RICS trenches and pits is from 800 to 1000 pcs. Accurate

locations of some of them need to be specified. Activities are underway on survey of territories of RICS in the exclusion zone, maintenance of trenches and pits and keeping them safe. The objective of survey is to search and specify location of trenches and pits, specify the inventory and activity of placed radwaste.

CRME performs efforts on retrieval and redisposal of radwaste from RICS trenches and pits that may have the most negative impact on personnel of the exclusion zone and the environment.

As of 01 July 2020, 7698.8 m^3 radwaste was retrieved and transferred for disposal. Radwaste was retrieved from trenches of RICS *Naftobaza* with a risk of flooding and from RICS *Nova Budbaza* located in places where active construction of NSC and ISF-2 is underway.

Within international project INSC U4.01/10-D, activities were performed on inspection, collection and systematization of data, safety assessment and ranking of RICS according to the level of hazard. Obtained safety assessment will be used as a basis for definition and optimization of priority measures on support and increase of RICS safety level, as well as for decision making on partial or complete retrieval and redisposal of radwaste from the most hazardous RICS areas.

Figure 17. RICS

Figures 18. RWDS Pidlisny Modules A-1 and B-1

Information on RICS and RWDS safety assessment is presented in Section H.2.2 of NRU-2017.

CLTSF

CLTSF is a key element in improving the entire system for the management of radiation sources in Ukraine. CLTSF shall ensure centralized location of the main volumes of radwaste in the form of disused radiation sources of different types and structures that are currently accumulated on sites of RADON ASSOCIATION specialized radwaste management facilities and radiation sources used in medicine and industry after being transferred into a category of radioactive waste.

Figure 19. CLTSF

Figure 20. Area for DRS Storage at CLTSF

The management of disused radiation sources includes their acceptance, identification, sorting, conditioning and long-term storage (during 50 years).

Detailed description of CLTSF is presented in NRU-2017.

As of 01 July 2020, comprehensive hot tests at CLTSF are underway.

Hot tests include mastering of radiation source treatment processes, radiation surveys to check reliability of biological protection of CLTSF structures, improvement of procedures for acceptance of radwaste in the form of disused radiation sources from suppliers, creation of the system for accounting and control of nuclear materials.

As of 01 July 2020, 21 067 disused radiation sources have been accepted for long-term storage to CLTSF within hot tests.

B.4.4. Radioactive Waste Management at RADON SISPs

Collection and storage of radwaste originating from the use of radiation sources in medicine, science and different industries in relevant Ukrainian regions are performed by State Interregional Specialized Plants for Radioactive Waste Management (SISP).

In April 2019, Resolution of the Cabinet of Ministers of Ukraine approved a decision on the liquidation of the State Corporation "Ukrainian State Association Radon". State Specialized Enterprise *RADON ASSOCIATION* was created instead. It includes the Central Production Site located in Kyiv and four regional affiliates located in Dnipro, Lviv, Odesa and Kharkiv (reorganized).

The Central Production Site and four affiliates of the RADON ASSOCIATION perform the following:

- operation of facilities for solid radwaste storage in containers;
- maintenance, inspection and monitoring of closed radwaste disposal facilities that were filled in the previous period (to 1996) according to disposal technology;
- collection, conditioning and transport of radwaste to relevant facilities;
- operation of decontamination stations for overalls, underwear, and individual protection means;

- keeping of state system for radwaste accounting;
- participation in mitigation of radiation accidents.

List of radwaste storage facilities located on sites of RADON ASSOCIATION affiliates is presented in Subsection 3.4 of Annex 3 of this Report. Data on radwaste and disused radiation sources located in storage facilities of RADON ASSOCIATION affiliates are presented in Subsection 4.6 of Annex 4 to this Report. The main type of radwaste managed by RADON ASSOCIATION includes disused radiation sources transferred in the category of radioactive waste. Information on the management of radwaste in the form of disused radiation sources located in RADON ASSOCIATION storage facilities is presented in Section J and in Subsection 4.6 of Annex 4 to this Report.

Figure 21. Container Storage of Radwaste in Hangar-Type Facilities

Operating radwaste storage facilities are hangar-type buildings for storage of radwaste and disused radiation sources in containers. These buildings were constructed at SISP sites in the 1990s after making a decision on SISP transfer to the radwaste storage technology.

The closed radwaste disposal facilities filled by 1996 are a system of near-surface reinforced concrete module-type facilities with a capacity of 200 m3 and 400 m3. They were constructed according to standard designs in 1960s-1970s. RADON ASSOCIATION performs maintenance, monitoring and safety review of these disposal facilities to make decisions on safety of each specific facility, defines periods during which these facilities can ensure reliable radwaste isolation and makes process decisions on radwaste retrieval and closure of facilities.

The priority of radwaste retrieval from facilities of RADON ASSOCIATION affiliates will be defined according to the roadmap, which establishes the procedure for radwaste retrieval from all facilities, which will be developed under international technical assistance project U4.01/14C “Comprehensive Safety Assessment of Radioactive Waste Management Sites Operated by State Corporation “Ukrainian State Association *Radon* and Design of Remediation for Specific Problematic Facilities”.

According to design decisions, radwaste after preliminary sorting will be placed into protective containers, which will allow further safe storage of retrieved radwaste until transfer for treatment, long-term storage or disposal at Vektor site facilities.

RADON ASSOCIATION also performs maintenance, radiation monitoring and control of storage sites for radwaste resulting from decontamination and sanitary treatment of vehicles (SSR/VTS) after the Chornobyl accident, which are located outside the exclusion zone in the Kyiv, Zhytomyr and Chernihiv regions. Under project INSC U4.01/12D “Remediation of Radioactive Waste Storage Sites Resulting from the Chornobyl

Nuclear Power Plant Accident and Situated outside the Exclusion Zone", additional surveys and safety assessments of SSR/VTS were carried out.

Information on SSR/VTS and their safety assessments is provided in Subsection H. 2.2 of this Report.

Within implementation of international technical assistance project of the European Union U4.01/12D "Remediation of Radioactive Waste Storage Sites Resulting from the Chornobyl Nuclear Power Plant Accident and Situated outside the Exclusion Zone", RWDS *Pisky* located in Pisky village in the Ivankiv district of the Kyiv region was selected as a pilot facility for taking remediation measures.

In order to implement the project, Kyiv SISP received mobile equipment for radiological monitoring and measurements, vehicles and equipment for transport and drilling, auxiliary equipment for on-site activities, hand tools, individual protective means, communication and office equipment and documentation means in 2017-2018.

In 2018, the international consultant developed a Technical Decision on Activities for RWDS *Pisky-1* Pilot Facility Remediation and Safety Analysis Report. Experts on Kyiv SISP performed comprehensive radiological survey of this facility using equipment obtained under the project.

In 2019, Kyiv SISP completed process activities on remediation of RWDS *Pisky-1* pilot facility. As a result, 11.4 t of decontamination waste that complied with retrieval criteria (specific activity of Cs137 > 1 kBq/kg) were retrieved. The total specific activity of retrieved decontamination waste was 1.71×10^8 Bq.

Specified decontamination waste that complied with retrieval criteria and radwaste acceptance criteria were transferred for long-term storage to RWDS *Buryakivka*.

Figure 22. Preparation of Radwaste Retrieved from RWDS Pisky-1 for Transfer to Disposal

After retrieval of decontamination waste and confirmation of reaching remediation criteria for end state (public exposure dose (higher than background contamination) < 0.1 mSv/year; specific activity of Cs-137 in soil < 1 kBq/kg), RWDS Pisky-1 location was remediated to natural conditions.

Figure 2.3 RWDS Pisky-1 Location Remediated to Natural Conditions

B.4.5. Radioactive Waste Management at Research Reactors

SRW at research reactor VVR-M of NASU NRI is collected in places of generation, sorted with development of certificates on certain types of SRW, accumulated, accounted and stored in interim solid radwaste storage facility. Further, SRW is transported to RADON ASSOCIATION. As of 01 July 2020, there is no low-level SRW in NASU NRI.

There are five special underground boxes (tanks) for interim storage of solid intermediate- and high- level radwaste. Information on their filling is presented in Annex 3.

Liquid radwaste is stored in four interim underground storage facilities, that are active drains tanks. Information on their storage are presented in Annex 4.3.

Liquid radwaste deep evaporation facility with further cementation of bottoms (closed waste treatment facility) was put into operation at the reactor for treatment of liquid radwaste.

There are five special underground boxes (tanks) for interim storage of solid intermediate- and high- level radwaste, Information on their filling is presented in Annex 4.3.

B.5. Criteria Used to Define and Classify Radioactive Waste

Detailed information on the radwaste classification system used in Ukraine is provided in Subsection B.5 of NRU-2005 and NRU-2011.

Taking into account new IAEA Safety Standard GSG-1 “Classification of Radioactive Waste”, Ukraine initiated revision and improvement of the radwaste classification system. This is aimed at implementing the radwaste classification system in accordance with the waste final disposal option.

Law of Ukraine “On Amendment of Some Laws of Ukraine to Improve Legislation on Radioactive Waste Management”, which provides for compliance of radwaste classes with envisaged way of their disposal was adopted on 17 October 2019. It will come into force from 07 November 2021. By-laws are being developed.

Existing classification of radioactive waste is used for operation purposes of existing facilities in the transient period before enforcement of an up-to-date classification system.

Implementation of an up-to-date radwaste classification will allow optimization of disposal, in particular, to divide radwaste into classes according to criteria for radwaste acceptance for disposal in four types of disposal facilities: in surface facilities, near-surface facilities, medium depth facilities and geological repositories.

Implementation of an up-to-date radwaste classification in 2021 will have a positive economic effect on radwaste disposal in Ukraine.

Section C. SCOPE OF APPLICATION (Article 3)

1. This Convention shall apply to the safety of spent fuel management when the spent fuel results from the operation of civilian nuclear reactors. Spent fuel held at reprocessing facilities as part of a reprocessing activity is not covered in the scope of this Convention unless the Contracting Party declares reprocessing to be part of spent fuel management.

2. This Convention shall also apply to the safety of radioactive waste management when the radioactive waste results from civilian applications. However, this Convention shall not apply to waste that contains only naturally occurring radioactive materials and that does not originate from the nuclear fuel cycle, unless it constitutes a disused sealed source or it is declared as radioactive waste for the purposes of this Convention by the Contracting Party.

3. This Convention shall not apply to the safety of management of spent fuel or radioactive waste within military or defence programmes, unless declared as spent fuel or radioactive waste for the purposes of this Convention by the Contracting Party. However, this Convention shall apply to the safety of management of spent fuel and radioactive waste from military or defence programmes if and when such materials are transferred permanently to and managed within exclusively civilian programmes.

4. This Convention shall also apply to discharges as provided for in Articles 4, 7, 11, 14, 24 and 26.

Spent fuel and radwaste management in Ukraine is considered as defined in Article 2 of the Joint Convention.

Ukraine has no facilities for spent fuel reprocessing.

Ukraine deals with uranium ore mining and processing resulting in uranium ore waste stored in tailing pits of SkhidGZK and former PChP, which are registered on Baryer books. Waste from mining industry, as well as waste resulting from mining of other minerals, is not declared by Ukraine as radwaste. In line with recommendations of the First and Third Review Meetings of the Contracting Parties to the Joint Convention, information on uranium milling waste is provided in Annex 10 to this Report.

Ukraine does not pursue any military or defense programs that would result in the generation of spent fuel or radwaste. However, there are four radwaste disposal sites that remained from the former military programs of the USSR.

In this regard, Ukraine applies requirements of the Joint Convention to ensure the safety of radwaste originating from former defense programs if this radwaste has been finally transferred for management under civil programs.

The Strategy for Radioactive Waste Management in Ukraine and National Target Ecological Program for Radioactive Waste Management envisage safety measures to keep these facilities in safe state, carry out safety reassessment and plan measures on their subsequent closure.

To date, two such sites are under control of the Ministry of Defense of Ukraine, two radwaste disposal sites are located on the territory not controlled by Ukraine. Two radwaste disposal sites: Vakulenchuk and Tsybuleve storage facilities were closed (see Subsection H.2.1 of this Report).

Section D. INVENTORIES AND LISTS (Article 32, Para. 2)

D.1. List of Spent Fuel Management Facilities Subject to the Joint Convention, Their Location, Main Purpose and Essential Features

A general description of facilities existing in Ukraine for spent fuel management is provided in Subsections B.2.1- 2.3 of this Report.

A list of spent fuel management facilities as of 1 July 2020 is presented in Annex 1 to this Report.

D.2. Inventory of Spent Fuel Subject to the Joint Convention

As required by the Law of Ukraine "On Nuclear Energy Use and Radiation Safety", spent fuel is accounted for under the state system for accounting and control of nuclear materials. Nuclear materials are accounted for in compliance with the "Rules for Nuclear Material Accounting and Control".

An inventory of spent fuel as of 1 July 2020 is presented in Annex 2 to this Report.

D.3. List of Radioactive Waste Management Facilities Subject to the Joint Convention, Their Location, Main Purpose and Essential Features

A general description of radwaste management facilities existing in Ukraine is provided in Subsections B.4.1 - 4.5 of this Report.

A list of radwaste management facilities as of 1 July 2020 is provided in Annex 3 to this Report.

D.4. Inventories of Radioactive Waste Subject to the Joint Convention

The state system for accounting of radwaste and control of its movement and location consists of two main elements: State Register of Radwaste and State Cadaster of Storages and Sites for Temporary Radwaste Storage. SAUEZM, as a state authority for radwaste management, arranges and coordinates state accounting of radwaste and storage facilities and conducts state inventories of radwaste. RADON, which includes the Chief Information and Analytical Center for Radwaste State Accounting System and Regional Centers for Radwaste Accounting, is responsible for the State Register and State Cadaster.

State inventories of radwaste are taken every three years. The first state inventory was taken in 1999-2000, second in 2003, third in 2007, fourth in 2010, fifth in 2013, sixth in 2016, and seventh in 2019.

Radwaste inventories as of 1 July 2020 are presented in Annex 4 to this Report.

D.4.1. Inventory of Radioactive Waste in Temporary Storage at Nuclear Power Plants and Research Reactors

Subsections 4.1–4.3 of Annex 4 to this Report provide data on radwaste accumulated in storages located at sites of *Energoatom* NPPs, ChNPP and research reactors as of 1 July 2020.

D.4.2. Inventory of Disposed Radioactive Waste

Subsection 4.4 of Annex 4 to this Report provides information on radwaste disposed of in near-surface radwaste disposal facilities as of 1 July 207: RWDS *Buryakivka* and ENSDF on the *Vektor* site.

D.4.3. Inventory of Radioactive Waste Resulting from Past Practices

Subsection 4.5 of Annex 4 to this Report provides data on radwaste originating from the Chornobyl accident.

Subsection 4.6 of Annex 4 to this Report contain data on radwaste placed at RADON facilities as of 1 July 2020.

D.5. Nuclear Facilities under Decommissioning

As of 1 July 2020, *Energoatom* has no nuclear facilities under decommissioning.

A list of ChNPP nuclear facilities being decommissioned, in particular at the stage of final closure and safe enclosure is presented in Annex 3.

Section E. LEGISLATIVE AND REGULATORY SYSTEM

E.1. Implementing Measures (Article 18)

Each Contracting Party shall take, within the framework of its national law, the legislative, regulatory and administrative measures and other steps necessary for implementing its obligations under this Convention.

In compliance with the Joint Convention, Ukraine established and maintain updated the state system for regulation of nuclear and radiation safety.

E.2. Legislative and Regulatory Framework (Article 19)

1. Each Contracting Party shall establish and maintain a legislative and regulatory framework to govern the safety of spent fuel and radioactive waste management.

2. This legislative and regulatory framework shall provide for:

i) the establishment of applicable national safety requirements and regulations for radiation safety;

ii) a system of licensing of spent fuel and radioactive waste management activities;

iii) a system of prohibition of the operation of a spent fuel or radioactive waste management facility without a licence;

iv) a system of appropriate institutional control, regulatory inspection and documentation and reporting;

v) the enforcement of applicable regulations and of the terms of the licences;

vi) a clear allocation of responsibilities of the bodies involved in the different steps of spent fuel and of radioactive waste management.

3. When considering whether to regulate radioactive materials as radioactive waste, Contracting Parties shall take due account of the objectives of this Convention.

E.2.1. National Safety Requirements and Radiation Safety Regulations

Requirements and regulations on nuclear and radiation safety of Ukraine are established in laws, Cabinet resolutions, and legal acts of central executive bodies. The system of nuclear legislation also includes international treaties of Ukraine, whose obligatory nature is appropriately acknowledged and which constitute an integral part of national legislation.

Regulatory requirements are developed by the SNRIU on a systematic basis considering regulatory experience and practices in nuclear and radiation safety in Ukraine, as well as experience of advanced countries, advances in science and technology, international standards, including European Commission documents and documents and recommendations of IAEA, WENRA and other international safety organizations.

The main priorities to develop the national regulatory and legal system in the reporting period include:

– Approximation of the Ukrainian legislation to the EU legislation on nuclear energy safety in connection with the signing of the Association Agreement between the European Union and its Member States, of the one part, and Ukraine, of the other part;

– implementation of strategic objectives for nuclear energy development according to the Strategy for Radioactive Waste Management and Energy Strategy;

– implementation of recommendations and suggestions of IRRS-2008 mission and IRRS-2010 follow-up mission;

– implementation of IAEA requirements and safety standards, WENRA recommendations considering SNRIU as a full member of WENRA.

In the reporting period, improvement of the regulatory framework in nuclear energy use continued.

The list of regulations in force in Ukraine on radwaste and spent fuel management is presented in Annex 6 to this Report.

On 11 June 2020, the Law of Ukraine "On Amendments to Certain Laws of Ukraine on the Nuclear Energy Safety" No. 613-IX of 19 May 2020 entered into force.

The Law of Ukraine returns standards, which allow the following in compliance with international requirements:

- annual state oversight of entities' activities classified as high risk; inspection of all NPPs simultaneously at all sites within one scheduled measure;
- licensing of activities in nuclear energy use according to the schedule and procedure established in compliance with the hazard level of these activities;
- bringing to responsibility of the nuclear entity for non-compliance with nuclear and radiation safety requirements;
- possibility of suspension of nuclear or radiation hazardous activities by the state regulatory body on nuclear and radiation safety in case of violation of nuclear and radiation safety;
- making independent decisions by the state regulatory body on nuclear and radiation safety on unscheduled (unannounced) inspections of compliance with the license conditions by the licensee; cessation of safety violations to prevent accidents with radiation consequences.

Thus, with the adoption of the Law, the independence of the state regulatory body on nuclear and radiation safety in making regulatory decisions was renewed.

The system of nuclear legislation also includes regulations of the Cabinet of Ministers of Ukraine, which establish the mechanism for implementing law standards, procedure for activities in nuclear energy use (without defining technical aspects).

An important component of legislation in the area of safety of nuclear energy use is standards and rules on nuclear and radiation safety. These documents set out criteria, requirements and conditions for safe nuclear energy use in all areas of nuclear energy use (safety of nuclear facilities, in particular NPPs, safety of radwaste management facilities, safety of radiation sources, safety of radioactive material transport, physical protection of nuclear facilities, nuclear materials, radioactive waste, other radiation sources, etc.)

SNRIU regulations shall be registered in the Ministry of Justice of Ukraine according to the procedure established by legislation, shall be officially divulgated and be subject to obligatory implementation by all entities to which their force is applied.

Due to the signing of the Association Agreement between the European Union and its Member States, of the one part, and Ukraine, of the other part, and its ratification by the Verkhovna Rada of Ukraine on 16 September 2014, the SNRIU intensified its activities to implement the provisions of the EU legislation on nuclear energy safety into the Ukrainian legislation.

The issues of cooperation between Ukraine and EU in nuclear safety are provided by the Agreement in Article 342 and Annex XXVII (in the Nuclear Energy Section)

Annex XXVII to the Association Agreement was amended by the Decision of the Council of the Association between Ukraine and EU, which was approved by the Verkhovna Rada of Ukraine on 6 June 2019. These amendments are aimed at updating the list of EU regulations to be implemented. The updated Nuclear Energy Section of Annex XXVII-B includes the following directives:

- Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation;
- Council Directive 2006/117/Euratom of 20 November 2006 on the supervision and control of shipments of radioactive waste and spent fuel;
- Council Directive 2009/71/Euratom of 25 June 2009 establishing a Community framework for the nuclear safety of nuclear installations;
- Council Directive 2014/87/Euratom of 8 July 2014 amending Directive 2009/71/Euratom establishing a Community framework for the nuclear safety of nuclear installation;
- Council Directive 2011/70/Euratom of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste.

In fact, the activities to implement these directives by the SNRIU started in 2015 in accordance with the decisions made by the Government of Ukraine during 2015-2019.

In accordance with Annex XXVII-B to the Association Agreement, the Action Plan for Association Agreement implementation was updated at the end of 2019 by Resolution of the Cabinet of Ministers of Ukraine No. 1015 of 20 November 2019 and No. 1065 of 4 December 2019.

Currently, the SNRIU is developing regulations provided in the Action Plan and provisions of the directives are taken into account in the ongoing development of standards and rules on radiation safety.

E.2.2. Licensing System for Spent Fuel and Radioactive Waste Management

During the reporting period, the procedures for licensing activities in spent fuel and radwaste management remained unchanged (see NRU-2014).

E.2.3. System of Prohibition to Operate a Spent Fuel or Radioactive Waste Management Facility without a License

The legislative provisions regarding the prohibition to operate a spent fuel or radwaste management facility without a license indicated in Subsection E.2.3 of NRU-2008 have not changed.

E.2.4. System of Institutional and Regulatory Control, Documentation and Reporting

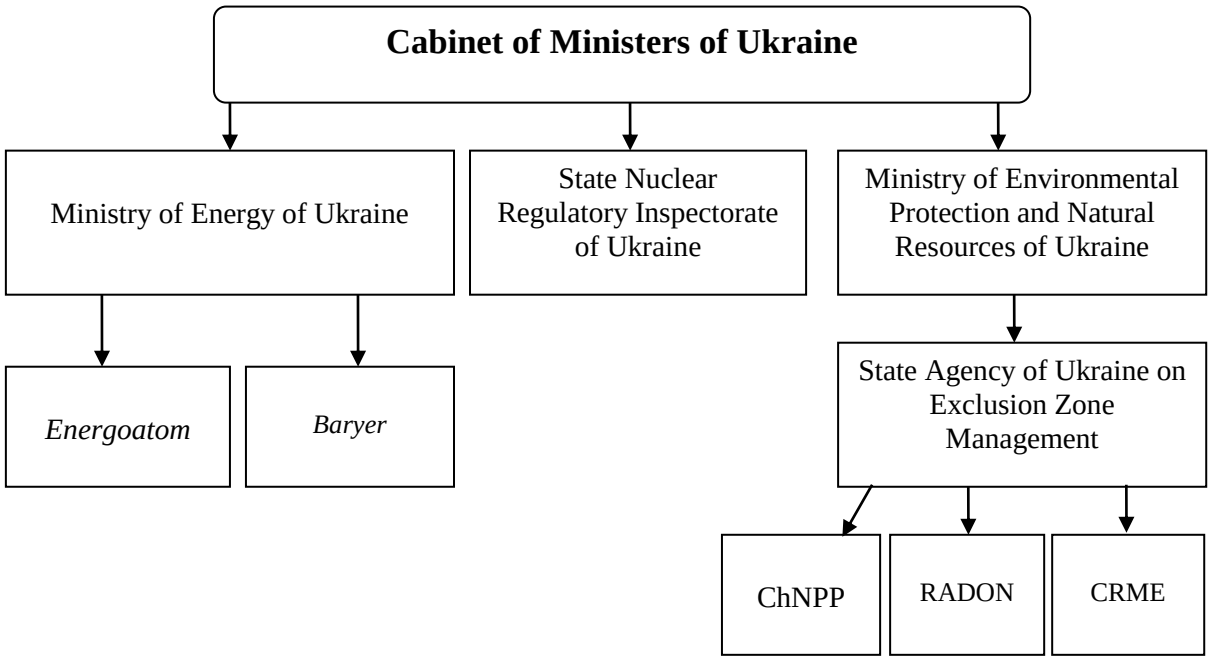
Legislative framework for regulatory control over compliance with nuclear and radiation safety have not changed in the reporting period (see NRU-2014).

E.2.5. Enforcement of Applicable Regulations and Terms of Licenses

In the reporting period, the procedure and criteria for enforcement of compliance with applicable regulations and licensing terms remained unchanged (see NRU-2014).

E.2.6. Allocation of Responsibilities for Bodies Involved in Different Stages of Spent Fuel and Radioactive Waste Management

According to the principles of state policy in nuclear energy use and radiation safety established in Article 5 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety", Ukraine separates state control in the areas of nuclear energy and state control of radwaste disposal and long-term storage.



The State Agency of Ukraine on Exclusion Zone Management (SAUEZM) is entrusted with functions of state management in the area of radwaste management at the stages of long-term storage and disposal and with implementation of the state policy for radwaste management. To perform its functions, the SAUEZM deals with state management of specialized radwaste management enterprises at ChNPP in decommissioning of ChNPP Units 1-3 and Shelter transformation into an environmentally safe system.

The SAUEZM efforts in the central executive system are coordinated by the Ministry of Environment and Natural Resources of Ukraine.

The Ministry of Energy of Ukraine (Minenergo) is in charge of the establishment and implementation of state policy.

The Minenergo exercises state management over the operating organizations of acting NPPs (*Energoatom*) and *Baryer*.

The Minenergo arranges and coordinates the safe management of spent fuel and radioactive waste in operation of nuclear facilities until radwaste is transferred to specialized radwaste management enterprises for long-term storage or disposal.

In compliance with the main principles of state policy for radwaste management (identified in Subsection B.3 of NRU-2011), the radwaste generators are responsible for management of waste before its transfer to specialized radwaste management enterprises. Radwaste disposal by radwaste generators is prohibited.

Waste generators are currently operating organizations of nuclear facilities: *Energoatom* for operating NPPs, NRI for the research reactor, State Specialized Enterprise ChNPP for the Chornobyl NPP and enterprises and organizations that use radionuclide sources.

The CRME is the national operating organization for radwaste management at the stages of long-term storage and disposal. Radwaste generated at enterprises that use radiation sources and at research reactors is collected and temporarily stored by RADON.

E.3. Regulatory Body (Article 20)

1. Each Contracting Party shall establish or designate a regulatory body entrusted with the implementation of the legislative and regulatory framework referred to in Article 19, and provided with adequate authority, competence and financial and human resources to fulfill its assigned responsibilities.

2. Each Contracting Party, in accordance with its legislative and regulatory framework, shall take the appropriate steps to ensure the effective independence of the regulatory functions from other functions where organizations are involved in both spent fuel or radioactive waste management and in their regulation.

The main functions of the regulatory body on NRS defined by 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, acting in compliance with the Statute of the State Nuclear Regulatory Inspectorate of Ukraine, approved by Cabinet Resolution No. 363 of 20 August 2014.

The organizational structure of the State Nuclear Regulatory Inspectorate of Ukraine is presented in Annex 11 to the Report.

To develop recommendations on significant issues and identify the most essential areas of nuclear and radiation safety regulation, the SNRIU Board is working on a permanent basis.

The SNRIU established the Commission for Regulatory Control of the State Nuclear Regulatory Inspectorate of Ukraine as a collegial advisory body to consider issues on regulatory control of NRS, security in nuclear energy use, accounting and control of nuclear materials and to develop proposals for addressing these issues.

The Licensing Commission of the State Nuclear Regulatory Inspectorate of Ukraine was established to develop proposals for decision making on issuance, refusal to issue, modification, reissuance, refusal to issue/modify/reissue, termination, cancellation and renewal of licenses in nuclear energy use.

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

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

SNRIU technical support organization is the SSTC NRS, providing analytical, scientific, expert, technical, engineering, informational, consultative and methodological support to the state nuclear regulatory body.

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 nuclear and radiation safety requirements in Ukraine.

The report is published in Ukrainian and English and posted at the SNRIU official website www.snriu.gov.ua.

In order 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.snriu.gov.ua.

Since 2008, the Management System of the State Nuclear Regulatory Inspectorate of Ukraine was certified in accordance with ISO 9001:2015 and supervisory audits are conducted annually by certification body International Management Systems, which is a business partner of TUV NORD CERT for compliance of QMS.

Section F. OTHER GENERAL SAFETY PROVISIONS

F.1. Responsibility of the License Holder (Article 21)

1. Each Contracting Party shall ensure that prime responsibility for the safety of spent fuel or radioactive waste management rests with the holder of the relevant licence and shall take the appropriate steps to ensure that each such licence holder meets its responsibility.

2. If there is no such licence holder or other responsible party, the responsibility rests with the Contracting Party which has jurisdiction over the spent fuel or over the radioactive waste.

The provisions of legislation establishing the licensee's responsibility specified in Paragraph F.1 of NRU-2017 have not changed.

F.2. Human and Financial Resources (Article 22)

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

i) qualified staff are available as needed for safety-related activities during the operating lifetime of a spent fuel and a radioactive waste management facility;

ii) adequate financial resources are available to support the safety of facilities for spent fuel and radioactive waste management during their operating lifetime and for decommissioning;

iii) financial provision is made which will enable the appropriate institutional controls and monitoring arrangements to be continued for the period deemed necessary following the closure of a disposal facility.

F.2.1. Qualified Staff Needed for Safety-Related Activities during the Operating Lifetime of a Spent Fuel and Radioactive Waste Management Facility

During the reporting period, development and improvement of the system for personnel training and skill improvement in spent fuel and radioactive waste management continued. This system is based on the systematic approach to training recommended by the IAEA and generalized training experience in leading IAEA member states.

According to Article 32 of the Law of Ukraine “On Nuclear Energy Use and Radiation Safety”, the licensee establishes requirements on qualification of personnel depending on their responsibility for the safety of nuclear facilities and radwaste management facilities, their monitoring, and proper operation of safety-related equipment.

In compliance with legislation, the licensee improves skills of its personnel who perform licensed activities on a permanent basis and admits them to work after appropriate training and examination. The licensee develops procedures for examinations on nuclear and radiation safety for managers and personnel and agrees them with the SNRIU. Some categories of personnel are examined in the presence of the regulatory body’s representative.

Compliance with personnel qualification requirements is also monitored under state supervision over enterprises that deal with spent fuel and radioactive waste management.

The national training system operates in cooperation with scientific organizations, enterprises, state control and regulatory bodies and other educational systems to ensure adequate training, retraining and professional development of personnel in order to maintain knowledge, skills and professional attitude.

The following higher educational establishments in Ukraine carry out training and professional development of experts in the sphere of nuclear energy use:

- Taras Shevchenko National University of Kyiv;
- National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute";
- Odesa National Polytechnic University;
- Odesa State Environmental University;
- Karazin Kharkiv National University;
- Kharkiv Polytechnic University "National Technical University";
- National University "Lviv Polytechnic";
- Vinnuytsia National Polytechnic University;
- National University "Zaporizhzhia Polytechnic".

Training of experts in higher educational establishments is carried out using modern equipment in specialized laboratories (radiochemical laboratories for activities with open radioactive substances, spent fuel and high-level radwaste, radiochemical and spectro-chemical laboratories, etc.).

Requirements for personnel qualification and examination are established in the relevant instructions, provisions and licenses for operation of radwaste management facilities. Radwaste and spent fuel management facilities are fully staffed with personnel of corresponding qualification.

The development of NPP training centers, serving as a basis for NPP personnel training, is underway. The centers are provided with skilled trainers. Individual and group programs of training within initial personnel training, as well as skill improvement were developed. Training for personnel of different categories is provided on radwaste management. Training tools are under improvement. The NPP training centers employ simulators and include practical exercises.

Professional training of ChNPP personnel is aimed at improving the occupational quality of the enterprise. Continuous professional development is one the major principles that promote high qualification and skills of ChNPP personnel. There is a training center at the enterprise.

The Training Center performs its activity based on the licenses and permits obtained according to the established procedure in the following areas:

- training of operating personnel taking into account the features of each decommissioning stage of NPP units and related organizational and technical safety measures (in accordance with the license of the State Nuclear Regulatory Inspectorate of Ukraine for the right to train personnel in the Training Center);
- training in the area of safe methodologies to perform the activities related to the increased hazard and the activities performed in launching the Shelter Implementation Plan (on the basis of the certificate of the State Committee of Ukraine on Industrial Safety, Labor Protection and Mining Supervision);
- vocational and technical training for the specialties mostly demanded to perform the activities at ChNPP site, namely: dosimetrist, radwaste processor, slinger, decontaminator (according to the license of the Ministry of Education and Science of Ukraine);

- psychological support of professional activities of ChNPP staff and personnel involved in launching the Shelter Implementation Plan (based on the certificate of the National Academy of Pedagogical Sciences for the right to conduct psychological and psychophysiological diagnostics of personnel).

In order to analyze the requirements for competence and the needs for training to perform activities related to safety at a certain stage of nuclear facility life cycle, the methodologies of advanced planning are used based on the approved National Program for Decommissioning of the Chornobyl Nuclear Power Plant and the Shelter Transformation into an Environmentally Safe System.

The personnel of contractors involved in the activities performed at the Shelter shall be trained according to a specially developed and approved program that covers all issues on safe work performance under conditions of increased radiation and nuclear risks. The permit to work for the contractor's personnel shall be issued only in presence of documented positive results of knowledge examination.

In planning and preparation of a separate power unit for transfer to the decommissioning life-cycle stage, *the Energoatom* plans maximum involvement of qualified and experienced personnel who worked at the power unit during its operation.

To improve quality and efficiency of human resources, CRME conducts systematic development of personnel aimed at building of a safety culture, ensuring of a relevant qualification and preparedness to perform their professional duties. Besides, international technical support is involved. Personnel of enterprises undergo training and professional development on safety assessment of radioactive waste management facilities, application of state-of-the-art safety assessment methodologies and presentation of assessment results, on operation and application of systems and components supplied to the enterprises within the international support (CLTSF process equipment, dosimetric equipment of emergency teams, devices for instrumental surveys of legacy facilities ant their territories, etc.), on safety assessment of radwaste management, storage and disposal facilities in the Chornobyl exclusion zone, management of spent fuel and preparation of geological radioactive waste disposal.

In order to effectively address the needs of personnel professional development, there is a permanently working system for personnel training and skill improvement, where the following approach is used: training without leaving the production process for employees working on radioactive waste management facilities. Periodic training and retraining of the management and operational personnel of the enterprises is performed by the Ukrainian Radiological Training Center (URTC). This training center is a core training establishment, which provides periodic training and professional development of personnel in the area of radiation safety in radioactive waste management.

During 2017-2019, URTC worked within two Long-Term Programs for Training and Professional Development of experts on radwaste management: for 2013-2018 and for 2019-2024. Moreover, Training Plans for these periods were developed and approved. The Programs and Training Plans were approved by the State Agency of Ukraine on Exclusion Zone Management.

The long-term program for training and professional development of experts on radioactive waste management is aimed at periodic professional development of experts on radioactive waste management and is intended to the heads of enterprises, heads of structural subdivisions, engineering and technical employees and personnel working in the sphere of radwaste management.

According to this program, training and certification of the managers, their deputies and engineering and technical personnel of enterprises is conducted in compliance with a 72-hour program of professional development every three years. Training of experts on radwaste processing, decontamination, radwaste transport handling, dosimetry and other (category A personnel) is carried out annually.

In the period from 2017 to 2019, 180 experts of specialized radwaste management enterprises improved their knowledge and successfully passed the certification in URTC, in particular: in 2017 – 53 experts, in 2018 – 54 experts, in 2019 – 73 experts.

From 2017 to 2019, URTC took an active part in implementing the international technical assistance project of European Commission U4.01/12E "Improvement of the national training system in radioactive waste management, decommissioning and remediation" as one of the end users.

URTC systematically participated in the activities of the project working groups, considered the submitted project material and provided its proposals and recommendations. Trainers of the center took part in the international training, which was conducted within the project. As an end user, based on the results of project activities, the URTC received developed training plans, programs and training material on radioactive waste management, decommissioning and remediation of contaminated areas. All training material of the project is developed at the level of up-to-date world standards taking into account IAEA requirements, contain a lot of valuable theoretical and practical information. From the beginning of 2020 to the present, URTC actively implements developed training material in the training process in order to improve the level of training and improve the culture of radwaste management among trainees of the center in accordance with world best practices and IAEA requirements.

In addition, the company has implemented a process of continuous retraining and professional development of physical protection experts, who are responsible for physical protection of radioactive waste management facilities. Annually, according to the scheduled retraining and professional development, physical protection experts undergo training on physical protection, fire safety, civil protection and life health and safety in educational institutions of Ukraine, as well as participate in IAEA trainings and workshops.

At the enterprises that are within SAUEZM management area, checking knowledge of rules, regulations and standards of nuclear and radiation safety is performed in accordance with the Procedure approved by Order No. 82 of the Ministry of Emergencies of Ukraine dated 30 January 2012. The Procedure establishes the framework for checking knowledge of regulations, rules and standards of nuclear and radiation safety and extends to:

– heads of subdivisions and experts of the State Agency of Ukraine on Exclusion Zone Management;

– heads and individuals of the examination boards at enterprises directly subordinated to SAUEZM of Ukraine;

– heads and individuals of examination boards of enterprises and organizations that are not subordinated to SAUEZM of Ukraine, but which act as contractors and subcontractors at Chornobyl NPP and specialized radioactive waste management facilities in the exclusion zone (design, equipment production, construction, mounting, adjustment, repair of equipment and piping, etc.);

– officials of operating organizations (operators) of radwaste disposal facilities and ChNPP.

At least once every three years, heads of enterprises, head and members of the enterprise examination board pass a test on the knowledge of nuclear and radiation safety

rules, regulations and standards in the central commission of SAUEZM with obligatory involvement of SNRIU and Ministry of Heath representatives.

Examination of managers and experts of enterprises is performed as follows: primary – before the admission to independent activities, periodic (regular), extraordinary (additional).

Checking knowledge of rules, regulations and standards of nuclear and radiation safety for personnel of NRI VVR-M nuclear research reactor is performed in accordance with Training Program "Nuclear and radiation safety during operation of VVR-M nuclear research reactor in NRI of NAS of Ukraine", which is agreed with the SNRIU.

F.2.2. Financial Resources to Support the Safety of Facilities for Spent Fuel and Radioactive Waste Management during Their Operating Lifetime and for Decommissioning

According to Article 32 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety", the licensee shall have financial, material and other resources to keep safety at the level accepted by safety standards and regulations and requirements of the license or authorization.

According to Article 33 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety", the operating organization (*Energoatom*) includes the costs of spent fuel storage, processing and disposal of radioactive waste, decommissioning of nuclear facilities in the cost of electric power generation.

The Law of Ukraine "On Regulation of Nuclear Safety Issues" defines a legal and administrative basis for funding of operation termination and decommissioning of nuclear facilities. This law states that a special account shall be opened at the State Treasury of Ukraine to accumulate decommissioning funds.

The Law of Ukraine "On Amendments to Certain Laws of Ukraine on Radioactive Waste Management" dated 17 September 2008 defines legal bases for the creation of the State Fund for Radioactive Waste Management. The Fund is an integral part of the State Budget of Ukraine and is formed at the expense of costs from the environmental tax paid by radwaste producers for the radioactive waste generation and temporary storage of radwaste beyond the established period considering safety requirements. Thus, one of the fundamental principles used in the international practice and named "polluter pays" is implemented. The Tax Code of Ukraine adopted on 2 December 2010 envisages provisions of legislation on forming the State Fund for Radioactive Waste Management within the State Budget of Ukraine.

Adoption of the Law of Ukraine No. 2124-19 dated 11 July 2017 "On Amendments to Article of the Law of Ukraine "On Radioactive Waste Management" on Improving Mechanism for Financing of Radioactive Waste Management", which determined that the environmental tax for radwaste generation is directed exclusively to a dedicated fund of the State Budget and noted that the Fund's costs are directed exclusively to implementing budget programs, under which activities are conducted to establish radioactive waste management facilities transferred by licensees to state property, legally restored the accumulative status of the State Fund for Radwaste Management and its intended use.

Resolution of the Cabinet of Ministers of Ukraine No. 330 of 25 April 2018 approved the Procedure for Allocation of Costs of the State Fund for Radwaste Management.

Within its financial obligations, *Energoatom*, which is the main payer to the State Fund for Radwaste Management, has been paying the tax for radioactive waste generation (including already accumulated) since 2009.

According to Article 12 of the Law of Ukraine "On Radioactive Waste Management", the relationship between enterprises that generate radioactive waste and specialized

enterprises for radioactive waste management is based on a contractual basis. Thus, the second source of funding radwaste management is funds of radwaste producers, which they pay to specialized enterprises for rendering services on collection, inspection, transport and acceptance radioactive waste for storage.

Energoatom Financial Resources to Ensure Safety of Spent Fuel and Radioactive Waste Management Facilities in Their Operation.

Energoatom as the operating organization responsible for reliable and safe operation of spent fuel and radwaste management systems at NPPs includes the required amount of annual funding in the Company's Investment Plan for the medium-term period (five years) and in the annual investment programs.

Spent fuel and radioactive waste management at NPP sites, as well as transport of spent fuel is funded from costs included into the electric and thermal energy tariff. Moreover, to improve the infrastructure for radwaste management at NPPs, resources of international cooperation are involved. For example, systems for solid radwaste treatment at the Zaporizhzhya and Rivne NPPs were constructed under EC technical cooperation projects.

To solve the issue of sufficient financing the CSFSF construction project by concluding an agreement with Merill Lynch, Pierce, Fenner & Smith Incorporated, funds were involved in the form of a long-term loan.

Issues on the Use of Financial Reserve for Decommissioning of Energoatom Nuclear Facilities (Decommissioning Fund)

The Law of Ukraine "On Regulation of Nuclear Safety Issues" defines a legal and administrative basis for funding of operation termination and decommissioning of nuclear facilities. According to this law, the operating organization (operator) deducts funds to a special account opened in the central executive body, which implements state policy in the field of treasury servicing of budget funds.

The total amount of costs allocated by *Energoatom* to the Financial Reserve for Nuclear Facility Decommissioning since its creation (in 2005) as of 10 January 2020 was 5096.468 million hryvnias. Since 01 January 2017, there was an increase in contributions to the Financial Reserve for Nuclear Installation Decommissioning from 283.4 million hryvnias to 785.4 million hryvnias per year. At the expense of the Financial Reserve, it is envisaged to decommission operating nuclear facilities of the *Energoatom*, including ZNPP DSFSF.

The use and investment of funds from the Financial Reserve for Decommissioning is controlled by the Supervisory Board for Control over the Use and Investment of the Financial Reserve (SB FRDE) funds, which was established by Resolution of the Cabinet of Ministers of Ukraine No. 21 of 22 January 2014.

Following the SB FRDE decisions on the proposals submitted by *Energoatom*, the Cabinet of Ministers of Ukraine adopted Resolution No. 280 of 19 April 2017 "On Amending Resolution of the Cabinet of Ministers of Ukraine No. 594 of 27 April 2006", which allows using the financial reserve to fund not only development of the decommissioning project, but also pre-project activities on decommissioning of NPP units (such as development of Decommissioning Concepts for each NPP, complex engineering and radiation inspections of power units, creation of the information support system for decommissioning, etc.).

The experience of accumulation and use of costs for decommissioning demonstrated the need to improve mechanisms of using Financial Reserve funds and protecting accumulated costs from inflation.

Recommendations on the need to establish an effective mechanism to protect RFDE funds from inflation were submitted to SB RFDE by the decommissioning consultant (Spanish company Empresarios Agrupados Internacional, S.A.) selected by the European Bank for Reconstruction and Development. One of the main recommendations of the consultant, which needs to be addressed at the state level, is to improve the existing mechanism of accumulation, use, protection of the financial reserve for decommissioning of operating nuclear power plants (hereinafter - FRDE) from inflation by removing FRDE from the State Budget, implementation of a new mechanism for appointing members of the supervisory board and procedure of their work.

Pursuant to the recommendations of the consultant, the Ministry of Energy developed the Draft Law of Ukraine "On Amending the Budget Code of Ukraine on the Protection of Financial Reserve for Decommissioning of Nuclear Facilities from Inflation", which is currently being approved by interested central executive bodies.

Funding of ChNPP Decommissioning and Safety Assurance of Spent Fuel and Radioactive Waste Management Facilities in ChNPP Decommissioning

According to the legislation, financing of preparation for the decommissioning of ChNPP Units, Shelter transformation into environmentally safe system, radiation safety, medical and biophysical control of personnel of ChNPP and contractors, social protection of ChNPP personnel and Slavutych residents are financed at the expense of the State Budget of Ukraine within special budget programs.

At ChNPP, maintenance of the reliable and safe functioning of spent fuel and radwaste management facilities, as well as collection, sorting, characterization and transfer of radwaste for disposal are performed from the State Budget of Ukraine.

The Law of Ukraine "On Radioactive Waste Management", as amended in 2010, establishes that management of radwaste resulting from the Chornobyl accident, shall be funded from the State Fund for Radioactive Waste Management.

In the period from 2018 to 2019 under budget program "Maintaining Safe State of Power Units and the Shelter and Measures on Preparing ChNPP for Decommissioning", the State Budget of Ukraine provided funding in the amount of UAH 2.374 million hryvnias, funded during the above years: UAH 2.358 million hryvnias.

Financial Resources to Ensure Safety of Spent Fuel and Radioactive Waste Management Facilities in Their Operation.

Spent fuel and radioactive waste management at operating NPP sites is funded from costs included into the electric and thermal energy tariff. Moreover, to improve the infrastructure for radwaste management at NPPs, resources of international cooperation are involved. For example, systems for solid radwaste treatment at the Zaporizhzhya and Rivne NPPs were constructed under EC technical cooperation projects.

The management of spent fuel and radwaste from research reactors during operation (including future decommissioning) is funded from the State Budget.

Radwaste management at the RADON SISPs (operation and future decommissioning) is funded from costs paid by enterprises that transfer radwaste to SISPs for storage on a contractual basis and from the State Budget of Ukraine (through the State Fund for Radioactive Waste Management).

Government also involves international technical assistance for radwaste management at RADON.

The CRME activities related to operation and safety assurance of radwaste management facilities in the exclusion zone are financed from the State Budget (through the State Fund for Radioactive Waste Management).

F.2.3. Financial Provision for Appropriate Institutional Control and Monitoring Arrangements for the Period Following the Closure of a Radwaste Disposal Facility

The institutional control and supervision of disposal facilities for CRME radwaste in the post-closure period is be funded from a dedicated fund of the State Budget through the State Fund for Radioactive Waste Management.

The control of closed radwaste disposal facilities of RADON SISPs is funded from the State Budget of Ukraine.

F.3 Quality Assurance (Article 23)

Each Contracting Party shall take the necessary steps to ensure that appropriate quality assurance programmes concerning the safety of spent fuel and radioactive waste management are established and implemented.

According to Article 11 of the Law of Ukraine "On Radioactive Waste Management", the development and implementation of the quality program is the responsibility of the licensee and the condition of obtaining permits from the regulatory body at all stages of spent fuel and radwaste management.

The regulatory documents "General Requirements for the Management System in the Area of Nuclear Energy" and "Requirements for the Management System of the Operating Organization (Operator)" were put in force in 2012. These documents were developed in accordance with the structure and contents of IAEA documents GS-R-3, GS-G-3.1 and GS-G-3.5, ISO 9001 standard and WENRA reference levels (2014). Licensee compliance with requirements of these documents is confirmed during inspections.

According to requirements of these documents, licensee management system shall combine (integrate) regulatory requirements for nuclear and radiation safety, environmental protection, labor protection and others (see NRU-2017) in order to implement the policy and reach the specified objectives in the safety area.

The licensees that deal with spent fuel and radwaste management, *Energoatom*, ChNPP, CRME, RADON SISPs, NRI of NASU ensure compliance of their management systems for activities (quality systems) with regulatory requirements and standard ISO 9001. In accordance with regulatory requirements, policy of these organizations is aimed at continuous improvement of activities in order to keep it in compliance with the specified regulatory documents and international standards.

Energoatom has implemented the integrated management system (IMS), which meets requirements of international standards ISO 9001:2015 "Quality Management System. Requirements", ISO 14001:2015 "Environmental Management Systems. Requirements with Guidance for Use", ISO 45001:2018 "Occupational Health and Safety Management System" that is confirmed by certificates of conformity issued by TÜV NORD CERT certification body based on recertification audit results in 2019.

The company has developed, approved and revise annually the "Statement *on Energoatom* Policy" and "*Energoatom* Objectives on IMS Improvement and Development

in the Interest of Safety", which states that safety is a priority over economic, technical, scientific and other purposes of activities.

The company's strategy in terms of spent fuel and radwaste management is to create an up-to-date radwaste management system at NPPs, as well as to create a centralized storage system for VVER spent fuel using state-of-the-art technologies to improve the Ukraine's energy safety.

The policy and implementation of the "*Energoatom* Objectives" is analyzed annually.

The *Energoatom* management system is described in the "General Guideline for the *Energoatom* Integrated Management System" and is developed in similar guidelines of separated subdivisions.

To coordinate maintenance of a high safety culture level, *Energoatom* has established a Safety Culture Council, working group on safety cultures, periodically inspects the state of safety culture at *Energoatom*, during which a number of quality management issues are checked.

The purpose of the operating organization of ChNPP in the area of quality assurance is to meet the requirements of legislation in accomplishing all tasks set for the company, and to meet the needs of citizens of Ukraine and other countries in the absence of unacceptable impact on their health caused by any activities at the ChNPP site.

Recognizing the importance of safety culture for achieving the stated goals in accordance with safety and quality policies, activities on its improvement are conducted at ChNPP for many years. They are based on the assessment of own and global achieved results. To build public confidence in ChNPP safe operation, the management declares its commitment to the principles of safety and considers all activities as objects of the quality management system of the enterprise.

ChNPP has implemented an integrated management system based on the principles of the process approach in activity management. The main elements of the management system:

– working board on quality, the main collegial body for making management decisions on quality assurance;

– functioning processes (currently, the enterprise activities covers 17 processes of the highest level, including 59 processes of the first level and 2 processes of the second level). Appropriate methods of monitoring, measurement and result assessment are used for all processes, which allow quick management of processes, analyzing progress of each process, recording deviations and making decisions on the need and reasonability of developing corrective and preventive actions.

– quality programs that are developed and implemented, primarily for processes and works that affect safety, including quality programs for the safety of spent fuel and radioactive waste management. Quality programs demonstrate how an existing management system is applied to a specific case, project or contract;

– quality programs that are developed and implemented, primarily for processes and activities that affect safety, including quality programs on safety of spent fuel and radioactive waste management. Quality programs show how an existing management system is applied to a specific case, project or contract;

– system of independent assessment of activities to determine the effectiveness of processes, state of compliance with safety and quality requirements, opportunities to improve the management system, including audits of existing processes and certain aspects of enterprise activities;

– system to assess risks that may adversely affect safety of spent fuel and radioactive waste management. The risk analysis identifies the sources and causes of risk, work stages during which risk arises, predicts practical benefits and possible negative consequences of the identified risks, determines the impact of decisions made by the enterprise at the stage of strategy development;

– system of independent assessment of suppliers and products, primarily for systems important to safety, in order to confirm the potential of suppliers to provide compliance of products with the requirements set for them.

CRME developed, recorded, implemented, maintained and constantly improved the enterprise management system (quality), which represents a set of interconnected processes, whose management is fully established in relevant procedures that define duties, responsibilities and resources, necessary for effective functioning of these processes.

The operation of the management system (quality) at the enterprise is recorded in the Statements on Physical Protection Policy, Recognition of Security Culture Priority for Nuclear Materials, Radioactive Waste, Other Radiation Sources, on Safety Policy, Quality Assurance, Construction of Storage Facilities, Risk Management; in the Guideline on Quality in Radioactive Waste Management, Guideline on Physical Protection Management System, Quality Assurance Programs, Quality Methodologies (Procedures), Protocols, as well as DMS Documents of Various Levels.

At RADON enterprises, the quality management system was established, recorded, implemented and maintained in accordance with the requirements of DSTU ISO 9001:2009 “Quality Management System. Requirements”. Documents of the quality management system include: recorded statement on safety and quality policies and objectives; quality guidelines; recorded quality methodologies; quality programs; accounting and reporting documents (journals, certificates, protocols, registers, reports, etc.).

At the end of 2018, all RADON affiliates developed and approved the Safety Culture Implementation Programs and statements of enterprise management on the commitment to safety culture, which were posted on the official website of the corporation.

In order to meet the requirements of the quality management system standards, the List of Legislative and Administrative Regulations, Standards and Rules on nuclear and radiation safety, other regulatory documents used at the corporation's enterprises in management of radioactive waste and radioactive materials.

Internal audits of processes were performed annually in accordance with the schedule. The results of previous audits were taken into account to verify the implementation and effectiveness of corrective and preventive measures. In order to eliminate inconsistencies identified during internal audits, corrective actions are planned and performed. The analysis of the results of internal audits showed that the quality management system of enterprises as a whole met the requirements of DSTU ISO 9001:2009 and enterprises were able to constantly render services that meet the requirements of regulatory documents.

The quality system (quality guideline) for operation of reactor components and on safety of spent fuel and radwaste management is developed and operated at the research nuclear reactor. The system meets the requirements of national standard DSTU ISO 9000: 2015.

F.4 Operational Radiation Protection (Article 24)

1. Each Contracting Party shall take the appropriate steps to ensure that during the operating lifetime of a spent fuel or radioactive waste management facility:

i) the radiation exposure of the workers and the public caused by the facility shall be kept as low as reasonably achievable, economic and social factors being taken into account;

ii) no individual shall be exposed, in normal situations, to radiation doses which exceed national prescriptions for dose limitation which have due regard to internationally endorsed standards on radiation protection; and

iii) measures are taken to prevent unplanned and uncontrolled releases of radioactive materials into the environment.

2. Each Contracting Party shall take appropriate steps to ensure that discharges shall be limited:

i) to keep exposure to radiation as low as reasonably achievable, economic and social factors being taken into account; and

ii) so that no individual shall be exposed, in normal situations, to radiation doses which exceed national prescriptions for dose limitation which have due regard to internationally endorsed standards on radiation protection.

3. Each Contracting Party shall take appropriate steps to ensure that during the operating lifetime of a regulated nuclear facility, in the event that an unplanned or uncontrolled release of radioactive materials into the environment occurs, appropriate corrective measures are implemented to control the release and mitigate its effects..

F.4.1. Radiation Protection of Workers and Public

Regulatory control over limitation of radiation exposure for personnel, the public and the environment in Ukraine is ensured by laws, standards and rules.

The following is applied for spent fuel and radioactive waste management:

1. Limits for routine exposure during practices - dose limits and derived permissible and reference levels . These regulatory values are based on the concept of annual effective dose limitation.

2. Limits for potential exposure during practices – reference levels of doses and probabilities of critical events.

These regulatory values are based on the concept of potential exposure risk limitation: 2×10^{-4} $year^{-1}$ for personnel and 2×10^{-5} $year^{-1}$ for the public. Accordingly, for critical events (CEs) that lead to potential exposure for a small group of people, the following reference levels to limit potential exposure are established, in particular: for personnel – CE probability is no higher than 1×10^{-2} $year^{-1}$ with effective dose no more than 100 mSv and no higher than 2×10^{-4} $year^{-1}$ with effective dose more than 100 mSv; for the public – CE probability is no higher than 1×10^{-2} $year^{-1}$ with effective dose no more than 50 mSv and no higher than 2×10^{-5} $year^{-1}$ with effective dose more than 50 mSv.

3. Exposure for the main personnel involved in emergency measures is limited by the above dose limits for routine exposure. Given proper informing and voluntary agreement of personnel, it is permitted to increase the effective dose to 100 mSv and increase the equivalent dose to 500 mSv to an organ (including uniform exposure to the whole body) in exceptional (specifically defined) cases required to save people’s lives.

In order to ensure radiation protection of the public, dose limit quotas are established for exposure from releases and discharges: they are 80 μSv/year for nuclear facilities and 40 μSv/year for radwaste management facilities in operation.

Based on the dose limit quota for each individual facility, permissible releases and discharges are determined, which are not allowed to be exceeded in normal operation.

4. Regulatory values for exposure to people from radwaste disposed of in near-surface facilities following 300 years after closure include limitation of:

- annual effective dose of 0.01 mSv for routine exposure;
- reference level of 1 $mSv \cdot year^{-1}$ for potential exposure.

Upon a separate regulatory decision, the level of potential exposure may be increased to 50 $mSv \cdot year^{-1}$ provided that additional measures are taken to reduce the risk of potential exposure.

At the same time, the "General Safety Provisions for Disposal of Radioactive Waste" approved by SNRIU Order No. 331 of 13 August 2018 and registered in the Ministry of Justice of Ukraine under No. 1008/32460 on 5 September 2018 establish that in the post-closure period of the disposal facility (or facilities if several disposal facilities are located and/or planned to be located at one site), assessment results of the annual effective exposure dose for critical groups of the public from all disposal facilities located and planned to be located at one site should not exceed 0.3 mSv under normal evolution scenarios determined upon justified features, events, processes (FEPs) for these scenarios".

Application of the ALARA Principle

The Law of Ukraine "On Nuclear Energy Use and Radiation Safety" and radiation safety standards of Ukraine determine optimization as one of the main principles of radiation protection. The optimization principle obliges the licensee to keep both individual and collective exposure of personnel and the public and the probability of critical events and associated potential doses as low as reasonably achievable, social and economic factors being taken into account.

There are the following key instruments for optimization of radiation protection in Ukraine:

- application of reference levels (RLs) for exposure for personnel, as well as RLs for gas-aerosol releases and water discharges of radioactive materials in the environment;
- improvement of radiation monitoring systems, including methodologies, metrological support and software;
- planning of radiation-related hazardous activities;
- minimization of radwaste generation;
- implementation of the training system;
- implementation of the quality system for radiation protection.

Reference levels are established by the licensee based on the achieved level of radiation safety and shall be decreased as safety improves. Any case of RL incompliance is investigated by the licensee, and the respective report and corrective measures are considered by regulatory bodies.

Application of the optimization principle allows the plants to keep individual doses to personnel as low as reasonably achievable, gradually decrease the collective dose (see Annex 8 to this Report) and ensure that plant releases and discharges be no more than percentage of permissible levels (see Annex 8 to this Report).

Compliance with the optimization principle is verified during regulatory supervision, through analysis of annual reports on nuclear and radiation safety and radiation protection at NPPs.

There are dose registries at each NPP in Ukraine to evaluate the effectiveness of the optimization principle.

Observation of Basic Dose Limits

Dose limitation is one of the main principles of radiation protection and safety in Ukraine.

According to radiation dose monitoring at facilities for spent fuel and radioactive waste management, the following conclusions can be made for 2014-2017:

- annual limits of individual equivalent doses for personnel of categories A and B were not exceeded in the reporting period;
- permissible airborne radionuclide concentrations in working areas were not exceeded at any enterprise;
- radiation safety of category C individuals (public) living around the respective enterprises complied with standards and rules in force according to radiation monitoring.

The average individual doses for personnel of operating NPPs, ChNPP, CRME, and RADON in the reporting period are shown in Figures L.8.1, L.8.2 and L.8.3 in Annex 8 to this Report.

In 2018, two persons of ZNPP personnel who received doses above 15 mSv and one person of KhNPP personnel who received a dose above 20 mSv in 2019 were recorded. The dose above 20 mSv received by an employee does not exceed the limit established by NRBU-97 of the individual annual effective dose and dose limit on average for the last 5 years (50 mSv and 20 mSv, respectively).

Average individual doses of NPP personnel in 2017-2019 ranged from 0.35 mSv/person per year (RNPP 2017) to 0.95 mSv/person per year (SUNPP 2017).

Individual exposure doses for category A personnel at RADON in 2017-2019 were in the following range: the lowest - 0.21 mSv per person per year at OIA in 2019, the highest - 6.52 mSv per person per year at CPS in 2018.

During 2017-2019, there was a gradual decrease in average individual exposure doses for category A personnel at RADON. In particular, the average individual exposure dose of personnel in 2017 was 1.09 mSv, in 2018 - 1.06 mSv, in 2019 - 0.94 mSv.

Indicators of collective exposure doses for category A personnel at RADON also decreased in 2017-2019. In 2017, collective exposure dose for RADON personnel was 121.71 mSv, in 2018 this value was 120.31 man-mSv, in 2019 - 107.51 man-mSv

The dynamics of average individual exposure doses for personnel of NRI nuclear research reactor also indicates a positive trend in reducing the average individual exposure dose for Category A personnel during last five years.

Prevention of Unplanned and Uncontrolled Radioactive Releases and Discharges to the Environment

To prevent unplanned and uncontrolled releases and discharges of radioactive materials into the environment, control and monitoring devices are used at spent fuel and radwaste management facilities. Procedures for radiation control and monitoring and for calibration, maintenance and repair of instrumentation are in place.

Procedures for radiation dose control and monitoring are agreed by regulatory authorities: Ministry of Health and SNRIU, and are periodically revised to take into account

operating experience, improvement of monitoring instrumentation and changes in the regulatory and legal framework.

The implementation of European Commission Project U4.01/12C "Integrated Automatic System for Environmental Radiation Monitoring at RADON Specialized Enterprises" was underway during 2018-2020.

The integrated automatic system for environmental radiation monitoring (IASRM) was installed by NUVIA a.s. (Czech Republic) to provide continuous radiation monitoring at RWDSs of RADON affiliates; increase radiation safety level for RWDSs in the observation and control areas, provide prompt response to possible radiation accidents, reduce expected risks and radiation impact on personnel and the environment, provide automatic data collection and submit the information on current radiological situation to relevant stakeholders for further decision making.

Installation and adjustment activities were performed and acceptance tests of the system were conducted during 2018-2019. In 2020, IASRM was put into trial operation.

F.4.2. Limitation of Releases and Discharges

The Radiation Safety Standards of Ukraine establish dose limit quotas for the public from releases and discharges, which are 80 μSv/year for nuclear facilities and radwaste treatment facilities and 40 μSv/year for radwaste disposal facilities in the operational period. These quotas are used as the basis for determining, for each facility, permissible releases and discharges, and relevant RLs that must not be exceeded in normal operation.

During the reporting period, according to the results of radiation control and monitoring, RLs of discharges and releases were not exceeded in the reporting period.

F.4.3. Corrective Measures to Control Unplanned or Uncontrolled Radioactive Release to the Environment and Mitigation of Its Effects

The protection of personnel and the public against unplanned or uncontrolled release of radioactive materials is governed by Articles 7 and 8 of the Law of Ukraine "On Human Protection against Ionizing Radiation" and Radiation Safety Standards of Ukraine.

The principles of justification, limitation and optimization are used to plan and implement intervention in case of uncontrolled or unplanned radioactive release. Intervention levels and action levels for countermeasures are determined as quantitative criteria; unjustified, justified and conditionally justified intervention is defined; and intervention termination procedure is established.

The Unified State Civil Protection System (USCPS) is in place in Ukraine to protect personnel and the public in case of unplanned or uncontrolled release of radioactive materials to the environment. The USCPS includes a system of emergency preparedness and response in case of nuclear and radiation accidents. The system and associated measures are described in Subsection F.5

F.5 Emergency Preparedness (Article 25)

1. Each Contracting Party shall ensure that before and during operation of a spent fuel or radioactive waste management facility there are appropriate on-site and, if necessary, off-site emergency plans. Such emergency plans should be tested at an appropriate frequency.

2. Each Contracting Party shall take the appropriate steps for the preparation and testing of emergency plans for its territory insofar as it is likely to be affected in the event

of a radiological emergency at a spent fuel or radioactive waste management facility in the vicinity of its territory.

F.5.1. On-site and Off-site Emergency Plans. Testing of Emergency Plans

Energoatom system of emergency preparedness and response

Requirements for the emergency plans at facilities that deal with practices involving nuclear and radiation technologies, including spent fuel and radioactive waste management facilities, are established in the Radiation Safety Standards of Ukraine, General Safety Provisions for NPPs and National Plan of Response to Radiation Accidents. Emergency planning takes into account radiation hazard categories of facilities (categories I-V), results of risk assessments, requirements of IAEA GSR Part 7 "Preparedness and Response for a Nuclear or Radiological Emergency. General Safety Requirements".

According to NP 306.2.141-2008 "General Safety Provisions for Nuclear Power Plants": before transport of nuclear fuel to the NPP, the NPP emergency plan and operating organization emergency response plan are developed, agreed and approved in accordance with the legislation. Plans are developed upon the initial data presented in NPP design and SAR.

The procedure of operating organization (licensee) actions in case of a nuclear or radiological emergency is established by the Standard Emergency Plan of Ukrainian NPPs, Emergency Response Plan of *Energoatom* Directorate and emergency plans of each NPP.

Emergency plans at the level of *Energoatom* Directorate and NPP are developed upon the requirements of the current nuclear legislation of Ukraine, legislation of Ukraine in civil protection, regulations, standards and rules on nuclear and radiation safety adopted taking into account (as required by Article 8 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety") recommendations of international organizations in nuclear energy use, in particular IAEA practical recommendations on arrangement of emergency planning.

In strict accordance with these recommendations, each NPP emergency plan defines NPP emergency organizational structure, distribution of responsibilities and duties for emergency response, emergency response means, external organizations involved in emergency response, establishes the procedure for NPP emergency response measures and emergency preparedness support, as well as contains comprehensive background and explanatory information.

The emergency response plan of the *Energoatom* Directorate was developed in compliance with para. 10.13.1, NP 306.2.141-2008 "General Safety Provisions for Nuclear Power Plants" approved by SNRIU Order No. 162 of 19 November 2007 and registered in the Ministry of Justice of Ukraine under No. 56/14747 on 25 January 2008 (as amended in accordance with SNRIU Order No. 133 of 20 September 2011).

Emergency response plan establishes arrangement and procedure to:

- coordinate actions of the emergency NPP management, Directorate and separated subdivisions of the company;
- mobilize resources of the operating organization and provide assistance to NPPs;
- to provide interaction of the company Directorate with the state management authority on nuclear energy use, specially authorized central executive authority on civil protection, state authority for nuclear and radiation safety regulation, other central executive authorities.

According to its level and significance, Standard Emergency Plan of Ukrainian NPPs is the next after the national plan of response to nuclear and radiation accidents (Plan of

Response to Radiation Accidents NP 306.5.01/3.083-2004 approved by joint Order of SNRIU and Ministry of Emergencies of Ukraine (now SESU - *note*) No. 87/211 of 17 May 2004 and registered in the Ministry of Justice of Ukraine under No. 720/9319 on 10 June 2004 (as amended by joint Order of the SNRIU and Ministry for Emergencies of Ukraine No. 24/126 of 2 March 2010 and registered in the Ministry of Justice Of Ukraine under No. 250/17545 on 25 March 2010) and is developed pursuant to it.

Standard emergency plan of Ukrainian NPPs establishes the procedure for development, agreement, approval, amendments and revision of NPP emergency plans, as well as generic requirements for their structure and content.

The standard emergency plan of Ukrainian NPPs and emergency plans of operating NPPs developed on its basis were repeatedly tested during IAEA, OSART, WANO missions, as well as the State Emergency Service of Ukraine (Ministry of Emergencies of Ukraine) commissions of various levels. At the same time, no fundamental remarks were made on the structure and content of plans, concept of emergency response, classification of accidents, emergency organizational structure of NPPs, functions, and tasks of emergency personnel.

NPP emergency plans and emergency response plans of the *Energoatom* Directorate are interconnected and coordinated.

Emergency response plan of the *Energoatom* Directorate envisages that, if necessary, *Energoatom* provides support to the emergency NPP by mobilization of resources of the operating organization, including mobilization of forces and means of other NPPs and specialized separated subdivisions of the company.

In addition, in terms of rescue and fire issues, all operating NPPs in Ukraine are serviced by state fire units of the territorial departments of the State Emergency Service of Ukraine. In accordance with Article 2 of the Civil Protection Code of Ukraine, these units are emergency rescue units of the State Emergency Service of Ukraine.

At the same time, these units are completely kept at the expense of NPPs (equipment included) with which they, as provided by Resolution of the Cabinet of Ministers of Ukraine No. 5 of 11 January 2017 “On Approval of the Procedure for Permanent and Obligatory Rescue Services of Economic Entities, Industries and Certain Territories”, concluded relevant agreements on rescue and fire service. The information on the fire and rescue units belongs to exclusive competence of the State Emergency Service of Ukraine.

If there is lack of the operating organization resources, the interaction of USCPS functional subsystems is provided at the state level (the so named provision was approved by the Cabinet of Ministers of Ukraine No. 11 of 1 September 2014 amended in accordance with Cabinet Resolutions of later years) by mobilizing resources of these subsystems.

Management, activities and interaction of control authorities of forces and means involved in the prevention or mitigation of emergencies at Ukrainian NPPs (including allocation of additional resources of external organizations) are implemented according to the procedure established by the “National Emergency Response Plan” approved by Resolution of the Cabinet of Ministers of Ukraine No. 223 of 14 March 2018 (as amended by Cabinet Resolution No. 916 of 6 November 2019) and “Radiation Accident Response Plan” (approved by the SNRIU and State Emergency Service of Ukraine).

Effectiveness and consistency of emergency plans of the *Energoatom* Directorate and NPP are systematically checked during emergency trainings of different levels and during scheduled annual comprehensive checking of preparedness of NPP departments and separated subdivisions responsible for ensuring and implementation of emergency measures

in the context of threat and (or) occurrence of radiation and nuclear accidents, man-made and natural emergencies.

Comprehensive inspections are conducted by the commissions of the company Directorate Board according to a specially developed program, as part of and within the deadlines set by relevant annual order. Based on each inspection results, the commission draws up a report with the conclusion on the compliance of the state of emergency preparedness and response, civil protection and man-made safety of a separated subdivision with the requirements of legislation, other regulations and its proposals indicating implementation timing. The *Energoatom* management approves the report and monitors implementing the commission's proposals presented in it.

The following emergency training types are conducted to train NPP emergency personnel, whose responsibilities include implementing emergency preparedness and response (civil protection) measures in nuclear or radiological emergency, improving their knowledge and skills to mitigate consequences of accidents or emergencies:

– joint general plant emergency training with *Energoatom* Directorate: emergency training at NPP site, which is conducted jointly with *Energoatom* Directorate and separated subdivisions of the company involving external institutions and organizations to check the ability of interacting with these organizations (every three years at each NPP in accordance with the "Schedule for General Plant Emergency Training jointly with the *Energoatom* Directorate and with Participation of Representatives from Relevant Ministries and Departments and Local Executive Bodies", developed by *Energoatom* for a period from 2009 to 2018 and agreed by the SNRIU);

– general plant emergency training: emergency training at NPP site for practical training of interaction with local and territorial bodies of the State Emergency Service of Ukraine, Ministry of Internal Affairs, local executive bodies (by consent), which should participate in emergency or accident mitigation at NPP (every year, except the years when joint general plant emergency training is conducted);

– training of emergency groups and teams (civil defense formations) (every six months).

Emergency training for personnel whose responsibilities include decision-making and taking actions for operating management and maintenance of power plants (involving personnel who implement emergency preparedness and response/civil protection) are divided into the following types:

1) by method of conduct:
- using diagrams;
- conditional actions on equipment under operation;
- with real actions on equipment taken out of service;
- using training equipment;
- combined.

2) depending on location, amount of equipment and involved operating and production personnel:
- operator;
- intersystem;
- system;
- network or district (in electric networks of the main electric networks and power supply organizations and their structural subdivisions);
- general plant (unit, shop, divisional);
- facility (divisional or substation).

3) by other features:

- planned (scheduled) and unscheduled;
- group and individual;
- combined with fire training.

The *Energoatom* develops and implements emergency training programs to exercise personnel actions in emergency conditions. Programs are formed to ensure annual checking of all components of NPP emergency plan and emergency response plan of the *Energoatom* during training.

During training, the adequacy and interrelation of emergency plans are verified, actions on coordinated prompt response of the authorities are tested, forces and means of functional and territorial subsystems of the unified state civil protection system for the public and territories are checked at all levels – facility, local, regional and national.

According to training results, actions of personnel from the affected facility with regard to protection of the public and personnel, actions to bring the conditionally affected unit to safe state, actions of the operating organization, state of emergency preparedness and response system are assessed. Training results are thoroughly analyzed. Relevant corrective measures approved and controlled by the SNRIU are planned and implemented according to training results.

Part 8 of Article 32 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety", Part 8 of Article 13 and Part 12 of Article 14 of the Law of Ukraine "On Human Protection against Ionizing Radiation" establish the following licensee's responsibilities:

- provide NPP accident assessment (classification);
- predict its progression and changes in radiological situation;
- timely inform local executive bodies on emergencies and radiation accidents, incompliance with technical specifications that pose a threat to human safety;
- provide recommendations to these bodies on the protection of the public.

ChNPP Emergency Preparedness and Response System

ChNPP emergency preparedness and response system is an integral part of the emergency preparedness and response system of the State Emergency Service of Ukraine.

The main guideline to prepare and implement organizational, engineering, radiation safety, evacuation and other measures to reduce radiation exposure of personnel and the environment in the event of an accident or emergency at ChNPP is "ChNPP Plan of Response to Accidents and Emergencies".

The main documents regulating personnel actions at emergency facilities are facility emergency plans.

Necessary training and exercises are conducted periodically at ChNPP to check functioning and preparedness of the emergency response system.

All activities on emergency planning, emergency preparedness and response in case of accidents and emergencies at ChNPP are conducted by the main ChNPP organizational structures.

ChNPP emergency organizational structures include:

- supervisor of emergency activities at industrial sites of ChNPP facilities;
- coordination and management body: headquarters of the supervisor of emergency activities or ChNPP emergency commission;
- permanent management body: emergency preparedness and response department;
- emergency teams and groups.

Two protective structures were equipped to protect personnel at the ChNPP site. One of the protective structures includes an equipped internal ChNPP emergency center established to mitigate emergencies at NPP. Maintenance of rooms, equipment, systems and equipment of the emergency center, ensuring its preparedness in case of an emergency and operation reliability is implemented in accordance with the procedures established by the operating organization, including periodic inspection and inventory, replenishment/renewal of emergency kits, testing, calibration, tests of equipment, systems and equipment of the emergency center to confirm confidence that organizational, technical and material resources provided by the emergency plan are available, adequate and operable to perform emergency response functions.

F.5.2. Preparation and Testing of Emergency Plans in Ukraine Considering Probability of a Radiological Emergency at a Spent Fuel or Radioactive Waste Management Facility in the Vicinity of Its Territory

Issues of organization and performance of urgent measures in case of radiation accidents are regulated by the "Emergency Response Plan" and "Model Plan of Response to Radiation Accidents of Territorial Subsystems of the Unified Civil Protection System, the Whole or Part of Whose Territory Belongs to NPP Observation Area" approved by order of the Ministry of Emergencies of Ukraine No. 339 dated 06 May 2008. In the event of a nuclear or radiological emergency at operating NPPs of Ukraine or accidents involving transboundary movement of radionuclides, central and local authorities should, in accordance with applicable law, make decisions and act upon relevant departmental and territorial plans taking into account recommendations of NPP and operating organization, as well as other authorized agencies.

"The Plan of Response to Radiation Accidents" states that "… to respond to radiation accidents in a timely manner and take effective measures to protect the public and territories, the following radiation accident response plans are being developed:

- emergency plans of facilities where practical activities related to radiation or radiation and nuclear technologies are carried out;
- response plans of territorial subsystems of the unified local civil protection system;
- response plans of territorial subsystems of the unified regional protection system…".

Territorial plan determine the main measures to arrange and perform activities related to the mitigation of radiation accident consequences, meeting minimum needs for life necessities of the public suffered from the accident, necessary forces and means, material, financial and other resources, establish the allocation of responsibilities and the procedure for activities of the authorities and forces of the territorial subsystem of the unified civil protection system for implementation of these measures.

As mentioned above in part 1 of this document, 30 minutes after accident classification, NPP issues recommendations for management of the territorial subsystem of the unified state civil protection system for iodine prophylaxis and evacuation of the working public from the territory of the control area, as well as for protective measures of the public living on other territories within the 30-km zone (observation area) of the emergency nuclear power plant. The territorial subsystem management bodies make decisions on iodine prophylaxis and evacuation of the public and ensure notification of the public to take protective measures.

At the same time, the adequacy of decisions and timeliness and effectiveness of activities of the local and central authorities in case of emergencies at NPP is conditioned by

general level of training and preparedness of these authorities for emergency actions, as well as pre-worked algorithm for their interaction with all participants in emergency response.

Moreover, in accordance with the Convention on Early Notification of a Nuclear Accident, Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, and in accordance with the Resolution of the Cabinet of Ministers of Ukraine No. 1570 dated 2 October 2003 (as amended by the Resolution of the Cabinet of Ministers of Ukraine of 13 August 2014 No. 336), SNRIU and the State Emergency Service are the relevant competent national authorities in the event of a radiological emergency:

SNRIU:

- is authorized to ensure notification and send information in case of nuclear accident or radiological emergency in Ukraine, and receive emergency notification and information in case of nuclear accident or radiological emergency in another country, and
- is the only competent national communication point responsible for 24 hours duty cycle in order to ensure emergency notification and information submittal at any time as well as request for assistance in case of nuclear accident or radiological emergency;
- the State Emergency Service of Ukraine is authorized to send and receive a request for assistance in case of nuclear accident or radiological emergency and receive proposals for assistance.

The system of exercises and training (*for emergency training - see also above in Part 1 of Article 25 of the Joint Convention*).

System of personnel and emergency training
(in compliance with PL-D.0.03.089-18 "Main Provisions for Arrangement of Energoatom System of Preparedness and Response to Accidents and Emergencies at Ukrainian NPPs")

Preparedness of emergency personnel for actions in emergencies is ensured by:

- current system of NPP personnel training and professional development;
- systematic emergency training;
- instructions and checking knowledge on emergency preparedness and response, civil protection.

Energoatom develops and implements the system of NPP personnel training and professional development, including on emergency preparedness and response. NPP structure includes training centers equipped with training means, including full-scale simulators required for training, professional development and retraining of NPP personnel, which are staffed by emergency preparedness and response instructors.

NPP personnel undergo training at the workplace and in the training center using simulators, checking knowledge before admission to independent activities, as well as periodic training in accordance with the requirements of standards, regulations and rules on nuclear and radiation safety. During personnel training, professional development and retraining, special attention is paid to exercising their actions during accidents, obtaining practical skills for management of the reactor, power unit and NPP in general. Personnel are trained taking into account operating experience, awareness of consequences of possible personnel errors for NPP safety.

Energoatom Directorate and NPPs develop and implement emergency training programs to exercise personnel actions in emergency conditions. The programs are developed in a way to ensure annual checking of all components of NPP emergency plan and emergency response plans of the *Energoatom* Directorate, and arrangement and conduct

of training should meet the requirements of current legislation on nuclear energy use, nuclear and radiation safety and civil protection regarding these issues.

General requirements for emergency training in separate subdivisions of the company are established in the "Methodology for Preparation, Arrangement and Conduct of Emergency Training in *Energoatom* Separate Subdivisions", which is developed, agreed and approved by *Energoatom*. This methodology takes into account the requirements of the "Procedure for Arrangement and Conduct of Special and Facility Exercises and Training on Civil Protection" approved by Order of the State Emergency Service of Ukraine of 28 November 2019 registered in the Ministry of Justice of Ukraine under No. 46/34329 on 16 January 2020.

At least once every three years, each NPP conducts a general plant emergency training jointly with *Energoatom* involving state regulatory body on nuclear and radiation safety, local executive bodies, other interested bodies, institutions and organizations. "Provisions on Preparation, Conduct and Assessment of Joint General Plant Emergency Training" is developed by *Energoatom* in accordance with the requirements of para. 10.13.7, NP 306.2.141-2008 "General Safety Provisions for Nuclear Power Plants" and approved by the SNRIU.

During joint general plant emergency training, personnel actions are exercised under emergency conditions and adequacy and effectiveness of the NPP emergency plan and emergency response plans at company Directorate level are verified regarding interaction with external bodies, institutions and organizations. According to *Energoatom* decision, exercising other emergency response measures may be additionally planned for some joint general plant emergency training.

Energoatom develops and approves provisions on preparation, implementation and assessment of joint general plant emergency training, as well as advance schedule of joint general plant emergency training and agrees them with the SNRIU.

Maintaining the appropriate level of personnel emergency preparedness is also ensured by the system of information exchange on abnormal events and feedback on NPP operating experience. The system includes: analysis of direct and probable accident consequences, clarification of accident causes, including drawbacks in management/arrangement and human errors, identification of corrective measures to prevent similar accidents in the future.

The received and analyzed information on abnormal events at NPP is taken into account in further personnel training.

Personnel of *Energoatom* Directorate and specialized enterprises: Emergency and Technical Center, *Atomremontservis*:

– undergo training on emergency preparedness and response independently with further knowledge examination;

– undergo functional and practical training in territorial educational and methodical centers of civil protection according to the established procedure;

– obtain experience of practical actions during participation in general station training and joint general station training.

Scheduled joint general station training: in 2017 – at RNPP, in 2018 – at SUNPP (23−24 May) and at ZNPP (14−15 November).

Joint general plant emergency training, which should be conducted in 2019 at KhNPP (6-7 November), was postponed to 2020 for reasons beyond control (*Energoatom* Order No. 1008 of 4 October 2019 "On Amendments to Order No. 274 of 25 March 2019).

It is also planned to hold joint general plant emergency training on 28-29 October 2020 at RNPP.

Training programs and scenarios conducted by the *Energoatom* Directorate and NPPs in the post-Fukushima period are developed taking into account events at Japanese NPPs adapted to zoning conditions of industrial sites of existing NPPs and conclusions of additional training conducted in 2011.

Emergency Preparedness of CRME

During the reporting period, CRME updated Facility Emergency Plans:

– Sections for decontamination of transport, equipment and materials of the shop for decontamination of transport, equipment, materials and operation of changing rooms (Revision 1).

– Centralized Long-Term Storage Facility for Radiation Sources (Revision 2).

Plans of response to radiation accidents, plans of actions and measures in case of accidents in radwaste transport and plans of response to emergencies have been developed and are in place at CLTSF. Emergency personnel are provided with an emergency medical kit, sanitary treatment means, overalls, individual protection means and radiation monitoring devices. Technical inspection and metrological certification of equipment used in mitigation in a radiation accident are conducted in accordance with the agreed schedule. Personnel included in emergency crews are systematically trained and take part in scheduled exercises in accordance with the "Plan of Organizational and Technical Measures on Theoretical and Practical Training". Emergency actions in case of an accident in the exclusion zone are also tested during training at CRME.

Emergency Preparedness of RADON *Enterprises*

By enterprise order, RADON approved membership of emergency crews numbering at least 10 people. The emergency crew operates on the basis of approved and agreed provisions. In case of emergencies at storage sites, there is an emergency plan agreed with the SNRIU and emergency plan for transport of radioactive materials, which includes provisions for cooperation with local governments, State Emergency Service, Ministry of Internal Affairs, and Security Service of Ukraine.

According to the Procedure for Interaction between Executive Bodies and Legal Entities Dealing with Nuclear Energy in Case of Illicit Trafficking of Radioactive Materials, approved by the Government, RADON SISPs are involved in emergency actions of competent authorities for mitigation of emergencies and accidents associated with the detection of orphan sources and radioactive materials in illicit trafficking.

Within international technical assistance project of the European Union "Equipment for Emergency Response at *Radon* SISPs" U4.01/12 B (Part II), specialized equipment and up-to-date devices of radiation reconnaissance and dosimetric control, auxiliary equipment for activities in the emergency response zone, transport equipment, electric and hand tools, personal protective equipment, communication equipment, equipment for storage of radioactively contaminated objects, office equipment and recording tools were provided in 2018-2019 to equip emergency crews of RADON SISPs.

In 2017-2019 and first quarter of 2020, RADON emergency crews participated in the mitigation of 72 radiation emergencies related to detection of orphan sources and illicit trafficking of radioactive materials.

Emergency Preparedness of Research Reactors

The NRI emergency plan is developed for preparation and conduct of coordinated actions to mitigate consequences of nuclear and radiation accidents at the VVR-M research

nuclear reactor in order to prevent or reduce radiation exposure of personnel, the public and the environment.

Response to man-made and natural emergencies, which are not related to accidents at the VVR-M research nuclear reactor, is implemented in accordance with the "Emergency Response Plan of the Nuclear Research Institute of the National Academy of Sciences of Ukraine".

NRI Emergency Plan and Emergency Response Plan are interconnected and coordinated with the plan of the Kyiv territorial subsystem.

In addition, the Instruction on Accident and Fire Prevention and Mitigation of Their Consequences for VVR-M nuclear research reactor was developed and put into force at VVR-M research reactor. This Instruction considers emergencies at the research reactor, which are possible in case of equipment or system failures, incompliance with instructions and human error, defines measures to mitigate accident consequences, specifies responsibilities and actions of reactor personnel in these situations and coordinates these actions with other NRI subdivisions and external organizations involved in the mitigation of accident and fire consequences.

F.6 Decommissioning (Article 26)

Each Contracting Party shall take the appropriate steps to ensure the safety of decommissioning of a nuclear facility. Such steps shall ensure that:
i) qualified staff and adequate financial resources are available;
ii) the provisions of Article 24 with respect to operational radiation protection, discharges and unplanned and uncontrolled releases are applied;
iii) the provisions of Article 25 with respect to emergency preparedness are applied; and
iv) records of information important to decommissioning are kept.

Decommissioning of Chornobyl NPP Units 1, 2, 3

Upon the license issued by SNRIU for the decommissioning stage (series EO No. 000040) and separate permit (series OD No. 000040/8) for activities at the stage of final closure and safe enclosure of ChNPP Units No. 1, 2 and 3, ChNPP continues implementing the stage of final closure and safe enclosure (FCSE) in accordance with the "Program of Implementing Final Closure and Safe Enclosure of ChNPP Units No. 1, 2 and 3".

More detailed information on ChNPP activities at the decommissioning stage is presented in NRU – 2017.

The main components of ChNPP activities during the reporting period were and remain:

– decommissioning of ChNPP Units No. 1, 2 and 3, in particular, FCSE implementation;
– completion of construction of decommissioning infrastructure;
– management of spent fuel, including damaged fuel (nuclear fuel was finally removed from the units in 2016);
– final shutdown of systems and components;
– reconstruction of life systems for decommissioning purposes;
– comprehensive engineering and radiation inspection;
– development of decommissioning documents;
– dismantling of equipment external to the reactor;
– removal of accumulated radioactive waste from power units.

During ChNPP FCSE implementation, dismantling activities are performed resulting in radwaste generation in the form of radioactively contaminated materials and equipment, which can be released from regulatory control in the future. In 2020, it is planned to dismantle certain equipment of Unit 2 external to the reactor (within reactor preparation (unit No. 2) for safe enclosure), installation for treatment of Shelter low-level LRW water from oil and certain buildings that do not belong to the decommissioning infrastructure and radioactive waste management.

Dismantled equipment and materials after their decontamination are supposed to be released from regulatory control using the Installation for Release of Materials from Regulatory Control which is provided at ChNPP.

The detailed information on ChNPP activities related to radwaste management, as well as on the Installation for Release of Materials from Regulatory Control is presented in Section B.4.2.

Decommissioning of Cooling Pond

Chornobyl cooling pond was decommissioned in accordance with the National Program for Decommissioning of the Chornobyl Nuclear Power Plant and the Shelter Transformation into an Environmentally Safe System and in accordance with the feasibility study for decommissioning of the ChNPP cooling pond approved according to the established procedure. According to these documents, termination of continuous feeding of the cooling pond with water from the Prypiat river was determined.

The main condition for safe water level decrease in the cooling pond is obligatory radiation and environmental monitoring:

- monitoring of changes in the radiation state when the water level decreases (provided by ChNPP experts),
- research activities on monitoring of the ecological and sanitary condition of the environment (performed under the agreement in 2015-2018 by the Institute of Hydrobiology of the National Academy of Sciences of Ukraine).

In 2019, when the criteria for completion of ChNPP cooling pond decommissioning were met, radiation and environmental well-being on the territory was not worse than in the areas adjacent to the cooling pond; all documents confirming completion of ChNPP cooling pond decommissioning were developed.

Decommissioning Plans for Operating NPPs in Ukraine

Operating organizations for decommissioning are prepared upon the decommissioning concepts for nuclear facilities agreed by the SNRIU, which contain, in particular, description of measures on radwaste management at the decommissioning stage.

Legislation and regulations that govern planning and implementation of decommissioning of nuclear facilities determine deadlines for development and revision of decommissioning concepts during the life cycle of nuclear facilities, development and approval of the project and safety analysis report of nuclear facilities.

Measures taken at the Shelter are qualified as its transformation into an environmentally safe system. The information on activities at this facility is provided in Annex 9 to this Report.

F.6.1. Qualified Staff and Adequate Financial Resources for Decommissioning

Human resources at Chornobyl NPP, in particular, personnel management, specification of the number, structural layout, staffing, qualification requirements, staff

selection, skill improvement, advanced training are envisaged in the "Quality Program at the FCSE stage for ChNPP Units No. 1, 2, 3".

Chornobyl NPP is fully stuffed by highly qualified personnel according to staff schedules for subdivisions and qualification requirements of job descriptions.

Detailed information on ChNPP personnel training system is presented in Section F 2.1 of this Report.

Information on funding preparation of ChNPP units for decommissioning and transformation of the Shelter into an environmentally safe system is presented in Section F 2.2 of this Report.

Information on forming a financial reserve for operation termination and decommissioning (decommissioning fund) by operator of operating NPPs *Energoatom* is also provided in Section F.2.2 of this Report.

During transfer of a power unit to the decommissioning life stage, *Energoatom* plans to involve as much as possible qualified and experienced personnel who worked at the unit during its operation to work places.

F.6.2. Radiation Protection, Minimization of Discharges and Unplanned and Uncontrolled Releases during Decommissioning

Information on radiation protection, minimization of discharges, unplanned and uncontrolled releases at ChNPP decommissioning stage is presented in Section F 4.

Energoatom does not have nuclear facilities under decommissioning. The program of radiation protection and monitoring of the environment during NPP unit decommissioning should be submitted to the SNRIU to obtain a license for activities at the stage of nuclear facility decommissioning.

F.6.3. Emergency Preparedness

Information on ChNPP emergency preparedness is presented in Section F 5.

F.6.4. Records of Information Important to Decommissioning

"Information Support System for Decommissioning of the Chornobyl NPP" was established and put into commercial operation in 2019 to meet the requirements of the "General Safety Provisions for Nuclear Power Plants" (NP 306.2.141-2008), tasks of the National Program for Decommissioning of the Chornobyl Nuclear Power Plant and Shelter Transformation into an Environmentally Safe System and to provide information support at the current and subsequent stages of ChNPP decommissioning.

In the framework of the international technical assistance project provided by the Government of the Kingdom of Norway, ChNPP launched the Center for Visualization of the Chornobyl NPP Decommissioning. The goal of its activity is to implement virtual reality technologies, 3D modeling and visualization technologies to improve the efficiency and safety of activities at the decommissioning stages.

Since 2016, the system is in trial commercial operation.

Records of Information Important to Decommissioning for Ukrainian NPPs Operated by Energoatom.

According to the *Energoatom* Enterprise Standard "NPP Decommissioning. Information Support System. Structure and Procedure for Collection, Processing and Storage of Information", South Ukraine, Rivne and Khmelnitsky NPPs implemented

automated systems to support comprehensive engineering radiation inspection (ASS CERI) of power units. The system is intended to:

– collect and organize information on radiation contamination of equipment, piping, rooms, structures of buildings and power units and NPP territory adjacent to the power units obtained in their comprehensive engineering and radiation inspection;

– store design and operational documents.

ASS CERI is under implementation at Zaporizhzhya NPP.

Section G. SAFETY OF SPENT FUEL MANAGEMENT

G.1. General Safety Requirements (Article 4)

Each Contracting Party shall take the appropriate steps to ensure that all stages of spent fuel management, individuals, society and the environment are adequately protected against radiological hazards.
In addition, each Contracting Party shall take the appropriate steps to:
i) ensure that criticality and removal of residual heat during spent fuel management are adequately addressed;
ii) ensure that the generation of radioactive waste related to spent fuel managements is kept as low as practically achievable that is consistent with the type of fuel cycle policy adopted;
iii) take into account interdependencies among the different steps in spent fuel management;
iv) provide for effective protection of individuals, society and the environment, by applying at the national level suitable protective methods as approved by the regulatory body, in the framework of its national legislation which has due regard to internationally endorsed criteria and standards;
v) take into account the biological, chemical and other hazards that may be related to spent fuel management;
vi) avoid actions that impose reasonably predictable impacts on future generations greater than those permitted for the current generation;
vii) aim at avoiding imposing of undue burdens on future generations.

The Ukrainian legislation provides for compulsory licensing of operating organizations during construction and commissioning, operation and decommissioning of facilities for spent fuel management.

General safety requirements at all stages of spent fuel management are established in the Laws of Ukraine “On Nuclear Energy Use and Radiation Safety” and “On Authorizing Activities in Nuclear Energy Use”.

Requirements and rules for spent fuel management are established by regulations that cover spent fuel management on NPP sites, research reactors and interim spent fuel storage facilities, namely:

– General Safety Provisions for Nuclear Power Plants;

– Nuclear Safety Rules for Nuclear Power Plants with Pressurized Water Reactors;

– General Safety Provisions for Design, Construction and Operation of Research Reactors;

– Nuclear Safety Rules for Research Reactors;

– Basic Safety Provisions for Dry Interim Spent Fuel Storage Facilities;

– Requirements for Modifications of Nuclear Facilities and Procedure for Their Safety Assessment;

– Safety Requirements for Spent Fuel Management;

– Requirements for Systems of Emergency Cooling of Nuclear Fuel and Heat Removal to Ultimate Heat Sink;

The regulatory and legal framework was improved after the Fukushima-1 NPP accident within implementation of the Action Plan for Special Targeted Safety Assessment

and Further Safety Improvement of NPP Units Considering Events at Fukushima-1 NPP approved by SNRIU Board on 19 May 2011.

G.1.1. Criticality and Residual Heat Removal

According to the requirements of the above regulations, the effective neutron multiplication factor in spent fuel management shall not exceed 0.95 in normal operation and design-basis accidents by appropriate characteristics of the facilities. Subcriticality in spent fuel storage is ensured by limitation of the fuel assembly pitch; fuel burnup credit (if burnup is used as a parameter in nuclear safety justification); use of heterogeneous or homogeneous absorbers and absorber credit; monitoring of the presence, state and composition of the cooling media in dry storage facilities; monitoring of process parameters of the spent fuel management systems, as well as certain organizational and technical measures. According to requirements of the document "Basic Safety Provisions for Dry Interim Spent Fuel Storage Facilities", subcriticality in dry interim spent fuel storage facilities shall be mainly ensured by the geometry of spent fuel location.

The design of spent fuel management systems provides for residual heat removal and for appropriate chemical composition of the heat-removing media to prevent increase on fuel cladding temperature and uncontrolled corrosion rate in excess of the design values for normal operation and design-basis accidents. Thus, for facilities where spent fuel is stored in water (spent fuel pools of operating NPPs and ChNPP ISF-1), devices and systems are provided for water supply, treatment and cooling, ventilation, and for monitoring of radioactivity, temperature, level, chemical composition of water and, if necessary, hydrogen concentration.

According to the results of implementation of post-Fukushima measures within C(I)SIP, upper racks of RNPP-1 and RNPP-2 spent fuel pools are planned to be replaced in 2020. The replacement of racks will lead to compliance with safety criteria in design-basis and beyond design-basis accidents and removal of limitation regarding their filling with nuclear fuel.

G.1.2. Minimization of Radioactive Waste Generation

In the reporting period, the requirements for radwaste generation related to spent fuel management have not changed (see Subsection G.1.2 of NRU-2003). Pursuant to the "Basic Safety Provisions for Dry Interim Spent Fuel Storage Facilities", the operating organization develops and implements the radwaste management program to identify measures for minimization of radwaste generation and safety assurance during collection, sorting, treatment, storage and transfer of radwaste for disposal or long-term storage.

G.1.3. Interdependencies among Different Steps in Spent Fuel Management

The interdependencies among different stages of spent fuel management are taken into account starting from the design of fresh nuclear fuel. The technical specifications for supply of fresh nuclear fuel contain requirements for spent fuel storage in spent fuel pools, permissible temperature of fuel claddings in spent fuel storage, etc. Two options are currently underway:

- transfer of ZNPP spent fuel from spent fuel pools of ZNPP units to ZNPP DSFSF;
- transport of spent fuel from RNPP, KhNPP and SUNPP to Russian enterprises for process storage and reprocessing and subsequent return of the resulting high-level radwaste to Ukraine.

In the reporting period, the requirements for interdependencies among different steps in spent fuel management have not changed.

G.1.4. Radiation Protection of Personnel, the Public and the Environment

The radiation protection system of Ukraine is described in Subsection F.4 of this Report.

G.1.5. Consideration of Biological, Chemical and Other Risks

Biological, chemical and other risks that can be related with spent fuel management shall be taken into account in safety assessment of spent fuel management facilities. Information on such risks is provided according to the "Recommendations on the Structure and Contents of the Safety Analysis Report for Spent Fuel Storage Facilities".

Biological, chemical and other risks are evaluated within state review.

G.1.6. Avoiding Reasonable Predictable Impacts on Future Generations Greater than Those for the Current Generation

Protection of future generations is considered in the safety analysis reports for spent fuel management facilities, which should demonstrate that future protection of the public and personnel will not be lower than that at the beginning of operation. If necessary, processes inside the containment and degradation of fuel elements and spent fuel storage components are inspected during operation with the purpose of taking timely corrective measures (if needed).

G.1.7. Avoiding Undue Burdens on Future Generations

The policy of avoiding undue burdens on future generations did not change in the reporting period, therefore information presented in Subsection G.1.7 of NRU-2017 is relevant.

G.2. Existing Facilities and Past Practices

Spent fuel in Ukraine is managed at the facilities listed in Annex 1 of this Report. Information on operation of the existing spent fuel management facilities is provided in Subsections B.2.1. - B.2.3. of this Report.

G.2.1. Safety of Existing Facilities

Facilities for storage of VVER spent fuel

The safety of existing spent fuel management facilities is ensured by current technical regulations, design decisions, technical specifications, operating and maintenance procedures, technical decisions and quality assurance procedures.

All spent fuel management facilities are designed to be equipped with surveillance and monitoring systems.

The automated radiation monitoring system *Koltso* and a network of observation wells to monitor underground and ground waters are in operation on the territories around the ZNPP DSFSF. Radiation parameters on the site and adjacent territory around the storage facility are monitored with the periodicity established in radiation monitoring procedures. The results are analyzed and compared with reference levels. Quarterly and summary annual safety reports on ZNPP DSFSF safety performance indicators are submitted to the SNRIU.

As was noted in previous NRUs, the safety review of Ukrainian NPPs and DSFSF did not reveal any fundamental drawbacks that would require modernization of the spent fuel management systems at operating NPPs.

The reactor cores of Ukrainian NPPs are reloaded in a timely manner and regulations that require free capacities in the cooling pools for complete accident core unloading are met owing to the efficient operation of the ZNPP DSFSF and compliance with the schedule for spent fuel transport to specialized enterprises of the Russian Federation for reprocessing.

Facilities for storage of RBMK spent fuel

According to Subsection B.2.2. of this Report, all spent fuel of RBMK-1000 is stored in ChNPP ISF-1.

ChNPP developed the "Plan of Measures for Improvement of ISF-1 Safety" and agreed it with SNRIU. The implementation of its activities is currently underway.

The safety assessment of ISF-1 for storage of ChNPP spent fuel is presented in the "Safety Analysis Report on Interim Spent Fuel Storage Facility (ISF-1)", Inv. No. 06 of 24 June 2015.

G.3. Siting of Proposed Facilities (Article 6)

1. Each Contracting Party shall take the appropriate steps to ensure that procedures are established and implemented for a proposed spent fuel management facility:
i) evaluate all relevant site-related factors likely to affect the safety of such a facility during its operating life;
ii) assess possible impact of such a facility on safety of individuals, society and the environment;
iii) inform the public on safety of such a facility;
iv) consult Contracting Parties in the vicinity of such a facility, insofar as they are likely to be affected by that facility, and provide them, upon their request, with general data relating to the facility to enable them to evaluate the likely safety impact of the facility upon their territory.
2. In so doing, each Contracting Party shall take the appropriate measures to ensure that such facilities shall not have unacceptable effects on other Contracting Parties by being sited in accordance with the general safety requirements of Article 4.

G.3.1. Evaluation of Site-Related Factors Likely to Affect Safety of the Facility during Its Operating Lifetime

Current legislation of Ukraine establishes the procedure to assess factors that are related to the site and that can affect safety of the facility during its operating lifetime.

Site-related factors that can affect safety of the facility during its operating lifetime are assessed during the development of EIA, which is a part of the Feasibility Study, and the design of the nuclear facility.

In addition, site-related factors that can affect facility safety can be assessed during:

– development of PSAR (as a justification of the possibility for obtaining a license for construction and commissioning);

– revision and extension of PSAR after completed construction and mounting of equipment (as a justification of the possibility for obtaining an individual permit for commissioning);

– development of FSAR (as a justification of the possibility to obtain a license for operation),

– periodic safety review of the nuclear facility.

Besides, the Law of Ukraine "On Environmental Impact Assessment" came into force in 2017.

This Law establishes legal and organizational foundations for environmental safety assessment aimed at prevention of causing harm to the environment, providing environmental safety, efficient use and recovery of natural resources, in the process of making decisions on economic activities, which can significantly affect the environment, taking into account state, public and private interests.

According to the provisions of this Law:

1) environmental impact comprises any consequences of planned activities for the environment, including consequences for safety of the public and public health, flora, fauna, biodiversity, soil, air, water, climate, landscape, natural areas and objects, historical monuments and other material objects or for a combination of these factors, as well as consequences for cultural heritage or social and economic conditions that result from changes in these factors.

2) Environmental impact assessment is the procedure, which includes the following:

- development of an environmental impact assessment report by the nuclear entity;
- conduct of public discussions;
- analysis of information presented in the environmental impact assessment report, any additional information provided by the nuclear entity and information received from the public during public discussions, during the procedure for transboundary impact assessment, other information by the authorized body (Ministry of Environmental Protection and Natural Resources);
- provision of justified conclusions on environmental impact assessment taking into account analysis results by the authorized body;
- consideration of conclusions on environmental impact assessment in the decision regarding the conduct of planned activities.

There were no other changes in requirements for assessing factors related to Ukrainian spent fuel storage facility sites in the reporting period.

G.3.2. Evaluation of Likely Safety Impact of the Facility on Individuals, Society and the Environment

NRU-2011, Subsection G.3.2 included the information on "Statement of Ecological Consequences resulting from Construction and Operation of the Centralized Spent Fuel Storage Facility for the Rivne, Khmelnitsky and South Ukraine NPPs Operated by *Energoatom* and Feasibility Study for CSFSF Construction".

A statement of intentions and environmental consequences of CSFSF construction, safeguards for implementation of measures to ensure environmental safety are presented in the mass media and on *Energoatom* website. The Company continues a wide information campaign to inform the public of Ukraine on the selected technology of spent fuel storage, relevant issues of construction and further operation of CSFSF through central and regional mass media of Ukraine, including Internet editions.

Based on the Feasibility Study of CSFSF construction, the task for design and town-planning conditions and constraints, the project "Construction of CSFSF for fuel from Ukrainian NPPs with VVER" was developed. The section "Nuclear and Radiation Safety" includes the assessment of radiation safety during the construction, operation and decommissioning of CSFSF. The implementation of the measures envisaged by the projects

will ensure an acceptable radiation safety level. The documents of the project on environmental impact assessment were subject to an individual state environmental review, upon which the Ministry of Ecology and Natural Resources of Ukraine issued a positive conclusion in May 2017. The Annual Report on "State of Environment During CSFSF Construction Design Implementation" confirms that CSFSF construction is performed according to the approved design and implemented measures on radiation safety and environmental protection comply with requirements of regulations and are sufficient and efficient.

According to the conclusion of the state review on nuclear and radiation safety of the preliminary SAR on CSFSF, "The design decisions for CSFSF and planned activities at CSFSF life cycle stages presented in the CSFSF project documentation and justified in the previous CSFSF SAR meet the regulatory requirements for nuclear and radiation safety. It ensures the implementation of fundamental safety principles and compliance with nuclear and radiation safety criteria for spent fuel management at CSFSF site. The implementation of the fundamental safety principles and compliance with nuclear and radiation safety criteria for spent fuel management at CSFSF site is provided".

All conclusions of reviews are available as public information.

Positive consequences of CSFSF design implementation in Chornobyl exclusion zone are as follows:

- environmental remediation of a part of 30-km exclusion zone;
- return of a part of this exclusion zone to economic activities;
- creation of new working places;
- possibility to improve the living conditions of the public in the storage facility area through contributions to the development of social infrastructure.

According to the Law of Ukraine "On Siting, Design and Construction of the Centralized Storage Facility for Spent Fuel of Ukrainian NPPs with VVER", costs in the amount of ten percent of the total estimated construction cost are directed to the construction of social facilities in Ivankiv and Polissia districts, in Slavutych of Kyiv region according to the list approved by the Kyiv Regional State Administration.

G.3.3. Informing Members of the Public of the Facility Safety

The following procedures are established by national legislation to fulfil commitments of Ukraine with regard to informing members of the public on safety of nuclear facilities:

- Procedure of the Public Hearings on Nuclear Energy Use and Radiation Safety approved by Resolution of the Cabinet of Ministers of Ukraine No. 1122 dated 18 July 1998;
- Procedure of the Public Hearings During Environmental Impact Assessment approved by Resolution of the Cabinet of Ministers of Ukraine No. 989 dated 13 December 2017.

The main objective of the public hearings on nuclear energy use and radiation safety issues is to implement the rights of the public and their associations for the participation in discussion of issues related to the siting, design, construction, operation and decommissioning of nuclear facilities, enterprises for uranium ore mining and processing and radioactive waste management facilities, radiation sources, etc.

The main objective of the public hearings during environmental impact assessment is the public discussion in the process of environmental impact assessment to reveal, collect and account comments and proposals of the public on planned activities.

In addition, the operating organizations perform the following to inform the public on safety of nuclear facilities:

- provide regular publications in central, regional and local mass media and provide information on TV channels of satellite cities;
- carry out lectures with visits to SFSF sites for the public;
- arrange press tours of mass media representatives to SFSF sites;
- post information and reference materials on official websites.

G.3.4. Consulting Contracting Parties in the Vicinity of the Facility

As it was stated in Subsection G.3.1. of this Report, the Law of Ukraine "On Environmental Impact Assessment" came into force in December 2017.

Among other, this Law specifies requirements of the Convention on Environmental Impact Assessment in a Transboundary Context and establishes clear procedure for assessment of the transboundary impact of planned activities that can have a significant negative transboundary environmental impact.

In the reporting period, there were no changes in the technology and design decisions on Ukrainian SFSF, therefore the procedure for transboundary environmental impact assessment of the planned activities that can have a significant negative transboundary environmental impact has not been applied.

There were no applications of other countries to provide genera data on Ukrainian SFSF necessary to assess possible impact of these facilities on safety of their territories.

G.4. Design and Construction of Facilities (Article 7)

Each Contracting Party shall take the appropriate measures to ensure that:
i) the design and construction of a spent fuel management facility provide for suitable measures to limit possible radiological impacts on individuals, society and the environment, including those from discharges or uncontrolled releases;
ii) at the design stage, conceptual plans and, as necessary, technical provisions for the decommissioning of a spent fuel management facility are taken into account;
iii) the technologies incorporated in the design and construction of a spent fuel management facility are supported by experience, testing or analysis.

G.4.1. Limitation of Possible Radiological Impacts of Spent Fuel Management Facilities

The following measures are implemented according to the current legislation of Ukraine to ensure limitation of possible radiological impact of spent fuel management facilities on personnel, the public and the environment:

- implementation of defense in depth based on the use of the system of physical barriers on the way of release of radioactive substances and radiation to production rooms and the environment;
- use of the system of technical and organizational measures to ensure integrity of barriers and maintain their efficiency.

The need for implementation of these measures is established by the spent fuel management facility design, and their compliance with requirements for nuclear and radiation safety is justified in PSAR.

The project "Completion of ChNPP ISF-2 Construction" includes measures to ensure acceptable level of radiation safety and radiological impact of this facility.

The conclusion of the state review of nuclear and radiation safety of ISF-2 PSAR approved by the SNRIU on 30 November 2012 confirmed that decisions envisaged by ISF-2 design comply with nuclear and radiation safety requirements.

The project "Construction of CSFSF for Ukrainian NPPs with VVER Reactors" provides measures to ensure appropriate radiation safety and limit radiological impact of CSFSF.

The conclusion of the state review on nuclear and radiation safety of CSFSF PSAR approved by the SNRIU on 03 November 2016 confirmed that decisions envisaged by CSFSF design comply with nuclear and radiation safety requirements.

G.4.2. Conceptual Plans and Technical Provisions for Decommissioning of Spent Fuel Management Facilities

There were no changes in the procedure for development of conceptual plans for decommissioning of nuclear facilities, including spent fuel storage facilities, established by Ukrainian legislation, therefore information presented in Subsection G.4.2. of NRU-2017 is relevant.

G.4.3. Support of Technologies Incorporated in the Design by Experience, Testing or Analysis

In the reporting period, the requirements for support of technology incorporated in the design by experience, testing or analysis have not been changed (see Subsection G.4.3 of NRU-2017).

The technology of dry storage of spent fuel developed by Holtec International (USA), the detailed description of which is presented in Subsection B.2.2. of this Report, will be used to ensure storage of spent fuel in spent fuel storage facilities that are being constructed in Ukraine.

The spent fuel storage and transport technology of Holtec is used more than on 70 light water reactors in the USA, Great Britain, Mexico, Spain, Switzerland, Belgium, Sweden, South Korea, China and will be used in Ukraine and Slovenia.

Individual, functional and comprehensive cold testing of main process equipment of Holtec were held at Ukrainian NPPs in 2019-2020.

G.5. Safety Assessment of Facilities (Article 8)

Each Contracting Party shall take the appropriate measures to ensure that:
i) before construction of a spent fuel management facility, a systematic safety assessment and an environmental assessment appropriate to the hazard presented by the facility and covering its operating lifetime is carried out;
ii) before the operation of a spent fuel management facility, updated and detailed versions of the safety assessment and of the environmental assessment is prepared when deemed necessary to complement the assessments referred to in paragraph (i).

G.5.1. Safety Assessment and Environmental Assessment

Current legislation of Ukraine establishes the procedure for the systemic safety assessment and environmental review comparable with risks related to the facility and covering the entire period of its operation (see Subsection G.5.1. of NRU-2014 and Subsection G.3.1. of this Report).

With regard to the enforcement of the Law of Ukraine "On Environmental Impact Assessment" (see Subsections G.3.1.-G.3.4. of this Report), environmental impact assessment is performed instead of environmental review.

G.5.2. Safety Review During Construction and Commissioning

In the reporting period, the requirements for safety review during construction and commissioning have not been changed (see Subsection G.5.2. of NRU-2011).

As it was stated above, two spent fuel management facilities are under the stages of construction and commissioning: ChNPP ISF-2 and CSFSF.

Within the design of CSFSF that is being constructed in the exclusion zone, which suffered from radioactive contamination after Chornobyl accident, *Energoatom* developed PSAR with safety justification of dry storage of spent fuel in CSFSF.

CSFSF PSAR was subject to the state review of nuclear and radiation safety. The conclusion of the review was approved by Ordinance of the SNRIU Board No. 8 dated 03 November 2016 "On the Results of Nuclear and Radiation Safety State Review of Preliminary Safety Analysis Report of the Centralized Spent Fuel Storage Facility", which confirmed compliance of CSFSF safety level with requirements of regulations, rules and standards of nuclear and radiation safety.

On 29 June 2017, the State Nuclear Regulatory Inspectorate of Ukraine provided *Energoatom* with license No. EO 001060 for the right to perform activities on the lifecycle stages "construction and commissioning of the nuclear facility (Centralized Storage Facility for Spent Fuel of National NPPs with VVER (CSFSF)". The license is valid until the license to perform activities on the lifecycle stage "nuclear facility operation" is issued.

Within the design of ChNPP ISF-2, ISF-2 PSAR was developed, which received positive conclusion of the state review of nuclear and radiation safety.

The conclusion of the state review of nuclear and radiation safety regarding the construction design and safety justification documents of ChNPP ISF-2 showed that the selected technology of spent fuel storage is justified in the view of ensuring nuclear and radiation safety and complies with the interim spent fuel storage policy approved in Ukraine. The principles of ensuring nuclear and radiation safety used during the design development comply with national regulatory and legal documents and approaches to safety.

In the end of construction, confirmation shall be provided to confirm compliance of constructed SFSF safety level with design safety level. Intermediate SAR submitted to the SNRIU to receive a permit for commissioning within the license "construction and commissioning" of ISF-2 shall include this information, as well as safety justification of changes, amendments and revisions of the design performed at the stage of construction, precommissioning inspections and tests of SFSF. Further, final PSAR revised upon the results of commissioning shall be added by the applicant to the application for obtaining a license for SFSF operation. Regular expert assessment is performed at this stage.

In the reporting period, the SNRIU performed the state review of ChNPP ISF-2 PSAR that was revised and extended after completed construction of this facility and equipment mounting. The results of the state review confirmed compliance of ISF-2 with nuclear and radiation safety requirements and preparedness for activities on facility commissioning.

G.6. Operation of Facilities (Article 9)

Each Contracting Party shall take the appropriate steps to ensure that:
i) the licence to operate a spent fuel management facility is based upon appropriate

assessments as specified in Article 8 and is conditional on the completion of a commissioning programme demonstrating that the facility, as constructed, is consistent with design and safety requirements;
ii) operational limits and conditions derived from tests, operational experience and the assessments, as specified in Article 8, are defined and revised as necessary;
iii) operation, maintenance, monitoring, inspection and testing of a spent fuel management facility are conducted in accordance with established procedures;
iv) engineering and technical support in all safety-related fields are available throughout the operating lifetime of a spent fuel management facility;
v) incidents significant to safety are reported in a timely manner by the holder of the licence to the regulatory body;
vi) programmes to collect and analyse relevant operating experience are established and that the results are acted upon, where appropriate;
vii) decommissioning plans for a spent fuel management facility are prepared and updated, as necessary, using information obtained during the operating lifetime of that facility, and are reviewed by the regulatory body.

G.6.1. License to Operate Facilities

In the reporting period, the licensing procedure for operation of facilities has not changed (see Subsection G.6.1 of NRU-2014). The regulation "Safety Requirements for Nuclear Fuel Management" (SNRIU Order No. 269 dated 21 June 2019) came into force. As of 01 July 2020, the operating organizations took measures to implement NP 306.2.221-2019 "Safety Requirements for Nuclear Fuel Management".

G.6.2. Definition and Revision of Operational Limits and Conditions

Information on the definition and revision of operational limits and conditions for nuclear facilities is provided in Subsection G.6.2 of NRU-2003. According to the requirements of the "Basic Safety Provisions for Interim Dry Spent Fuel Storage Facilities", the design shall define operational limits and conditions to be revised by the operating organization with the periodicity established by the SNRIU.

Ukraine currently operates DSFSF for VVER-1000 fuel at the ZNPP and ISF-1 at ChNPP.

Safety review of ZNPP DSFSF was completed in 2016 and finalized in the "Periodic Safety Review Report for ZNPP Dry Spent Fuel Storage Facility". The report received a positive conclusion of state nuclear and radiation safety review and was approved by SNRIU.

The safety review showed the following:

Abnormal operation or emergencies were not revealed at DSFSF site during the reporting period.

The difference between the temperature of the air coming out of the ventilation channels and the environmental temperature for all vented storage containers did not reach 61 ^{o}C that is the normal operation limit specified in the SAR.

The exposure dose rate of gamma-radiation beyond the external fence of DSFSF site (at the distance of 50 meters) is at the level of the natural background typical for the region of ZNPP layout of 0.12 ÷ 0.13 μSv/h.

The correctness of the approach selected for storage of spent fuel was confirmed.

DSFSF has no negative impact on the environment and shows a high level of environmental safety.

In 2015, safety review of ISF-1 was performed taking into account the revised procedure for storage of damaged nuclear fuel in ISF-1 based on which the Safety Analysis Report of ISF-1 Spent Fuel Storage Facility (Rev. 3.02) was developed. This report received a positive conclusion of the state review of nuclear and radiation safety and the operating organization received a permit to place all spent (including damaged) nuclear fuel in ISF-1. In 2016, all spent fuel, including damaged nuclear fuel, was transferred to ISF-1.

G.6.3. Operating Procedures

Information on operating procedures for spent fuel storage facilities is provided in Subsection G.6.3 of NRU-2011.

G.6.4. Engineering and Technical Support in Operation

Information on engineering and technical support in operation of spent fuel storage facilities is provided in Subsection G.6.4 of NRU-2011.

The scientific engineering and technical support to operation of spent fuel management facilities is provided by the Scientific and Technical Center of the *Energoatom* in cooperation with the research institutions such as:

– National Science Center "Kharkiv Institute of Physics and Technology" of the National Academy of Sciences of Ukraine;

– State Research and Engineering Center of Control Systems and Emergency Response of the National Academy of Sciences of Ukraine;

– Nuclear Research Institute of the National Academy of Sciences of Ukraine;

– Frantsevich Institute for Problems of Materials Science of the National Academy of Sciences of Ukraine;

– Institute for Safety Problems of Nuclear Power Plants of National Academy of Sciences of Ukraine.

In particular, the first-priority areas of scientific, engineering, and technical support in spent fuel management are as follows:

– research of the behavior of fuel rod cladding during long-term storage in dry spent fuel storage facilities to justify the boundary permissible terms for safe dry storage of fuel rods;

– development of the Concept for management of spent fuel from national NPPs with the definition of strategic areas for spent fuel management until 2035 and for further future);

– improvement of existing and creation of the new regulatory framework and operating documents on handling operations with spent fuel at NPPs, ensuring conditions for safe storage of spent fuel in spent fuel pools and dry long-term storage facilities;

– enforcement of the document "State Economic Program for Management of Spent Nuclear Fuel from National Nuclear Power Plants until 2025". According to Resolution of the Cabinet of Ministers of Ukraine No. 385-r dated 05 June 2019 "On Approval of the Concept of the State Economic Program for Management of Spent Nuclear Fuel from National Nuclear Power Plants …";

– development of the regulatory document SOU NAEK 197-2020 "Radiological Characteristics and Residual Heat of Spent Fuel Assemblies of VVER-440";

– update of the regulatory framework, etc.;

– reactor tests and implementation of concretes with improved neutronic properties based on titanium hydride, produced according to the technology developed by the Institute for Problems of Materials Science (National Academy of Sciences of Ukraine) and tested at the Nuclear Research Institute for the use in nuclear energy (in particular, DSFSF containers).

The examples of cooperation between *Energoatom* and institutes of the National Academy of Sciences of Ukraine include the development of:

– prototype of facility for immediate burnup control of spent fuel from VVER-1000 that allows designing of the national facility for spent fuel burnup control with the characteristics exceeding foreign analogues;

– development of formulations and technology for immobilization of evaporator bottoms of Ukrainian NPPs with VVER; development of new neutron shielding material based on titanium hybrids and obtaining of two Ukrainian Patents No. 56381 "Neutron Shielding Titanium Hydride" and No. 56382 "High-Hydrogen Zirconium Hydride Neutron Moderator".

– development of liquid radwaste treatment formulas, etc.

G.6.5. Reporting of Safety-Significant Incidents to the Regulatory Body

Current regulatory document NP 306.2.100-2004 (Provisions) "Procedure for Investigation and Reporting of Operational Events at Nuclear Power Plants" established the following procedure for informing the regulatory body on incidents (operational events) related to drop and/or damage of fuel assemblies, fuel elements, absorber rods during handling operations with dry or spent fuel (P01, P02, P06 categories):

1. NPP shift supervisor or his official upon his order shall immediately inform the SNRIU duty officer and Head of On-Site State Nuclear Safety Inspectorate on an incident (operational event) via telephone immediately (P01, P02) or in one hour (P06) after detection of an incident (operational event).
2. Preliminary notification on an incident signed by NPP Chief Engineer and the Head of NPP On-Site State Nuclear Safety Inspectorate is transferred via telephone or Internet to the regulatory body and its department on safety analysis of nuclear facilities.
3. If needed, a supplementary (clarifying) notification signed by these persons is sent to the same address as the preliminary notification within five days.

Energoatom unconditionally fulfills these requirements.

Since the moment of accident occurrence and until the moment of completion of emergency measures, *Energoatom* and the State Nuclear Regulatory Inspectorate of Ukraine constantly cooperate. According to NP 306.2.100-2004 "Procedure for Investigation and Accounting of NPP Operational Events", shift supervisor or an official appointed by the shift supervisor immediately after the classification shall transfer the immediate notification on accident to the shift duty officer of the nuclear facility monitoring group for further transfer to the SNRIU.

The nuclear facility monitoring group working according to general schedule (day and night duty) was created by *Energoatom* Order No. 989 dated 22 November 2011 within the Emergency Technical Center to improve the emergency preparedness system considering SNRIU proposals on improvement of emergency preparedness service and crisis response in emergency situations and modes and to provide additional monitoring of nuclear facilities.

The main functions of this group are:

– interaction (information transfer and exchange) with the state authorities and other organizations responsible for making decisions and implementation of emergency response plans in crisis and emergency situations and accidents at nuclear facilities;

– monitoring of NPP parameters on a regular basis to define critical safety functions, check compliance with limits and conditions of reactor safe operation and preparedness of safety system trains;

– information support to departmental oversight services and appropriate services of the state governmental authorities related to functioning of equipment important to NPP safety and its specified parameters and states;

– participation in emergency exercises and training combined with application of all communication systems, equipment, involving personnel and using procedures for which this group is responsible;

– maintaining constant preparedness of the equipment and communication systems for operation in crisis and emergency modes, their testing and inspection including checking of communications with foreign partners established in compliance with the requirements of international conventions and treaties;

– keeping of computerized database in emergency centers of Ukraine and other countries.

Further interaction is carried out by:

– at NPP level: through the participation of a representative of the State Nuclear Regulatory Inspectorate of Ukraine in the work of NPP commission on emergencies (on-site leader of emergency activities) and information exchange of NPP emergency center with SNRIU emergency information center (EIA), including the use of NPP emergency center data transfer system and video conferencing;

– at *Energoatom* Directorate level – through the participation of a representative of the State Nuclear Regulatory Inspectorate of Ukraine in activities of *Energoatom* commission on emergencies, as well as information exchange of *Energoatom* emergency center with SNRIU emergency information center, including the data transfer system and video conferencing.

A space emergency communication system and a videoconferencing system have been created at *Energoatom* to provide the existing NPPs of Ukraine with reliable communication in case of emergency. A system for collection, transfer, receiving and processing of NPP process parameters has been developed and approved. *Energoatom* data transfer system ensures immediate transmission and real-time display of NPP process parameters, safety state of certain power units and NPPs in general, results of radiological monitoring on the site, in the control area and observation area.

At the same time, according to the technical specifications of information exchange of NPP emergency centers with SNRIU emergency information center, the data characterizing NPP state are continuously transferred to the workplace of the SNRIU representative at the NPP and to SNRIU EIA.

Information to SNRIU EIA is provided by *Energoatom* commission on emergencies and NPP commission on emergencies to ensure the completeness of information on the course of the accident, countermeasures, measures to protect personnel and the public taken at the NPP and at the level of *Energoatom* Directorate.

G.6.6. Analysis of Relevant Operating Experience

Information on analysis of relevant operating experience is provided in Subsection G.6.6 of NRU-2011.

G.6.7. Decommissioning Plans

Information on legislative requirements of Ukraine on decommissioning of nuclear facilities, such as spent fuel storage facilities, and on the development of decommissioning plans is provided in Subsection G.4.2 of this Report.

In 2013, ChNPP developed "ISF-1 Decommissioning Concept" and submitted it to the SNRIU for approval.

In addition, Section 13 "Decommissioning" of the Safety Analysis Report of ISF-1 Spent Fuel Storage Facility (Rev. 3.02) provides the description of the general ISF-1 decommissioning concept and considers several approaches to this facility decommissioning. The final decommissioning option will be selected in the final stage of ISF-1 operation.

G.7. Disposal of Spent Fuel

As stated in Subsection B.1 of this Report, the Energy Strategy of Ukraine Until 2035 (hereinafter called the Energy Strategy of Ukraine) approved by Resolution of the Cabinet of Ministers of Ukraine on 18 August 2017 under No. 605-r established the need to complete the construction of storage facilities for spent fuel and high-level radioactive waste of its processing. In addition, it is envisaged to implement the so-called deferred decision for spent fuel management, which includes long-term storage (50 years and more) and subsequent definition and approval of the final decision on spent fuel reprocessing or disposal.

According to para. 5 of the Decree of the President of Ukraine No. 141 dated 13 April 2016 "On Additional Measures for Transformation of the Shelter into an Environmentally Safe System and the Remediation of the Territories Exposed to Radioactive Contamination Resulting From Chornobyl Disaster" and Council Directive 2011/70/EURATOM dated 19 July 2011, the report "Concept for Spent Fuel Management of Ukrainian NPPs" was developed and submitted to the Ministry of Energy and Environmental Protection. The report provides preliminary results of comparative assessment of spent fuel management options, which include reprocessing of spent fuel or its disposal in geological formations. Spent fuel management infrastructure available in Ukraine was considered. The comparative assessment of nuclear fuel cycle options was performed for short-term (until 2035) and long-term (until 2100) development scenarios. It was confirmed that upon the results of analysis, spent fuel storage in dry long-term storage facilities with further disposal in geological formations is an appropriate option in long-term perspective until 2100.

According to Task 3 of the National Target Ecological Program for Radioactive Waste Management, a facility for long-term storage of high-level waste generated from reprocessing of spent fuel from Ukrainian NPPs in the Russian Federation is being constructed on Vektor site.

There are plans to create a geological repository for final disposal of high-level and long-lived waste, including waste resulting from spent fuel reprocessing, in accordance with the Strategy for Radioactive Waste Management in Ukraine.

Section H. SAFETY OF RADIOACTIVE WASTE MANAGEMENT

H.1. General Safety Requirements (Article 11)

Each Contracting Party shall take the appropriate steps to ensure that at all stages of radioactive waste management individuals, society and the environment are adequately protected against radiological and other hazards.
In so doing, each Contracting Party shall take the appropriate steps to:
i) ensure that criticality and removal of residual heat generated during radioactive waste management are adequately addressed;
ii) ensure that the generation of radioactive waste is kept to the minimum practicable;
iii) take into account interdependencies among the different steps in radioactive waste management;
iv) provide for effective protection of individuals, society and the environment, by applying at the national level suitable protective methods as approved by the regulatory body, in the framework of its national legislation which has due regard to internationally endorsed criteria and standards;
v) take into account the biological, chemical and other hazards that may be associated with radioactive waste management;
vi) strive to avoid actions that impose reasonably predictable impacts on future generations greater than those permitted for the current generation;
vii) aim to avoid imposing undue burdens on future generations.

General safety requirements for all stages of radwaste management are established in legislative and regulatory documents identified in Subsection H.1 of NRU-2008.

Annex 6 to this Report presents the list of regulations.

The licensees' compliance with safety requirements is confirmed by safety assessments of radwaste management facilities and radwaste management activities and analysis of annual reports on compliance with radiation safety requirements during operation and state oversight.

According to the regulatory requirements, the licensee conducts periodic safety reassessment taking into account experience in activities.

H.1.1. Criticality and Removal of Residual Heat

The information on the measures taken to provide subcriticality and removal of residual heat occurred during radwaste management is presented in NRU -2017.

The design of the storage facility for vitrified HLW at the *Vektor* envisages input natural ventilation system. If the allowable temperature inside storage facility sections is exceeded or if air speed in ventilation channels is reduced below the established limit, forced ventilation shall be connected.

During the development of technical specifications for the ventilation system of the storage module, the thermal regime in emergencies will be additionally analyzed, in particular, to determine the limit values of control parameters at which forced ventilation shall be activated.

The design documents provide a computer analysis of thermal regimes in sections and cells with HLW packages and an analysis of criticality during storage of HLW packages.

The computer analysis of subcriticality during storage of HLW packages is expected to be performed at the stage of working design.

H.1.2. Minimization of Radioactive Waste Generation

Basic provisions of legislation to minimize radioactive waste generation are presented in Subsection H.1.2 of NRU-2011.

In practice, this is implemented by taking measures to minimize radwaste.

The *Energoatom* Comprehensive Program for Radioactive Waste Management is a fundamental document of the operating organization on radioactive waste management specifying the main activities, technical and organizational measures on radioactive waste management, particularly: minimization of radioactive waste generation, improvement of NPP radioactive waste management systems, improvement of handling operations for radwaste packages etc.

Implementation of Comprehensive Program measures is a condition of licenses for the operation of power units. Reports on implementing these measures shall be submitted to the SNRIU and the Ministry of Energy every six months.

To minimize liquid radwaste, NPPs annually analyze the sources and amounts of floor drains and liquid radwaste. Based on analysis, NPPs developed and implement measures to minimize liquid radwaste, including: elimination of leakages in spent fuel pools, change in regeneration of filters for active water treatment facilities, separation of liquid flows, application of modern decontamination technologies for equipment, rooms and individual protection means, monitoring and account of floor drains from NPP compartments etc.

An important aspect in management of solid radwaste is to implement waste minimization measures. These measures (definition of limits for radwaste generation, introduction of thermal insulation reuse, limited introduction of packaging materials to the controlled area, separate collection and disposal of clean and contaminated chips etc.) allowed quite high tendencies to decrease in low-level waste flows transferred to storage facilities on NPP sites.

At each NPP, including ChNPP, the reference levels for generation and transfer of liquid and solid radwaste to NPP storage facilities are developed and approved. They are periodically revised (every three years) depending on the actual levels of radwaste generation resulting from the implementation of radioactive waste minimization measures.

The administrative and technical measures taken at NPP have resulted in a clear tendency toward decrease in the annual generation and accumulation of radwaste.

Reference levels for generation and transfer of solid and liquid radwaste to plant storages have been developed and approved at each NPP, including the Chornobyl NPP. These levels are periodically revised to consider their decrease depending on the actual amounts of radwaste generation due to measures aimed at minimizing radioactive waste generation at *Energoatom* plants and ChNPP. In 2016, NPPs introduced new “Reference Levels for Radioactive Waste Generation and Transfer to Storage Facilities”.

The ChNPP administrative and technical measures to minimize radwaste generation to the extent possible include:

- decontamination of dismounted contaminated equipment;
- release of radioactive materials as equipment fragments and metal structures from regulatory control;
- operation of the site for temporary storage of process materials that are generated in Shelter transformation into an environmentally safe system and may be reused in construction.

Decontamination of equipment fragments and metal structures from carbon steel, stainless steel and nonferrous metal as parts of generator turbines, piping and transformer

winding, circuits of heating systems, and metal structures of post-emergency armor cars is performed by chemical and hydraulic methods (using high-pressure apparatus).

Currently, a facility for release of materials from regulatory control after their decontamination is being created at ChNPP (see Section B 4.2).

To reduce radwaste amount, RADON takes measures to prevent the spread of radioactive contamination during activities with radwaste through detailed work planning, measures to protect work site, radwaste sorting, and preventing the generation of secondary radwaste.

The effectiveness of this was confirmed during radwaste removal from RWDS Pisky-1.

The total amount of radwaste to be removed and redisposed was approximately 300 cubic meters.

To implement the project, a Technical Solution for activities was first developed. According to the developed Technical Solution, the first stage of site remediation was its detailed characterization. These activities were performed by Kyiv SISP in the summer of 2018 and included: a detailed radiological inspection of decontamination waste disposal site (DWDS) surface, drilling and research of additional wells around the perimeter and in the body of DWDS, inspection of DWDS surface using a gamma visor, clarifying DWDS internal structure through georadar surveys.

To identify and localize “hot spots” with increased exposure dose rate of gamma radiation at DWDS, the site was inspected using a portable gamma visor Canberra iPIX. To identify possible presence of individual large objects (concrete beams, large metal objects, etc.) and to confirm physical boundaries of DWDS territory, soil structure was inspected by georadar MALA GS Ground Explorer and territory was scanned by metal detector Lorenz DEEPMAX Z1.

Radwaste minimization during removal and transfer was provided by sorting and characterization under continuous radiation dose monitoring. Radwaste removed from DWDS and placed in so-called “big bags” was characterized using a scintillation gamma spectrometer Canberra Inspector 1000 by determining a specific activity of ^{137}Cs for each big bag. After that, correlation calculations of a specific activity of ^{90}Sr, ^{241}Am, ^{238}Pu, ^{239}Pu, ^{240}Pu, and ^{241}Pu were performed using the relation established in the Technical Solution between the specific activity of these radionuclides and specific activity of ^{137}Cs.

Upon the results of spectrometric measurements, 17 big bags with a total mass of 11.4 tons (volume of 6.6 cubic meters) and a total activity of $1.71 \cdot 10^8$ Bq met the criteria of radwaste acceptance for disposal in RWDS Buryakivka, which was only 2.2% of the expected radwaste volume of 300 cubic meters.

The specific activity of ^{137}Cs in decontamination waste in the rest of the big bags did not exceed 1000 Bq/kg (the release criterion established in the Technical Solution). These bags with relatively pure material were poured into a pit of the former DWDS (623 bags with a total mass of 432 tons). After soil backfilling and improvement of DWDS territory, exposure dose rate of gamma radiation on the site surface was 0.09 - 0.16 μSv/h, which is lower than the average background values for this area.

The information on radwaste removal from RWDS Pisky-1 is also presented in Section B 4.4 of this Report.

The following methods were implemented in NRI for radwaste minimization:

- application of up-to-date methods for decontamination of reactor equipment and tools contaminated with radionuclides taking into account radionuclide content of equipment in the places of waste generation;

- analysis of generation sources, assessment and prediction of radwaste generation dynamics, determination of localization sites, amount, content and other characteristics of radwaste generation sources;
- analysis of maintenance activities at VVR-M nuclear research reactor and studies that may result in radwaste generation;
- separation of radioactive waste from non-radioactive waste during operational activities and research at the reactor, sorting, optimization of packages for transport.

H.1.3. Interdependencies among Different Steps of Radioactive Waste Management

Requirements on interdependencies among different steps in radwaste management are determined in a number of regulations. The main regulations are indicated in Section H.1.3 of NRU-2008. Annex 6 to this Report presents current regulations in radwaste and spent fuel management.

Strategic areas and practical measures for interdependencies among different steps of radwaste management are described in Subsections B.3, B.4.1 - B.4.4 of this Report. The main measures include creation and implementation of an integral infrastructure of radioactive waste management in Ukraine.

The main area of the technical policy for radioactive waste management of *Energoatom* is to develop the modern radioactive waste management infrastructure to ensure interdependency of all radwaste management stages from collection to transfer for disposal, namely:

- safe collection and primary processing of radioactive waste to a state acceptable for temporary storage in storage facilities and at NPP sites;
- processing of radioactive waste in order to obtain the final product that can be transported for long-term storage and disposal.

The ChNPP developed and operates the Radioactive Waste Management Program at Chornobyl NPP site. The objective of this program is to develop and maintain an integrated optimized system for radioactive waste management at ChNPP taking into account the existing radwaste management facilities and the ones to be constructed at ChNPP and in the exclusion zone. The integrated system for radioactive waste management at ChNPP will ensure management of all radioactive waste flows at ChNPP, both accumulated during operation and generated during the mitigation of the consequences of ChNPP disaster, and flows that will be generated during decommissioning and activities at the Shelter.

H.1.4. Effective Protection of Individuals, Society and the Environment

The radiation protection system for personnel, the public and the environment and radiation protection measures taken in Ukraine for radwaste management are described in Section F.4 of this Report.

H.1.5. Biological, Chemical and Other Risks

The information provided in NRU-2017 has not changed.

H.1.6. Avoiding Reasonably Predictable Impacts on Future Generations Greater Than Those for Current Generation

According to the main principles of state policy for nuclear energy use identified in Article 5 of the Law of Ukraine “On Nuclear Energy Use and Radiation Safety”, no activity in the area of nuclear energy use may bring greater detriment to future generations than that accepted for the present generation.

The practical implementation of this principle is reflected in the safety analysis reports for radwaste processing facilities. SAR objective is to justify that during operation of the radwaste processing facility and during its decommissioning, the level of radiation safety for personnel, the public and the environment will be ensured not lower than that provided by regulations, standards and rules for nuclear and radiation safety.

H.1.7. Avoiding Undue Burdens on Future Generations

According to the main principles of state policy for nuclear energy use identified in Article 5 of the Law of Ukraine "On Nuclear Energy Use and Radiation Safety", no activity in the area of nuclear energy use may bring greater detriment to future generations than that accepted for the present generation.

Regarding radwaste processing and storage facilities, regulations require that projects of future decommissioning be developed in the design stage to be periodically revised to incorporate advanced technologies and means.

In order to decrease financial burdens on future generations, a financial mechanism should function for the State Fund for Radioactive Waste Management, according to which radwaste generators pay appropriate taxes during their activities to contribute to the development of an appropriate infrastructure for radwaste management. Financial provisions for radwaste management are considered in detail in Subsections F 2.2 and F 2.3 of this Report.

H.2. Existing Facilities and Past Practices (Article 12)

Each Contracting Party shall in due course take the appropriate steps to review:
i) the safety of any radioactive waste management facility existing at the time the Convention enters into force for that Contracting Party and to ensure that, if necessary, all reasonably practicable improvements are made to upgrade the safety of such a facility;
ii) the results of past practices in order to determine whether any intervention is needed for reasons of radiation protection bearing in mind that the reduction in detriment resulting from the reduction in dose should be sufficient to justify the harm and the costs, including the social costs, of the intervention.

A list of the existing radwaste management facilities as of 1 July 2020 is presented in Annex 3 to this Report. Information on operation of the existing radwaste management facilities is provided in Section B.4.

A list of radwaste resulting from past practices is provided in Annex 4 of this Report.

H.2.1. Safety of Existing Facilities

The safety of existing radwaste management facilities is ensured and monitored in compliance with technical specifications and procedures for operation and maintenance, procedures for radiation monitoring, emergency response plans and quality assurance procedures.

All facilities are designed to be equipped with radiation monitoring systems, and observation boreholes to monitor underground and ground waters are arranged around the radwaste facilities. Radiation performance indicators of facilities and the environment are monitored with the periodicity and are compared with the established reference levels.

Personnel are provided with adequate individual protection means and are subject to individual dose monitoring.

All radwaste management facilities are also equipped with engineered safety features such as systems for fire alarm and fire-fighting, ventilation and air purification, active drainage, moisture detection and removal, leakage and water level monitoring (for liquid radwaste storage facilities), redundant tanks, etc. The radwaste treatment facilities include systems for control and monitoring of radwaste treatment processes.

In compliance with the "Requirements for Periodicity and Contents of Reports Submitted by the Licensees in Nuclear Energy Use", the licensees provide the regulatory body with quarterly and annual reports on radiation safety of radwaste management facilities, which contain data on results of individual dose and radiation monitoring, compliance with reference levels, analysis of incompliance with reference levels and safety improvement measures.

The annual reports of the licensees and annual inventory of radwaste indicate that the existing radwaste management system is satisfactory. There were no deviations in the performance of protection systems of radwaste management facilities in the reporting period. The radwaste management conditions comply with regulatory requirements on safety. There are no leakages of radwaste into soil or radwaste loss in transport and storage.

All amendments in design and operating documentation, upgrading, modernization and major repairs that may affect safety are subject to state review on nuclear and radiation safety.

H.2.2. Past Practices

Legacy radwaste in Ukraine includes the following:

- radwaste disposed in Soviet times at RADON facilities;
- radwaste resulting from the Chornobyl accident and placed at RWDS, RICS and VTS/SSR;
- radwaste resulting from military programs of the former USSR.

Information on this radwaste is provided in Subsections 4.5 and 4.6 of Annex 4 to this Report.

Information on current activities related to radwaste storage/disposal facilities is provided in Subsections B.4.3 and B. 4.4 of this Report.

According to the Strategy for Radioactive Management in Ukraine, measures are implemented to ensure safety of these facilities, including their safety assurance, safety reassessment, planning of further remediation and closure.

The information on safety review measures for RWDS, RICS in the exclusion zone was presented in NRU-2017.

Safety Reassessment of SISP Radwaste Storage Facilities

Within activities to provide safe management of radioactive waste, since July 2018, the European Union Project U4.01/14C "Comprehensive Safety Assessment of Radioactive Waste Management Sites operated by *Radon* and Planning Remediation of Certain Sites" is being implemented. The overall objective of the project is to perform comprehensive safety assessments for five RADON sites; transfer the permanent ability to perform safety assessments to RADON and develop measures for remediation of "problem" storage facilities (except for well-type storage facilities) located at these five sites.

During project implementation in 2019-2020, an international consultant developed the "Standard Solution for Radwaste Retrieval and Remediation of RADON Kyiv SISP Storage Sites No. 5, 6, 7" and "Safety Assessment of SRW Storage Facility No. 5 of RADON Kyiv SISP". Deadline for completion of activities: July 2021.

To implement a full conversion, first of all, it is necessary to retrieve legacy radwaste from its current location in near-surface storage facilities, which were filled by 1996 using the disposal technology. Now RADON experts in cooperation with international experts are developing technical solutions to retrieve radioactive waste from the most problematic storage facilities. Thus, the main efforts and priority attention were paid to the retrieval of radioactive waste from storage facilities No. 5, 6, 7 CPS, since they are located within the capital of Ukraine. The proposed technical solutions to retrieve the mentioned radwaste provide their preliminary sorting and placement in protective containers. This will ensure their further safe storage before processing, long-term storage or disposal at *Vektor* facilities.

Remediation of Radioactive Waste Storage Sites

Within the international technical assistance project of the European Union U4.01/12D "Remediation of Radioactive Waste Storage Sites formed after the Chornobyl Accident outside the Exclusion Zone", DWDS *Pisky-1* located near Pisky village in the Ivankiv region of the Kyiv oblast was selected as a pilot facility for remediation. The information on the activities performed is presented in detail in Subsection B 4.4 of this Report.

Remediation of Tsybuleve Disposal Facility Resulting from Military Programs of Former USSR

On the territory of Ukraine, there are several legacy facilities (storage facilities) of the 1970s-1980s. They contain radioactive waste resulting from military programs of the former USSR. The transfer of these legacy storage facilities to the ecologically safe state (remediation) by removal and further management of radioactive waste is envisaged by Task 12 of the National Targeted Environmental Program for Radioactive Waste Management.

In order to support implementing this task, the Cabinet of Ministers of Ukraine has concluded an Implementing Agreement with the NATO Support Agency for Management of Radioactive Waste resulting from implementing military programs of the former USSR.

At the end of April 2020, in the framework of this agreement, LLC NT-ENGINEERING carried out activities on radwaste retrieval from the *Tsybuleve* radwaste storage facility and transported this radwaste to a specially equipped site in the exclusion zone for temporary storage.

Figure 24. Radwaste Retrieval from Tsybuleve Facility

Figure 25. Tsybuleve Site after Remediation

After radwaste retrieval from the *Tsybuleve* storage facility, a dosimetric survey of the site and access road was carried out. It showed that the dose rate of gamma radiation, flux density of alpha-, beta-particles and neutrons on the surface of the working areas meet remediation criteria and are within background values. In relevant samples of soil formed during excavation of a storage facility pit, content of the main radionuclides also meet background levels. Site remediation was completed on its territory: the pit was filled up, trees were planted.

Figure 26. Storage at Specially Equipped RWDS Buryakivka

H.3. Siting of Proposed Facilities (Article 13)

1. Each Contracting Party shall take the appropriate steps to ensure that procedures are established and implemented for a proposed radioactive waste management facility:
i) to evaluate all relevant site-related factors likely to affect the safety of such a facility during its operating lifetime as well as that of a disposal facility after closure;
ii) to evaluate the likely safety impact of such a facility on individuals, society and the environment, taking into account possible evolution of the site conditions of disposal facilities after closure;
iii) to make information on the safety of such a facility available to members of the public;
iv) consult Contracting Parties in the vicinity of such a facility, insofar as they are likely to be affected by that facility, and provide them, upon their request, with general data relating to the facility to enable them to evaluate the likely safety impact of the facility upon their territory.
2. In so doing, each Contracting Party shall take the appropriate steps to ensure that such facilities shall not have unacceptable effects on other Contracting Parties by being sited in accordance with the general safety requirements of Article 11.

The information presented in NRU–2017 remains unchanged.

H.4. Design and Construction of Facilities (Article 14)

Each Contracting Party shall take the appropriate steps to ensure that:
i) the design and construction of a radioactive waste management facility provide for suitable measures to limit possible radiological impacts on individuals, society and the environment, including those from discharges or uncontrolled releases;
ii) at the design stage, conceptual plans and, as necessary, technical provisions for the decommissioning of a radioactive waste management facility other than a disposal facility are taken into account;
iii) at the design stage, technical provisions for the closure of a disposal facility are prepared;
iv) the technologies incorporated in the design and construction of a radioactive waste management facility are supported by experience, testing or analysis.

According to Article 24 of the Law of Ukraine "On Radioactive Waste Management", radwaste management facilities are designed in compliance with current standards and regulations using technologies proven by experience, testing or analysis. The design of a radwaste disposal facility must rely on safety assessment for the operational period and long-term post-closure period.

Compliance of the design decisions on a radwaste management facility with standards and rules on radiation safety is assessed during the state review of such designs.

Designing New Radioactive Waste Management Facilities

In order to further develop the radwaste management system, in accordance with the requirements of the Strategy for Radioactive Waste Management in Ukraine and the National Targeted Environmental Program on Radioactive Waste Management, facilities for long-term radioactive waste storage and radioactive waste treatment facility at the *Vektor* site are designed, in particular:

- long-term storage facility for vitrified HLW resulting from VVER-440 spent fuel reprocessing that will be transferred from the Russian Federation;

- facilities for long-term storage of high-level waste and facility for long-term storage of long-lived waste. Generation of high-level and long-lived radwaste to be stored at these storage facilities, is expected during the removal of radwaste and fuel-containing materials from the Shelter and RWDS *Pidlisnyi*, during ChNPP decommissioning, during operation of existing NPPs;

- process building for centralized processing of radwaste of small producers and radwaste flows. Designing is carried out within industrial project INSC U4.01/11A. The process building envisages implementing radwaste management technologies, which provide: radwaste acceptance, sorting and fragmentation; incineration; compaction; processing of secondary radwaste; cementing; radwaste placement in containers; certification.

Facilities for long-term storage at the *Vektor* site will ensure centralized long-term storage (100 years) of relevant radwaste types prior to its disposal in a geological repository.

Currently, the following was done for construction of a facility for storage of vitrified HLW resulting from VVER-440 spent fuel reprocessing:

- feasibility study was developed for "Construction of the interim spent fuel storage facility for vitrified high-level waste (HLW) returned from the Russian Federation after reprocessing of spent fuel from Ukrainian NPPs", which has undergone the state review and was approved by Order of the State Agency of Ukraine on Exclusion Zone Management No. 81 dated 01 July 2016;
- project "Construction of the interim spent fuel storage facility for vitrified high-level waste (HLW) returned from the Russian Federation after reprocessing of spent fuel from Ukrainian NPPs" was corrected;
- state review for the design of the facility for storage of vitrified HLW resulting from VVER-440 spent fuel reprocessing (stage P) was conducted.

The following activities were performed for construction of the storage facility and objects of its infrastructure:

- engineering-geodetic and engineering-geological surveys for construction;
- processing of satellite geodetic observations to construct a railway track;
- radiation survey of the Substation and Railway Track objects;
- assessment of the impact of scheduled activities on the environment.

Facilities for long-term storage at the *Vektor* will ensure centralized long-term storage (100 years) of relevant radwaste types prior to its disposal in a geological repository.

During previous years, under support of the European Commission, within consideration of the tasks on forming additional capacities for disposal of low- and intermediate-level radioactive waste, calculations were performed to assess safety of RWDS *Buryakivka* after its reconstruction by constructing 6 additional inter-trench radioactive waste storage facilities. Safety assessment was conducted under international project INSC - U4.01/08 B "Improvement of the Infrastructure for Radioactive Waste Management in the Chornobyl Exclusion Zone" and was used in implementing project U4.01/10C + D + F "Support of Radioactive Waste Management in Ukraine".

The main conclusions on RWDS safety assessment are presented in the report developed by the executor of project U4.01/10C + D + F PLEJADES Independent Experts taking into account the results of the DBE Technology report under project U4.01/08-B on the safety analysis of RWDS *Buryakivka* after its reconstruction.

The report proved that in comparison with existing RWDS *Buryakivka*, possible expansion due to new trenches will not significantly affect the results of long-term safety assessment of the facility, since in the future it is planned to dispose mainly low- and intermediate-level radioactive waste.

In 2019, project "Reconstruction of RWDS *Buryakivka* in the exclusion zone of the Ivankiv region, Kyiv oblast" was developed with the aim of further expansion of RWDS *Buryakivka* capacities. Based on the results of the state review on NRS, a positive conclusion was prepared.

The reconstruction project provides construction of 6 additional inter-trench radwaste disposal facilities in the space between two existing disposal storage facilities, which are filled and closed.

The information on design and construction of NPP radwaste treatment plants is presented in Subsection B.4.2 of this Report.

H.5. Assessment of Safety of Facilities (Article 15)

Each Contracting Party shall take the appropriate steps to ensure that:
i) before construction of a radioactive waste management facility, a systematic safety assessment and an environmental assessment appropriate to the hazard presented by the facility and covering its operating lifetime shall be carried out;
ii) in addition, before construction of a disposal facility, a systematic safety assessment and an environmental assessment for the period following closure shall be carried out and the results evaluated against the criteria established by the regulatory body;
iii) before the operation of a radioactive waste management facility, updated and detailed versions of the safety assessment and of the environmental assessment shall be prepared when deemed necessary to complement the assessments referred to in paragraph (i).

Safety assessment of a radwaste management facility is finalized into a safety analysis report (SAR). Requirements for the SAR structure and contents are established in relevant regulations. SARs are developed and gradually updated at all life stages of facilities: from siting and design to decommissioning and closure.

The SAR for a radwaste disposal facility for the post-operational period is revised to incorporate operating experience and data of environmental monitoring and to include additional safety justification for the post-closure period.

Assessment of long-term safety of a radwaste disposal facility includes estimates of radiological impact of the disposal facility on human and the environment for different scenarios and comparison of these estimates with established safety criteria.

In accordance with the current regulations on licensing procedure, safety analysis reports were developed for NPP radwaste management facilities, in which safety of their operation was assessed.

In the framework of developing design documentation "Construction of Interim Storage Facility for High-Level Waste Returned from the Russian Federation after Reprocessing of Spent Fuel of VVER-440 Ukrainian NPPs", SAR was developed for the construction of this facility.

For LRTP and ICSRM designed for radwaste treatment at the ChNPP site, the final SARs were developed taking into account commissioning activities (cold and hot tests).

For CLTSF on the *Vektor* site, the final SAR will be developed taking into account commissioning activities.

H.6. Operation of Facilities (Article 16)

Each Contracting Party shall take the appropriate steps to ensure that:
i) the licence to operate a radioactive waste management facility is based upon appropriate assessments as specified in Article 15 and is conditional on the completion of a commissioning programme demonstrating that the facility, as constructed, is consistent with design and safety requirements;
ii) operational limits and conditions, derived from tests, operational experience and the assessments as specified in Article 15 are defined and revised as necessary;
iii) operation, maintenance, monitoring, inspection and testing of a radioactive waste management facility are conducted in accordance with established procedures. For a disposal facility the results thus obtained shall be used to verify and to review the validity of assumptions made and to update the assessments as specified in Article 15 for the period after closure;
iv) engineering and technical support in all safety-related fields are available throughout the operating lifetime of a radioactive waste management facility;
v) procedures for characterization and segregation of radioactive waste are applied;
vi) incidents significant to safety are reported in a timely manner by the holder of the licence to the regulatory body;
vii) incidents significant to safety are reported in a timely manner by the holder of the licence to the regulatory body;
viii) decommissioning plans for a radioactive waste management facility other than a disposal facility are prepared and updated, as necessary, using information obtained during the operating lifetime of that facility, and are reviewed by the regulatory body;
ix) plans for the closure of a disposal facility are prepared and updated, as necessary, using information obtained during the operating lifetime of that facility and are reviewed by the regulatory body.

H.6.1 License to Operate Radioactive Waste Management Facilities

Information on the licensing system for spent fuel and radioactive waste management is provided in Subsection E 2.2 of this Report.

H.6.2 Definition and Revision of Operational Limits and Conditions

The SAR on the radwaste management facility and technical specifications for operation include a detailed list of activities related to operation of a facility depending on its purpose, waste acceptance, internal transport, treatment processes, procedure for radwaste placement for storage or disposal, radwaste accounting, decontamination of equipment and tools for radwaste management, acceptance inspection of radwaste packages (for treatment facilities). The SAR also justifies operational limits and conditions for process systems and equipment, radiation monitoring systems and systems of storage or disposal barriers. Taking into account commissioning activities, operational experience or experience in facility safety reassessment, decisions may be taken to improve safety of the facilities by correction of operational limits and conditions, modifications and reconstructions. The documents on changes in operational limits and conditions, modification, reconstruction, and major repair are subject to the state review on nuclear and radiation safety.

H.6.3 Operating and Maintenance Procedures

In the framework of its quality system, the licensee develops technical specifications and provisions needed to support processes, maintenance operations, radiation monitoring and emergency measures.

Technical assistance for the activities of the Ukrainian NPPs in radwaste management is provided by:

- *Energoatom* Scientific and Technical Center;
- NPP Operation Support Institute of the National Academy of Sciences of Ukraine;
- State Research Center of Control Systems and Emergency Response.

Within the international technical assistance in the framework of INSC projects, support is provided in designing, developing systems and equipment for radwaste management facilities taking into account the best international practice.

In the reporting period, in the framework of the Instrument for Nuclear Safety Cooperation (INSC) funded by the European Commission, the implementation of the following technical assistance projects for *Energoatom* on radwaste management was completed:

- U4.01/10 B+E "Improvement of radioactive waste characterization systems at operating NPPs" and "Procedures and methodology to release materials from regulatory control";
- U1.04/10 C+D+E "Optimization of the national infrastructure for transport and processing in radioactive waste management in Ukraine".

Now another project is being implemented: U4.01 / 14 A "Determination of waste forms ensuring safe processing, storage and disposal of radioactive waste stored at Ukrainian nuclear power plants". Project implementation period is 1 November 2018 – 31 October 2021.

Ukraine is actively involved in implementing research, interregional, regional and national projects under the IAEA Technical Cooperation Program. In addition, Ukraine participates in international forums and initiatives such as the International Framework for Nuclear Energy Cooperation (IFNEC), Nuclear Energy Agency of the Organization for Economic Cooperation and Development (NEA OECD) and World Nuclear Association (WNA) to discuss the issues of cooperation in the area of management, processing, placement of geological repositories and disposal of radioactive waste, experience exchange and innovations.

H.6.5 Radioactive Waste Characterization and Sorting Procedures

Radwaste management facilities constructed on the sites of operating NPPs and Chornobyl NPP (see Subsections B 4.1, 4.2) are designed to be equipped with radwaste sorting and characterization systems using modern dosimetric and spectrometric instrumentation. Therefore, radwaste characteristics important for disposal will be determined: radionuclide composition and specific activity of each radionuclide. Sorting will take into account radwaste acceptance for the appropriate option of further treatment – incineration, compaction and cementation.

Characterization and sorting of radioactive waste in the reporting period was performed in accordance with the OSPU and operational and technical documents, which are in force at ChNPP.

The radwaste sorting and characterization systems using up-to-date dosimetric and spectrometric measuring equipment are provided in the designs of LRTP and ICSRM intended for radwaste management at the ChNPP site. This ensures determination of

radwaste characteristics important in terms of radwaste disposal, namely radionuclide content, specific activity of each radionuclide. Moreover, sorting is supposed to be performed taking into account radwaste suitability for relevant method of further processing: incineration, compaction, and cementing.

Considering characteristics of liquid radwaste to be treated at LRTP, the ChNPP developed the compositions for cementing liquid radwaste so that the LRTP final product complies with acceptance criteria for disposal in ENSDF.

During commissioning of the retrieval facility and solid radwaste treatment plant within ChNPP ICSRM, additional tests of the radwaste sorting system are performed. The specific features of the sorting system are associated with the characteristics of radwaste accumulated at the ChNPP, one part of waste generated from operation and the other from the Chornobyl accident. This radwaste has different radionuclide composition, which was not determined during waste loading into the ChNPP SRSF because appropriate equipment was missing at that time (to 2003).

The radwaste sorting and characterization systems using up-to-date dosimetric and spectrometric measuring equipment are provided in the designs of radwaste management facilities for the sites of operating NPPs (see Subsections B 4.1, 4.2). This ensures determination of radwaste characteristics important in terms of radwaste disposal, namely radionuclide content, specific activity of each radionuclide. Moreover, sorting is supposed to be performed taking into account radwaste suitability for relevant method of further processing: incineration, compaction, and cementing.

CLTSF on the *Vektor* site provides for identification and sorting of radwaste as disused radiation sources and their placement in containers according to the type of radiation and half-life and further storage of containers with radiation sources of different types in separate storage compartments, marking of containers according to radionuclide half-life in order to optimize management of this radwaste after retrieval of packages from the storage facility after completion of the storage period.

H. 6.6 Reporting of Incidents Significant to Safety to the Regulatory Body

Detailed information is presented in NRU – 2017.

In the reporting period, there were no incidents or accidents in radwaste management activities.

H.7 Institutional Measures after Closure (Article 17)

There are no radwaste disposal facilities in Ukraine that would pass the closure stage.

Detailed information on institutional measures after closure is presented in NRU-2017.

Section I. TRANSBOUNDARY MOVEMENT (Article 27)

1. Each Contracting Party involved in transboundary movement shall take the appropriate steps to ensure that such movement is undertaken in a manner consistent with the provisions of this Convention and relevant binding international instruments.

In so doing:

i) a Contracting Party which is a State of origin shall take the appropriate steps to ensure that transboundary movement is authorized and takes place only with the prior notification and consent of the State of destination;

ii) transboundary movement through States of transit shall be subject to those international obligations which are relevant to the particular modes of transport utilized;

iii) a Contracting Party which is a State of destination shall consent to a transboundary movement only if it has the administrative and technical capacity, as well as the regulatory structure, needed to manage the spent fuel or the radioactive waste in a manner consistent with this Convention;

iv) a Contracting Party which is a State of origin shall authorize a transboundary movement only if it can satisfy itself in accordance with the consent of the State of destination that the requirements of subparagraph (iii) are met prior to transboundary movement;

v) a Contracting Party which is a State of origin shall take the appropriate steps to permit re-entry into its territory, if a transboundary movement is not or cannot be completed in conformity with this Article, unless an alternative safe arrangement can be made.

2. A Contracting Party shall not licence the shipment of its spent fuel or radioactive waste to a destination south of latitude 60 degrees South for storage or disposal.

3. Nothing in this Convention prejudices or affects:

i) the exercise, by ships and aircraft of all States, of maritime, river and air navigation rights and freedoms, as provided for in international law;

ii) rights of a Contracting Party to which radioactive waste is exported for processing to return, or provide for the return of, the radioactive waste and other products after treatment to the State of origin;

iii) the right of a Contracting Party to export its spent fuel for reprocessing;

iv) rights of a Contracting Party to which spent fuel is exported for reprocessing to return, or provide for the return of, radioactive waste and other products resulting from reprocessing operations to the State of origin.

Ukraine does not undertake nor is involved in transboundary movement of radwaste.

Transboundary movement of spent fuel takes place from Ukrainian NPPs to the Russian Federation in compliance with the Agreement between the Governments of Ukraine and the Russian Federation on Cooperation in Radioactive Material Transport of 1996.

Ukraine does not send spent fuel for storage or disposal to the south of latitude 60 (para. 2 in Article 27 of the Joint Convention).

To comply with para. 1(i) in Article 27 of the Joint Convention, the SNRIU uses an authorization procedure for each spent fuel movement according to the Procedure for Authorization of International Transport of Radioactive Material.

As one of the conditions to obtain an authorization, the Russian consignee (operator) shall have a permit for spent fuel import issued by the authorized state body of the Russian Federation to confirm the consent of the State of destination. Preliminary notification on transboundary movement takes place according to a contract under which the Ukrainian

operator shall notify the Russian operator no later than seven days before spent fuel departure.

Section J. DISUSED SEALED SOURCES (Article 28)

1. Each Contracting Party shall, in the framework of its national law, take the appropriate steps to ensure that the possession, remanufacturing or disposal of disused sealed sources takes place in a safe manner.
2. A Contracting Party shall allow for reentry into its territory of disused sealed sources, if, in the framework of its national law, it has accepted that they be returned to a manufacturer qualified to receive and possess the disused sealed sources.

The main amount of disused radiation sources is placed in the facilities of the RADON ASSOCIATION for safe and secure storage. Information on the RADON ASSOCIATION plans and measures to ensure and improve the operational safety of facilities for storage of radioactive waste and disused sources is provided in Subsections B.4.4, H.2.2 of this Report. Data on radiation sources transferred into the category of radwaste and stored at RADON ASSOCIATION facilities are provided in Subsection 4.6.2 of Annex 4 to this Report.

The system for management of disused radiation sources in Ukraine was established in the 1950s after the start of using radiation sources in industry, agriculture, medicine and scientific research in the former Soviet Union. Radiation sources after service life expiry or due to other reasons (cladding corrosion, change in production technology, etc.) are transferred into the category of disused radiation sources.

Before 1990s, management of disused radiation sources was limited to collection, transport and disposal in near-surface well-type disposal facilities. The specified disused radiation sources were disposed in well-type disposal facilities for high-level radiation sources without biological shielding.

Currently, disused radiation sources are accepted only in biological shielding or in packages that comply with requirements of regulatory documents and ensure sufficient radiation protection.

During transfer of disused radiation sources from the supplier to the RADON ASSOCIATION, a registration card for a disused radiation source shall be submitted to the Chief Registration Center of the State Register of Radiation Sources. The registration card shall include information about the transfer of disused radiation source. This ensures monitoring of the source since the moment of its use to the moment of its transfer for storage.

According to the procedure of 1990s, disused radiation sources after retrieval from the biological shielding shall be placed into near-surface well-type disposal facilities if there is a relevant license. A well-type disposal facility for disused radiation sources is a cylindrical stainless steel vessel with a receiving tank. The receiving tank of the disposal facility is placed in a reinforced concrete well up to 6 m deep from the soil surface. Disused radiation sources are transferred to the vessel through a corrugated pipe, which ensures protection against direct radiation from disposed sources. In some cases, covers or light structures are built over the storage facilities to prevent precipitation.

Such disposal facilities were in operation during 30-35 years. Long-term monitoring of disposal facilities showed that storage of sources in underground tanks in bulk did not ensure reliability and safety. Loose discharge of radiation sources led to their arbitrary distribution in the tank and unsealing of some sources. The design of the disposal facility

was aimed at long-term storage of sources in the dry state; however, condensation moisture is always present in disposal facilities.

Experts of the RADON ASSOCIATION in close cooperation with experts from the Swedish Radiation Safety Authority (SSM) are working to find solutions for the management of radiation sources placed in well-type disposal facilities.

Data on radiation sources transferred into the category of radioactive waste and stored in RADON ASSOCIATION facilities are presented in Subsection 4.6.2 of Annex 4 of this Report.

In addition to disused radiation sources of industry, medicine, scientific and research institutions, the RADON ASSOCIATION accepts also disused radiation sources of nuclear power plants.

Energoatom transferred disused radiation sources to the RADON ASSOCIATION from 2017 to 2019 as follows:

- 77 disused radiation sources from ZNPP to Dnipro Interregional Affiliate;
- 40 disused radiation sources from SUNPP to Dnipro Interregional Affiliate. In addition, 78 sources withdrawn from dismantled equipment (radiation monitoring sensors) were transferred by SUNPP in 2017. These sources were not on the balance of SUNPP. In total, 118 radiation sources were transferred.
- 275 radiation sources from RNPP to Lviv Interregional Affiliate;
- 94 radiation sources from KhNPP to the Central Production Site;
- 90 radiation sources from the Emergency Technical Center to the Central Production Site.

The safety in management of radiation sources prior to their transfer to specialized radwaste management enterprises is ensured by:

- licensing of use and manufacture of radiation sources;
- supervision over compliance with safety standards and rules and licensing terms for use and manufacture of radiation sources;
- functioning of the State Register of Radiation Sources;
- implementation of tax liabilities within the Tax Code of Ukraine for radiation source users to pay taxes for temporary storage of sources after expiry of their lifetime to encourage the enterprises to transfer disused radiation sources to specialized radwaste management enterprises in a timely manner.

At the same time, there are enterprises, organizations and establishments that used radiation sources in industrial and research activities but now cannot ensure proper monitoring of their radiation sources because of change in activity or bankruptcy and cannot transfer radiation sources to specialized enterprises because of lack of funding.

This problem is resolved mainly by the involvement of resources of the international technical assistance provided bilaterally by Germany, the USA and other donor countries within the Non-Proliferation Initiatives.

Under the Treaty between the Federal Ministry for Environment, Nature Conservation and Reactor Safety (BMU) and Company for Installations and Reactor Safety (GRS) of Germany for contribution to G8/GP to ensure removal and safe storage of unprotected radiation sources in Ukraine, the project “Decommissioning of Irradiation Facilities and Safe Storage of Radiation Sources” is continued. Within this project, radiation sources of bankrupt enterprises are retrieved and transported for further safe storage.

In the framework of the project, 19,642 disused radiation sources with a total activity of 1.19E+15 Bq were retrieved from enterprises in different regions of Ukraine, and their containerization and safe storage in RADON ASSOCIATION radwaste facilities were

provided. Current efforts under the project include making the next list of bankrupt enterprises.

The key element in improving the management system for disused radiation sources declared as radwaste is CLTSF on the *Vektor* site (see also Subsection B.4.3 of this Report).

From 2017 to 2019, 20,535 sealed disused radiation sources with the total activity of 1.13E+14 Bq were transferred by the RADON ASSOCIATION for long-term storage of *Vektor* site CLTSF.

Section K. GENERAL EFFORTS TO IMPROVE SAFETY

K.1. Measures Taken to Solve Issues Defined as Challenges and Suggestions According to the Sixth Review Meeting

The following challenges were identified for Ukraine:

1. Construction of radioactive waste and spent fuel management facilities in the exclusion zone and on ChNPP site, *including:*

- *construction and commissioning of CSFSF;*

Detailed information on the progress of construction and commissioning of CSFSF is presented in Subsection B.2 of this Report.

- *construction and commissioning of a storage facility for long-term storage of vitrified HLW from VVER-440 spent fuel reprocessing returned from the Russian Federation;*

In pursuance of the National Target Environmental Program for Radioactive Waste Management, the design "Construction of an Interim Storage Facility for HLW Returned from the Russian Federation after Reprocessing of Spent Nuclear Fuel from Ukrainian NPPs" was developed. The construction design was approved in April 2020 taking into account results of the comprehensive state review and positive conclusion of nuclear and radiation safety review.

As of 01 July 2020, CRME performed measures to identify subcontractor for developing operating documentation on safety justification of such a facility operation.

- *design and construction of a radioactive waste treatment facility at the Vektor site*

The design documents for the construction of a Process Building for Radwaste Processing on the *Vektor* site within the international contract NSI/2015/360-150 under U4.01/11A Support to the Construction of Radioactive Waste Processing Facilities at the *Vektor* Stage II were developed.

The SNRIU with the involvement of Riskaudit and SSTC NRS experts developed the Report on Assessment of the Preliminary Revision of Design Documents and PSAR and submitted to CRME with comments. The design documents are revised taking into account comments of experts.

Considering the enforcement of the Law of Ukraine "On Environmental Impact Assessment" http://zakon3.rada.gov.ua/laws/show/2059-19/page in 2017, the procedure for environmental impact assessment is obligatory. According to the construction procedure, the following documents shall be developed:

– notification on planned activities;
– environmental impact assessment report;
– announcement on a start of public discussions of environmental impact assessment report.

- design and construction of additional facilities for ChNPP radwaste management

The Feasibility Study for Design and Construction of New Additional Facilities for Management of Radioactively Contaminated Materials and Radioactive Waste at Chornobyl NPP was developed. It was approved by SAUEZM Order No. 35 dated 16 March 2017.

An application has been submitted for the allocation of funds for the development of the design "Construction of Facilities for Management of Radioactively Contaminated Materials and Radioactive Waste at ChNPP".

2. Legislative consolidation of the special status of the zone of special industrial use in the exclusion zone for its effective use in economic and nuclear complexes and protection of the next generations.

The draft Law of Ukraine "On Amendments to Some Laws of Ukraine on the Creation of the Special Industrial Use Zone" was developed. As the main developer of the draft law, SAUEZM implements measures to agree and adopt the draft law according the procedure established by the legislation.

3. Intensification of activities on the construction of a geological repository for radwaste disposal:

- development of the operating organization (operator) of a geological repository;

- development of an action plan for the construction of a geological repository for radwaste disposal;

- start of activities on repository siting.

Measures on the construction of a geological repository for radwaste disposal are defined in the Strategy for Radioactive Waste Management in Ukraine and in the National Target Environmental Program for Radioactive Waste Management. The activities completed in previous years were aimed at geological repository siting and development of its construction concept. Various formations (crystalline, clays and salts) and options for repository construction were considered (see details in Subsection H.3 of NRU-2017).

As a result of considered recommendations of the projects that were implemented under the financial assistance of the European Union, there was a progress in the creation of the national radioactive waste management organization, which in future will become the national operator of the geological repository (CRME).

INSC U.04.01/14B "Development of a National Plan for the Geological Disposal of Radioactive Waste in Ukraine and Implementation Schedule" was launched under the Instrument for Nuclear Safety Cooperation of the European Commission in 2018. The project objective is to develop the national plan for the design, operation and closure of the geological repository for intermediate-level, high-level waste and spent fuel in Ukraine.

A group on geological repository issues, which will deal with the implementation of a state policy on geological repository construction in Ukraine, was created within the organizational structure of CRME (future operator of the geological repository).

In the beginning of 2020, the Radioenvironmental Centre of NAS of Ukraine transferred the results of preliminary siting studies held in different years by different organizations (including with the support of the European Union) to CRME for consideration and use in further activities on geological repository creation.

The Action Plan on geological repository creation envisaged the following measures:

1. Development and implementation of research and design activities on siting (a set of search, assessment, scientific and methodological, research and design activities to select sites potentially suitable for a geological repository);

2. Development and approval of the feasibility study for siting, safety assessment and environmental impact assessment;

3. Consideration of characteristics of selected site, development of technologies for radwaste disposal and repository construction;

4. Design and necessary safety assessment of the repository;

5. Construction, licensing and commissioning of the repository (construction of an underground experimental laboratory as a pilot section of the repository).

In recent years, scientists from the institutes of the National Academy of Sciences of Ukraine and experts of enterprises performed thematic activities to assess the viability of various formations, in particular, the Ukrainian Crystalline Shield for the geological repository.

From 2017 to 2019, the National Academy of Sciences of Ukraine performed research and development "Screening of Ukrainian Territory Regarding Prospects for Geological Disposal of Radioactive Waste". Research and development report was submitted to CRME.

The screening methodology used in activities fully complies with IAEA recommendations on phasing, procedures and criteria for siting of a geological repository and is similar to the methodologies used in other countries.

Regional screening of Ukrainian territory on the prospects of radwaste geological repository placement was performed based on a set of criteria established by the analysis of regulatory requirements and available geological data received from stock materials. The stock materials are sufficient for defined procedures of regional screening with the use of established groups of criteria.

Based on consideration of geological conditions of Ukrainian regions, concepts of geological disposal, economic, social and demographic factors, it was concluded that Chornobyl exclusion zone with adjacent territories was considered the most promising region of Ukraine for the geological repository. Crystalline rocks of the foundation of this region were identified as the most acceptable geological formation.

The local screening area was about 9000 km^2. According to the results of screening, three areas (Novosilkivska, Zhovtneva and Veresnianska) were defined for further research in order to select promising areas and sites. The size of the areas is from 80 to 450 km^2.

The ultimate objective of the screening is to select at least three candidate sites with an area of about 10 km2 within the promising areas. It is necessary to perform a set of engineering (and according to their results – geological exploration) activities, as it is defined by the National Target Environmental Program for Radioactive Waste Management.

The level of geological and geophysical study of the selected areas is different and requires further research in order to compare and select the most promising site for the creation of the geological repository.

Following the results of the Sixth Review Meeting, the Contracting Parties **recommended to continue the following safety improvement measures during the next three years**:

<u>implementation of spent fuel and radioactive waste management strategies;</u>

Information is presented in Subsection B.1, B.2 and B.3 of this Report.

<u>safety impact of spent fuel and radioactive waste long-term management;</u>

According to the Strategy for Radioactive Waste Management, the following facilities are planned to be constructed:

- geological repository for final disposal of high-level and long-lived waste, including waste resulting from spent fuel reprocessing.

- storage facility for long-term storage of vitrified HLW from VVER-440 spent fuel reprocessing returned from the Russian Federation.

In order to solve comprehensive branch problems in management of spent fuel of national nuclear power plants, increase economic efficiency of spent fuel management, the Concept of the State Economic Program for Management of Spent Nuclear Fuel from National Nuclear Power Plants until 2024 was developed and approved in June 2019. According to this document, long-term storage (50-100 years) of spent fuel in special dry storage facilities is envisaged. The decision on the final management of spent fuel will be made before the end of the storage period, taking into account the results of a comprehensive comparative assessment of options for management of spent fuel of Ukrainian NPPs in the long-term perspective after 2035.

ensuring consistency of the stages of long-term storage of disused radiation sources and their disposal;

Ensuring consistency of the stages of long-term storage of disused radiation sources and their further disposal are performed within the integrated process of radioactive waste management with the following:

– the interdependence and connections between all stages of management of disused radiation sources before their disposal, as well as the forecasted disposal option for disused radiation sources;
– use of such technologies of processing and long-term storage of disused radiation sources that ensure further safe disposal of disused radiation sources;
– requirements for identification and sorting of disused radiation sources taking into account the need to ensure safe management of disused radiation sources at the following stages, including disposal, shall be defined in the development and implementation of technologies, design decisions, other measures for predisposal management of disused radiation sources at any stage. It is necessary to provide sorting of disused radiation sources for separate storage depending on the half-life of radionuclides, type of radiation and activity;
– packages containing radioactive waste in the form of disused radiation sources are placed for long-term storage depending on the characteristics of disused radiation sources. The main sorting criteria are the specific activity and radionuclide composition of disused radiation sources. After sorting, disused radiation sources are divided into groups according to the criteria;
– the system for keeping and storage of documents and data on accounting and control of disused radiation sources is implemented at all stages of management of disused radiation sources. The information is stored in a way that will ensure its availability in the future, throughout the period before the disposal of disused radiation sources.

remediation of legacy sites and facilities;

Information on the ongoing remediation of Tsybuleve legacy site for radwaste generated as a result of the implementation of the military programs of the former USSR is presented in Subsection H.2.1 of this Report.

Information on the ongoing remediation of sites for radioactive waste (generated as a result of ChNPP accident) located outside the exclusion zone, namely Pisky-1 RWDS, is presented in Subsection B.4.4.

K.2. Major Challenges Related to Spent Fuel and Radioactive Waste Management in Ukraine and Ways of Their Solution

The major challenges for Ukraine related to spent fuel and radwaste management are as follows:

1. Construction of a long-term storage facility for vitrified HLW resulting from reprocessing of VVER-440 spent fuel and design of a long-term storage facility for vitrified HLW resulting from reprocessing of VVER-1000 spent fuel returned from the Russian Federation.
2. Approval and start of implementation of the national plan on the creation of a geological repository for radioactive waste disposal.
3. Transfer of NPP radwaste for long-term storage and disposal to the *Vektor* site.
4. Construction and commissioning of KhNPP SRW treatment plant.
5. Commissioning of ChNPP ISF-2 and CSFSF.
6. Continued implementation of safety improvement measures on a permanent basis, which are recommended by the Contracting Parties upon the results of the Sixth Review Meeting.

K.3. Improvement of Safety in Spent Fuel and Radioactive Waste Management Considering Lessons Learnt from Fukushima-1 Accident

In June 2011, Ukraine joined the European stress-test initiative for NPPs in European Union member states and neighboring countries (Declaration on Stress Tests). The stress tests for Ukrainian NPPs were conducted in accordance with the methodology agreed by the European Commission and ENSREG (13 May 2011, Declaration of ENSREG, Annex 1 "EU Stress-Test Specifications").

On 30 December 2011, the SNRIU submitted the National Report developed according to ENSREG recommendations to the Stress Test Secretariat to perform a peer review of the results of stress tests for Ukrainian NPPs.

In early 2013, the National Action Plan was developed for the operating organizations to implement safety improvement measures determined in stress tests, ensure effective SNRIU supervision and implement recommendations of the stress test peer review for Ukrainian NPPs.

The National Action Plan upon Stress Test Results (2013) was updated taking into account recommendations presented in the document "ENSREG Post-Fukushima National Action Plans Workshop 20-24 April 2015. Terms of Reference".

It should be noted that as a result of updating the National Action Plan, the number of measures planned for implementation, both for operating NPPs and for ChNPP, has not changed and the scope of implementation of measures has not changed.

Activities on updating the National Action Plan are performed by the SNRIU on a regular basis. For this purpose, information presented in the National Action Plan was updated in 2015, 2017 and 2020 to reflect the current progress of planned measures. In addition, a new measure No. 33 "Implementation of the external RPV cooling system" with the deadline of 31 December 2021 was added to the National Action Plan.

Part I "Safety improvement measures" of the updated National Action Plan provides the list of measures of the National Action Plan upon Stress Test Results (2020) both for operating NPPs and for ChNPP with updated information on the current state of implementation of measures and deadlines.

Part II "State of implementation of safety improvement measures" of the updated National Action Plan provides information on the implementation of planned measures,

namely: there is brief information on each measure regarding the planned scope of measure implementation; state of measure implementation (more detailed information is presented for completed measures); relevant deadline.

All measures defined upon stress test results for ChNPP were implemented.

Regarding measures identified upon stress test results for operating NPPs, it is necessary to state that implementation of a set of measures of the National Action Plan was arranged within the implementation of the Comprehensive (Integrated) Safety Improvement Program (C(I)SIP). In 2019, this program was extended up to 2023 by Resolution of the Cabinet of Ministers of Ukraine.

At present, 191 (76.1 %) measures out of 251 post-Fukushima measures of C(I)SIP were completed. 28 more measures (11.1 %) shall be completed in 2020, 8 measures (3.2 %) shall be completed in 2021, 4 measures (1.6 %) measures shall be completed in 2022, 20 measures (8 %) shall be completed in 2023.

K.4. Measures to Ensure Openness and Transparency of Activities on Compliance with Obligations under the Joint Convention

All NRUs and reports upon IRRS-2008 and IRRS-2010 missions are open for the public at the official SNRIU website www.snriu.gov.ua.

CONCLUSIONS

The Report demonstrates that Ukraine is making every effort and taking all measures to fulfill its obligations under the Joint Convention.

This is ascertained by a detailed description of the tasks identified in the Strategy for Radioactive Waste Management and the Energy Strategy of Ukraine and the progress of measures implemented to ensure the safety of spent fuel and radioactive waste management.

The national legislation, regulatory requirements, strategies, programs and associated infrastructure rely on fundamental safety principles, are continuously updated and harmonized with EC directives and IAEA standards and incorporate the best international practices.

The role and independence of the SNRIU as a state competent nuclear regulatory body are enhanced through legislative status, competences and required resources, compliance with quality procedures for regulatory activity and international technical cooperation.

Section L. Annexes

Annex 1. List of Spent Fuel Management Facilities (as of 1 July 2020)

Facility	Location	Purpose	Status
Spent fuel pool of ZNPP Unit 1	ZNPP 71500, Energodar Zaporizhzhya Region	Temporary storage to reduce decay heat	In operation
Spent fuel pool of ZNPP Unit 2	ZNPP 71500, Energodar Zaporizhzhya Region	Temporary storage to reduce decay heat	In operation
Spent fuel pool of ZNPP Unit 3	ZNPP 71500, Energodar Zaporizhzhya Region	Temporary storage to reduce decay heat	In operation
Spent fuel pool of ZNPP Unit 4	ZNPP 71500, Energodar Zaporizhzhya Region	Temporary storage to reduce decay heat	In operation
Spent fuel pool of ZNPP Unit 5	ZNPP 71500, Energodar Zaporizhzhya Region	Temporary storage to reduce decay heat	In operation
Spent fuel pool of ZNPP Unit 6	ZNPP 71500, Energodar Zaporizhzhya Region	Temporary storage to reduce decay heat	In operation
ZNPP DSFSF, Stage 1	ZNPP 71500, Energodar Zaporizhzhya Region	Interim spent fuel storage	In operation since 2001
ZNPP DSFSF, Stage 2	ZNPP 71500, Energodar Zaporizhzhya Region	Interim spent fuel storage	In operation since 2012
Spent fuel pool of KhNPP Unit 1	KhNPP 30100, Netishin Khmelnitsky Region	Temporary storage to reduce decay heat	In operation
Spent fuel pool of KhNPP Unit 2	KhNPP 30100, Netishin Khmelnitsky Region	Temporary storage to reduce decay heat	In operation
Spent fuel pool of Rivne Unit 1	RNPP 34400, Varash, Rivne Region	Temporary storage to reduce decay heat	In operation
Spent fuel pool of Rivne Unit 2	RNPP 34400, Varash, Rivne Region	Temporary storage to reduce decay heat	In operation
Spent fuel pool of Rivne Unit 3	RNPP 34400, Varash, Rivne Region	Temporary storage to reduce decay heat	In operation
Spent fuel pool of Rivne Unit 4	RNPP 34400, Varash, Rivne Region	Temporary storage to reduce decay heat	In operation

Facility	Location	Purpose	Status
Spent fuel pool of SUNPP Unit 1	SUNPP 55000, Yuzhnoukrainsk Mykolaiv Region	Temporary storage to reduce decay heat	In operation
Spent fuel pool of SUNPP Unit 2	SUNPP 55000, Yuzhnoukrainsk Mykolaiv Region	Temporary storage to reduce decay heat	In operation
Spent fuel pool of SUNPP Unit 3	SUNPP 55000, Yuzhnoukrainsk Mykolaiv Region	Temporary storage to reduce decay heat	In operation
CSFSF	Exclusion zone	Interim spent fuel storage	Construction under completion, commissioning planned
ChNPP ISF-1	ChNPP 07100, Slavutych Kyiv Region	Interim spent fuel storage	In operation
ChNPP ISF-2	ChNPP 07100, Slavutych Kyiv Region	Long-term spent fuel storage (to 100 years)	Under commissioning
Spent fuel storages for VVR-M research reactor (SFP-1, SFP-2)	NRI 03680, Kyiv 47 Nauki Avenue	Temporary storage	In operation

Annex 2. Spent Fuel Inventory (as of 1 July 2020)

Material	Location	Number of SFAs	Weight of heavy metal, t
VVER-1000 SFAs	KhNPP Unit 1	421	181.75
VVER-1000 SFAs	KhNPP Unit 2	498	216.46
VVER-440 SFAs	RNPP Units 1 and 2	1151	140.89
VVER-1000 SFAs	RNPP Unit 3	471	200.51
VVER-1000 SFAs	RNPP Unit 4	442	190.22
VVER-1000 SFAs	SUNPP Unit 1	282	122.63
VVER-1000 SFAs	SUNPP Unit 2	282	125.11
VVER-1000 SFAs	SUNPP Unit 3	420	184.42
VVER-1000 SFAs	ZNPP Unit 1	357	154.93
VVER-1000 SFAs	ZNPP Unit 2	343	148.47
VVER-1000 SFAs	ZNPP Unit 3	387	167.57
VVER-1000 SFAs	ZNPP Unit 4	413	179.21
VVER-1000 SFAs	ZNPP Unit 5	376	163.07
VVER-1000 SFAs	ZNPP Unit 6	378	164.15
VVER-1000 SFAs	ZNPP DSFSF	3762	1539.70
VVER-1000 SFAs	ChNPP ISF-1	21284	2396.111
Research reactor VVR-M SFAs	NRI	none	none

Annex 3. List of Radioactive Waste Management Facilities (as of 1 July 2020)

3.1. List of Radioactive Waste Management Facilities at Operating NPPs

Facility	Location	Purpose	Design capacity	Commissioned, year
UGU-1-500	ZNPP	Deep evaporation of bottoms	500 dm^3/h	1987
UGU-1-500	ZNPP	Deep evaporation of bottoms	500 dm^3/h	2000
UGU-1-500	KhNPP	Deep evaporation of bottoms	500 dm^3/h	1990
UGU-1-500	RNPP	Deep evaporation of bottoms	500 dm^3/h	2004
UGU-1-500	RNPP	Deep evaporation of bottoms	500 dm^3/h	2007
Incineration facility	KhNPP	Incineration of radioactive oil	5 dm^3/h	1994
Centrifuge	KhNPP	Treatment of floor drains	1-10 m^3/h	2011
Bituminization facility*	RNPP	Bituminization of liquid radwaste	150 dm^3/h	1995
Centrifuge	RNPP	Treatment of floor drains	1.5-7 m^3/h	2004
Incineration facility**	ZNPP	Incineration of low-level waste	40 kg/h – solid radwaste 12 kg/h – liquid radwaste	1992
Compaction facility VNR-500	ZNPP	Volume reduction of low-level solid radwaste	P = 500 kN Volume reduction factor = 4	1991
Compaction facility C-26	SUNPP	Volume reduction of low-level radwaste	P = 2000 kN Volume reduction factor = 4	1997
Radwaste incineration facility (RWTP)	ZNPP	Volume reduction of solid and liquid radwaste	30 kg/h – solid radwaste 12 kg/h – liquid radwaste 12 kg/h - oil	2018
Release monitoring system		Monitoring of flue gas parameters	Continuously and periodically	2019
Fragmentation	ZNPP	Solid radwaste	200 t/year	2019

Facility	Location	Purpose	Design capacity	Commissioned, year
facility		fragmentation	(30 kg/h)	
Certification facility	ZNPP	Measurement of radwaste activity and radionuclide composition	20 containers/ 3 shifts	2019
Solid radwaste retrieval facility	ZNPP	Retrieval of solid radwaste	Crane lifting capacity 1.25 t	2019 (trial operation)
Supercompaction facility	ZNPP	Volume reduction of solid radwaste	P = 1500 t 4-6 compacts/h	2018
Supercompaction facility	RNPP	Volume reduction of solid radwaste	P = 1500 t 4-6 compacts/h	2018
Cementation facility	RNPP	Radwaste conditioning	8 containers/shift	2018
Metal decontamination facility	RNPP	Decontamination of radioactively contaminated metal	200 t/year 800 kg/day	2018
Oil treatment facility	RNPP	Treatment of radioactively contaminated oil	not less than 0.58 m^3/h	2018
Solid radwaste retrieval facility	RNPP	Retrieval of solid radwaste	15 m^3/week	2018
Fragmentation and sorting facility	RNPP	Fragmentation of sorting of solid radwaste	4.5 m^3/shift	2018
Activity measurement facility	RNPP	Monitoring of activity in containers and radiological situation in RWTP rooms	12 container measurements/ shift.	2018
Interim liquid radwaste storage area in special building 1	ZNPP	Acceptance and storage of liquid radwaste	3800 m^3	1984
Interim liquid radwaste storage area in special building 2	ZNPP	Acceptance and storage of liquid radwaste	1000 m^3	1987
Solid radwaste storage in special building 1	ZNPP	Acceptance and storage of solid radwaste	5910 m^3	1984
Solid radwaste storage in special	ZNPP	Acceptance and storage of solid	1906.7 m^3	1989

Facility	Location	Purpose	Design capacity	Commissioned, year
building 2		radwaste		
Solid radwaste storage in processing building (storage area)	ZNPP	Acceptance and storage of solid radwaste	11174 m^3	1986
Liquid radwaste storage in special building 1	RNPP	Acceptance and storage of liquid radwaste	4590 m^3	1981
Liquid radwaste storage in special building 2	RNPP	Acceptance and storage of liquid radwaste	3800 m^3	1986
Storage within reactor compartment of Units 1 and 2	RNPP	Storage of high-level solid waste	84.2 m^3	1981
Solid radwaste storage in special building 1	RNPP	Acceptance and storage of solid radwaste	4180 m^3	1981
Solid radwaste storage in special building 2	RNPP	Acceptance and storage of solid radwaste	6042 m^3	1986
Solid radwaste storage within storage area in radwaste processing building	RNPP	Acceptance and storage of solid radwaste	7756 m^3	2001
Liquid radwaste storage (LRSF-1)	KhNPP	Acceptance and storage of liquid radwaste	800 m^3	1987
Liquid radwaste storage (LRSF-2)	KhNPP	Acceptance and storage of liquid radwaste	2250 m^3	2004
Site "BB-Cube"	KhNPP	Storage of liquid radwaste (containers with salt fusion cake)***	240 m^3	1997
Storage area within solid radwaste storage facility	KhNPP	Storage of liquid radwaste (containers with salt fusion cake), acceptance and storage of solid	7183 m^3	2002

Facility	Location	Purpose	Design capacity	Commissioned, year
		radwaste		
Solid radwaste storage in special building	KhNPP	Acceptance and storage of solid radwaste	6368.1 m^3	1987
Liquid radwaste storage No. 1	SUNPP	Acceptance and storage of liquid radwaste	2121 m^3	1982
Liquid radwaste storage No. 2	SUNPP	Acceptance and storage of liquid radwaste	1969 m^3	1987
Liquid radwaste storage No. 3	SUNPP	Acceptance and storage of liquid radwaste	760 m^3	1989
Low-level waste storage	SUNPP	Acceptance and storage of solid radwaste	12000 m^3	1982
Solid radwaste storage No. 1	SUNPP	Acceptance and storage of solid radwaste	1250 m^3	1982
Solid radwaste storage No. 2	SUNPP	Acceptance and storage of solid radwaste	3053 m^3	1989
Solid radwaste storage No. 3	SUNPP	Acceptance and storage of solid radwaste	10811 m^3	2002

* preserved in 2002

** operated until 2019 (inclusive)

*** operated until 2016; containers with salt fusion cake are currently in LSRSF tanks

3.2. List of Radioactive Waste Management Facilities at Chornobyl NPP

Facility	Location	Purpose	Commissioned, year
Solid radwaste storage facility	ChNPP site	Temporary storage of solid radwaste in operation and decommissioning of power units	1978 Acceptance of high-level solid radwaste terminated on 9 May 2003
Liquid radwaste storage facility	ChNPP site	Temporary storage of liquid radwaste in operation and decommissioning of power units	1977
Liquid and solid radwaste storage facility	ChNPP site	Temporary storage of liquid radwaste in operation and decommissioning of power units	1981 Storage compartments for solid radwaste were not operated. Within ICSRM, compartments for solid radwaste were upgraded and temporary storage for high-level waste and low- and intermediate-level long-lived waste was created
Temporary storage facility for high-level and low- and intermediate-level long-lived waste	ChNPP site	Temporary storage of packages with high-level waste and low- and intermediate-level long-lived waste to be transferred from SRTP	2010 LSRSF at upper elevations within ICSRM
Temporary storage facility for solid high-level waste	ChNPP site	Temporary storage of high-level solid waste	2004
Temporary storage for spent radioactive oil	ChNPP site	Temporary storage of spent radioactive oil	1999
Temporary storage for oil-fuel mixture in diesel generator station of first stage	ChNPP site	Temporary storage of oil-fuel mixture	2012 Arranged in diesel generator station of ChNPP stage I (1AMB-1, 1ATB-1

Facility	Location	Purpose	Commissioned, year
			tanks)
Liquid radwaste treatment plant	ChNPP site	Management of liquid radwaste accumulated during ChNPP operation and radwaste to be generated during ChNPP decommissioning and SIP	2018
Solid radwaste retrieval facility Solid radwaste treatment plant within ICSRM	ChNPP site	Management of solid radwaste accumulated during ChNPP operation and radwaste to be generated during ChNPP decommissioning and implementation of SIP	Planned for 2018

3.3. List of CRME Radioactive Waste Management Facilities

Facility	Location	Purpose	Design capacity (for radwaste storages)	Commissioned, year	Status
ENSDF	Exclusion zone *Vektor*	Disposal of solid radwaste packages	71 280 m^3	2009	Operation
RWDS *Buryakivka* [-1]	Exclusion zone	Disposal of solid radwaste packages	707500 m^3	1987	Operation
RWDS *Pidlisny*	Exclusion zone	Storage of accident-origin radwaste	50000 m^3 (for modules A-1, B-1)	1986	Stabilized, monitoring, maintenance
RWDS *ChNPP Stage III*	Exclusion zone	Storage of accident-origin radwaste	[-2]	1986	Stabilization, monitoring, maintenance
RICS	Exclusion zone	Storage of accident-origin radwaste	[-2]	1986-1987	Survey, monitoring, maintenance
Decontamination facility	Exclusion zone VTS Leliv	Decontamination of radwaste, vehicles		1987	Operation
Station for decontamination of individual protection means and overalls	Exclusion zone Prypiat	Decontamination of individual protection means and overalls		1986	Not operated
Decontamination facility No. 1	Exclusion zone	Radwaste decontamination		1987	Preserved in 2012
Decontamination facility No. 2 (Dibrova)	Exclusion zone	Radwaste decontamination		1987	Preserved in 2007

Facility	Location	Purpose	Design capacity (for radwaste storages)	Commissioned, year	Status
Vektor Stage I, SRW-1, SRW-2	Exclusion zone *Vektor*	Solid radwaste disposal	19 200 m^3	2015	Construction
CLTSF	Exclusion zone *Vektor*	Processing and storage of DRS	500 000 pcs.	2015	Hot tests
Experimental facility for incineration of radioactively contaminated wood (incinerator)	Exclusion zone Prypiat	Radwaste processing		2015	Trial operation

1. Design capacity of 30 filled RWDS *Buryakivka* trenches is 690 000 m^3 of radwaste and design capacity of additional trench No. 21A is 17 500 m^3 of radwaste
2. Design documents are missing

3.4. List of Radioactive Waste Management Facilities at RADON SISPs

Enterprise/ Location	Basic activity	Design capacity	Commissioned, year	Facility	Status
DIA 23-km Dnipro–Zaporizhzhya highway	Radwaste transport, processing, storage	Solid radwaste (near-surface tanks) – 450.0 m^3	1962	SRW-1	Preserved
			1982	SRW-2	In operation, radwaste not accepted
			1963	BRW-5	
		Solid radwaste (surface storage) – 1300.0 m^3	2014	SRW-6	In operation (container storage)
		Solid radwaste (surface storage)– 700 m^3	2005	Hangar covering above SRW- 2	
		DRS storage – 50 kg-eqv. Ra by ^{60}Co	1979	DRS-3	In operation, radwaste not accepted
		Liquid radwaste – 200.0 m^3;	1965	LRW-4	In operation, radwaste not accepted
CPS Kyiv 1 Komunalna St.	Radwaste transport, processing, storage	Solid radwaste (near-surface underground tanks) – 1800.0 m^3	1985	SRW-5-6	In operation, radwaste not accepted
			1975	SRW-7	
			1971	SRW-8	Preserved
			1967	SRW-9-10	
		Solid radwaste (surface container storages) – 334.0 m^3	1995	Hangar storage 2, hangar 11	In operation (container storage)
		Container – 10.5 m^3	2000	Container storage 18 – under covering	Radwaste not accepted
		DRS – 120 kg-eqv. Ra by ^{60}Co	1985	DRS-1-5	In operation, radwaste not accepted
			1978	DRS-6	
		Liquid radwaste – 800.0 m^3	1968	LRW-12-14	In operation, radwaste not accepted
			2016	LRW-3	

Enterprise/ Location	Basic activity	Design capacity	Commissioned, year	Facility	Status
	Monitoring of SSRs in Kyiv, Zhytomyr and Chernihiv regions	Solid radwaste – 36090.0 m^3 (design capacity indicated for 9 SSR storages in Chernihiv region, no data for other storages)	1986-1995 (mitigation of Chornobyl accident consequences)		Monitoring and maintenance
LIA Yavoriv District Lviv Region	Radwaste transport, processing, storage	Solid radwaste (near-surface tanks) – 1140.0 m^3	1963	SRW-1	Preserved
			1989	SRW-2-8 (under hangar covering)	In operation (container storage)
			1989	BRW	In operation
		Liquid radwaste – 200.0 m^3	1962	LRW	Not operated, empty
		DRS – 80 kg-eqv. Ra by ^{60}Co	1978 1989	DRS DRS-1	In operation, radwaste not accepted
			2005	DRS-2	
OIA 75-km Odessa–Kyiv highway	Radwaste transport, processing, storage	Solid radwaste (near-surface tanks) – 583.0 m^3	1962	SRW-1-6	Preserved
				SRW-7-11 (under hangar covering)	In operation
		Liquid radwaste – 400.0 m^3	1963	LRW-1	In operation, radwaste not accepted
				LRW-2	Not operated, empty
		DRS – 50 kg-eqv. Ra by ^{60}Co	1968	DRS-13	In operation, radwaste not accepted
		Solid radwaste (containers) - 687 m^3	2001	Containers 14, 14a, 14b, sections 17, 22 (under hangar covering)	In operation

Enterprise/ Location	Basic activity	Design capacity	Commissioned, year	Facility	Status
		DRS "RITEG"	2002	DRS "Riteg" 15	In operation, radwaste not accepted
KhIA Derhachiv District Kharkiv Region	Radwaste transport, processing, storage	Solid radwaste (near-surface underground tanks) – 2275.7 m^3	1962	SRW 1-13 (under hangar covering)	In operation (container storage)
			1991	SRW-18-20	Preserved
		Liquid radwaste – 1000.0 m^3;	1962	LRW-21	In operation
				LRW-22-25	Redundant
		DRS – 60 kg-eqv. Ra by ^{60}Co	1990	DRS-15, 16, 17	In operation, radwaste not accepted
		Tubing storage – 812 m^3	1998	NKT-30	In operation, radwaste not accepted
		Facility 'Paket'	2011	SRW-14	In operation
		Experimental decontamination of tubing	2013	Experimental section for decontamination of tubing	Experimental work

Annex 4. Radioactive Waste Inventory (as of 1 July 2020)

4.1. Data on Radioactive Waste in Storage at Sites of Operating NPPs

Material	Location	Volume, m^3	Activity, Bq	Main radionuclides
Filtering materials	KhNPP	185.8	3.53E+05[1]	^{134}Cs, ^{137}Cs, ^{60}Co[1]
Evaporation bottoms	KhNPP	428.2	2.52E+06[2]	^{134}Cs, ^{137}Cs, ^{60}Co[2]
Dehydrated sludge	KhNPP	82.6	1.693E+05	^{134}Cs; ^{137}Cs; ^{60}Co; ^{125}Sb; ^{54}Mn; ^{110m}Ag
Salt fusion cake	KhNPP	1161.2	3.345E+07	^{134}Cs, ^{137}Cs, ^{60}Co, ^{54}Mn
Low-level solid radwaste	KhNPP	5915.6	8.39E+05	^{134}Cs, ^{137}Cs, ^{60}Co, ^{58}Co, ^{54}Mn, ^{110m}Ag
Intermediate-level solid radwaste	KhNPP	136.6	1.87E+06	^{134}Cs, ^{137}Cs, ^{60}Co
High-level solid radwaste	KhNPP	10.98	-[3]	-[3]
Filtering materials	ZNPP	350(348.6)[5]	1.00E+07[1]	^{134}Cs, ^{137}Cs, ^{60}Co, ^{58}Co, ^{54}Mn, ^{124}Sb, ^{122}Sb, ^{110m}Ag[1]
Evaporation bottoms	ZNPP	2787	1.68E+07[2]	^{134}Cs, ^{137}Cs, ^{60}Co, ^{58}Co, ^{54}Mn, ^{124}Sb, ^{122}Sb, ^{110m}Ag [2]
Salt fusion cake	ZNPP	5354.4	7.26E+07	^{134}Cs, ^{137}Cs, ^{60}Co, ^{58}Co, ^{54}Mn, ^{124}Sb, ^{122}Sb, ^{110m}Ag
Low-level solid radwaste	ZNPP	8062	2.470E+06[4]	^{134}Cs, ^{137}Cs, ^{60}Co,^{54}Mn
Intermediate-level solid radwaste	ZNPP	879.8	1.0E+06[4]	^{134}Cs, ^{137}Cs, ^{60}Co,^{54}Mn
High-level solid radwaste	ZNPP	104.31	-[3]	-[3]
Filtering materials	SUNPP	427	4.76E+04[1]	^{54}Mn, ^{58}Co, ^{60}Co, ^{134}Cs, ^{137}Cs, ^{124}Sb[1]
Evaporation bottoms	SUNPP	2723	8.135E+07[2]	^{54}Mn, ^{58}Co, ^{60}Co, ^{134}Cs, ^{137}Cs, ^{124}Sb[2]
Low-level solid radwaste	SUNPP	17305.6	-[3]	^{58}Co,^{134}Cs, ^{137}Cs, ^{60}Co,^{54}Mn
Intermediate-level solid radwaste	SUNPP	641	-[3]	^{34}Cs, ^{137}Cs, ^{60}Co,^{54}Mn
High-level solid radwaste	SUNPP	17.5	-[3]	-[3]
Filtering materials	RNPP	563.95	7.07E+05[1]	^{134}Cs; ^{137}Cs; ^{60}Co; ^{54}Mn; ^{110m}Ag[1]

Material	Location	Volume, m^3	Activity, Bq	Main radionuclides
Evaporation bottoms	RNPP	2843	8.82E+06[2]	^{134}Cs; ^{137}Cs; ^{60}Co; ^{54}Mn; ^{110m}Ag[2]
Salt fusion cake	RNPP	2620	2.02E+08	^{134}Cs, ^{137}Cs, ^{60}Co
Dehydrated sludge	RNPP	28.2	5.45E+05	^{134}Cs; ^{137}Cs; ^{136}Cs; ^{60}Co; ^{58}Co; ^{54}Mn; ^{110m}Ag
Bituminous compound	RNPP	147.8	1.46E+07	^{134}Cs, ^{137}Cs, ^{60}Co
Low-level solid radwaste	RNPP	8177	-[3]	^{134}Cs, ^{137}Cs, ^{60}Co, ^{58}Co,^{54}Mn
Intermediate-level solid radwaste	RNPP	583.1	-[3]	^{58}Co, ^{137}Cs, ^{60}Co,^{54}Mn
High-level solid radwaste	RNPP	100.4	-[3]	-[3]

[1] - average total activity and radionuclide composition of surface samples taken from tanks with spent filtering materials

[2] - average total activity and radionuclide composition of evaporation bottoms

[3] - specific activity and radionuclide composition of solid radwaste accumulated in storage facilities since the beginning of power unit operation will be determined in solid radwaste retrieval and solid radwaste total activity will be evaluated

[4] - tentative data obtained by calculation

[5] - amount of the solid phase shown in brackets (for filtering materials)

4.2. Data on Radioactive Waste in Storage at Chornobyl NPP Site

Radwaste material	Location	Volume, m^3	Weight, t	Activity, Bq	Main radionuclides
Low-level solid radwaste	SRSF	1069.00	–	1.11E+11	Mixture of nuclides*: Cs; Sr; Co; Pu; Am
Intermediate-level solid radwaste		926.50	–	4.11E+12	
High-level solid radwaste		506.93	–	1.28E+14	
High-level solid radwaste	Temporary storage for HLW and low- and intermediate-level long-lived waste	6.262	–	1.27E+12	^{137}Cs; ^{241}Am; ^{154}Eu; ^{94}Nb; ^{60}Co, ^{40}K
Low- and intermediate-level long-lived waste		1.807	–	2.36E+11	^{137}Cs; ^{241}Am; ^{154}Eu; ^{94}Nb; ^{60}Co, ^{40}K
High-level solid radwaste	Temporary storage for solid high-level waste	3.0899	–	6.06E+12	^{137}Cs; ^{90}Sr; ^{241}Pu; ^{60}Co; ^{241}Am; ^{134}Cs; ^{154}Eu; ^{94}Nb; $^{238\text{-}240}$Pu
Low- and intermediate-level long-lived waste		0.33	0.211	2.78E+10	^{137}Cs; ^{60}Co; ^{154}Eu
Evaporation bottoms	LRSF	9473.64	–	2.66E+14	^{137}Cs; ^{90}Sr; ^{134}Cs; ^{60}Co
Ion-exchange resins		2851.02	–	1.71E+12	^{137}Cs; ^{90}Sr; ^{238}Pu, ^{60}Co; ^{239,240}Pu; ^{241}Am
Filter pearlite pulp		1628.98	–	2.92E+12	^{137}Cs; ^{90}Sr;^{134}Cs; ^{238}Pu; ^{60}Co; ^{239}Pu; ^{240}Pu; ^{241}Am
Evaporation bottoms	LSRSF	3892.00	–	1.08E+14	^{137}Cs; ^{90}Sr; ^{134}Cs; ^{60}Co
Ion-exchange resins		1263.80	–	5.62E+11	^{137}Cs; ^{90}Sr; ^{238}Pu, ^{60}Co; ^{241}Am; ^{134}Cs;^{239,240}Pu

Radwaste material	Location	Volume, m^3	Weight, t	Activity, Bq	Main radionuclides
Filter pearlite pulp		669.00	–	9.55E+11	^{137}Cs; ^{90}Sr; ^{60}Co; ^{241}Am; ^{134}Cs; $^{239,240}Pu$
Spent radioactive oil	Temporary oil storage	104.80	–	1.44E+07	^{137}Cs
Oil-fuel mixture	Temporary storage for oil-fuel mixture	40.49	–	1.19E+07	^{137}Cs

* - radwaste nuclide composition was not determined when the facility was filled because required tools and guidelines were missing

4.3. Data on Radioactive Waste in Storage at Sites of Research Reactors (NRI)

Material	**Location**	**Volume, m^3**	**Weight, t**	**Specific activity,** Bq/L (Bq/kg)	**Main radionuclides**
Intermediate- and high-level solid radwaste	Tanks for temporary storage of solid radwaste (storages 008 – 012)	- *	7.261	2.05E+13	^{60}Co, ^{137}Cs
Low-level solid radwaste	Temporary storage area in reactor hall	-	none	-	-
Low-level liquid radwaste	Active drain tanks 1- 4	478.1	- *	3.65E+10	^{60}Co, ^{137}Cs

*- not measured

4.4. Data on Radioactive Waste in Disposal and Long-Term Storage at CRME Facilities

Waste state	Waste category	Facility	Weight, t	Volume, m^3 (pcs.)	Activity, Bq	Main nuclides
Solid radwaste	Low- and intermediate-level	RWDS *Buryakivka*	1444451	703526[1)]	2.54E+15	Mixture of nuclides Cs, Sr, Eu, Pu, Am
Solid radwaste	High-level, long-lived	RWDS *Pidlisny*	22000 [2)]	11000 [2)]	2.59E+15	137Cs, 90Sr, 134Cs, 154Eu, 155Eu, 238Pu, 239,240Pu, 241Pu, 241Am
Solid radwaste	Low- and intermediate-level, long-lived	RWDS *ChNPP Stage III*	41900	26200	2.75E+14	137Cs, 90Sr, 238Pu, 239,240Pu, 241Pu, 241Am
Solid radwaste packages	Low-level solid waste	ENSDF	1255.8	835.42	4.31E+12	90Sr, 137Cs, 135Cs, 134Cs, 235U, 236U, 238U, 237Np, 241Pu , 241Am, 242Am
Solid radwaste	DRS	CLTSF *Vektor*	42.8	21 067 pcs	1.29E+14	Cs, Co, Am, Ra

1. The data are based on estimates considering compaction of radwaste in trenches.
2. The total amount of radwaste in modules A1 and B1 is based on the inventory of 1990 considering the materials used to stabilize radwaste; total amount of high-level waste disposed in the RWDS is 7920 t and 3960 m^3.

4.5. Data on Chornobyl-Origin Radioactive Waste Placed at CRME RICSs

Waste state	Waste category	Location	Weight, t	Volume, m^3	Activity, Bq
Solid radwaste	Low- and intermediate-level	RICS *Nova Budbaza*	44900	29927	7.70E+12
		RICS *Stara Budbaza*	62630	40555	3.79E+13
		RICS *Naftobaza*	173770	128809	2.26E+13
		RICS *Pischane Plato*	91660	57293	5.77E+12
		RICS *Yaniv Station*	15000	30000	3.70E+13
		RICS *Rudyy Lis*	250000	500000	3.74E+14
		RICS *Prypiat*	180	150	4.58E+09
		RICS *Kopachi*	90000	110000	3.33E+13
		RICS *Chystohalivka*	80500	53670	4.94E+12
Total:			808640	950399	5.23E+14

Notes. The radwaste characteristics for the radwaste sites that were surveyed, such as RWDS *ChNPP Stage III* and RICSs *Nova Budbaza*, *Stara Budbaza*, *Naftobaza*, *Pischane Plato*, *Prypiat* and *Chystohalivka*, consider additional surveys conducted by CRME and analyzed within international project U4.01/10-D.

The radwaste characteristics for the radwaste sites that were not and were partially surveyed *Yaniv Station*, *Kopachi*, *Rudyy Lis*) are based on the inventory of radwaste storage and disposal sites as of 1 January 1990 and require to be surveyed further.

4.6. Data on Radioactive Waste and Disused Radiation Sources Placed in RADON Facilities

4.6.1. Data on Radioactive Waste Placed in RADON Facilities

Waste material	Location	Volume[-1], m[3]	Weight[-1], t	Activity[-2], Bq	Main radionuclides
Low- and intermediate-level solid radwaste	CPS	2115.0	1483.7	1.50E+15	Cs-137, Ra-226, C-14, H-3,Th-232, U-238+U-235
	DIA	624.3	733.9	5.85E+11	Cs-137, Pu-239, Ra-226, U-238+U-235
	OIA	530.1	346.3	1.49E+13	Cs-137, Kr-85, Ra-226, U-238+U-235
	LIA	699.0	732.5[-3]	4.98E+12	C-14, H-3, U-238+U-235
	KhIA	2053.4	2091.7 1955.1	5.05E+12	H-3, Cs-137, Tc-99, Ra-226, U-238+U-235
Low- and intermediate-level liquid radwaste	CPS	480	-	1.05E+13	H-3, C-14
	DIA	124	-	1.17E+10	H-3, Cs-137
	OIA	183	-	1.10E+11	C-14, H-3, Cs-137
	KhIA	2	-	7.43E+06	Cs-137
Tubing contaminated by technology-enhanced naturally-occurring sources	KhIA	812	780.2	2.71E+08	Ra-226

1. The weight and volume of solid radwaste include shielding of disused radiation sources.
2. The activity takes into account decay of radionuclides.
3. The weight of solid radwaste includes the material used for layer-by-layer cementation of facilities.

4.6.2. Data on Waste as Sealed DRS Stored at RADON Facilities

Waste material	Location	Number, pcs.	Activity, Bq	Main radionuclides
Sealed DRS placed in well-type storages	CPS	6609	1.05E+14	Cs-137, Co-60, Pu-239, Am-241
	DIA	8391	9.50E+13	Cs-137, Am-241, Co-60
	OIA	19312	5.10E+13	Cs-137, Pu-239, Co-60
	LIA	8151	3.59E+13	Cs-137, Co-60, Sr90+Y90
	KhIA	15348	7.52E+13	Cs-137, Co-60, Am-241
Sealed DRS in shielding	CPS	159891	2.27E+15	H-3, Cs-137, Co-60, Pu-239, Sr90+Y90,
	DIA	212391	6.03E+14	Am-241, Cs-137, Co-60, Sr90+Y90, Pu-239
	OIA	38723	4.32E+14	Cs-137, Sr90+Y90, Pu-239
	LIA	97232	2.17E+14	Cs-137, H-3, Am-241, Pu-239
	KhIA	75249	4.56E+14	H-3, Cs-137, Co-60, Pu-239
Sealed high-power DRS (RITEG)	OIA	15	2.24E+16	Sr90+Y90

Annex 5. List of Nuclear Facilities in Decommissioning (as of 1 July 2020)

Facility	Power unit	Location	Reactor type	Date of shutdown
Nuclear facility	No. 1	ChNPP	RBMK-1000 (modified RBM-K2)	30.11.1996
Nuclear facility	No. 2	ChNPP	RBMK-1000 (modified RBM-K2)	11.10.1991
Nuclear facility	No. 3	ChNPP	RBMK-1000 (modified RBM-K7)	15.12.2000

Annex 6. Ukrainian Regulatory and Legal Documents on Nuclear and Radiation Safety

International Conventions, Treaties and Agreements

1. Convention on Early Notification of a Nuclear Accident. Decree of the Presidium of the Verkhovna Rada of the Ukrainian Soviet Republic "On Ratification of the Convention on Early Notification of a Nuclear Accident and Convention on Early Notification of a Nuclear Accident" No. 3339-XI of 30 December 1986.
2. Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency. Decree of the Presidium of the Verkhovna Rada of the Ukrainian Soviet Republic "On Ratification of the Convention on Early Notification of a Nuclear Accident and Convention on Early Notification of a Nuclear Accident" No. 3339-XI of 30 December 1986.
3. Vienna Convention on Civil Liability for Nuclear Damage. Law of Ukraine "On Accession of Ukraine to the Vienna Convention on Civil Liability for Nuclear Damage" No. 334/96-VR of 12 July 1996.
4. Convention on Nuclear Safety. Law of Ukraine "On Ratification of the Convention on Nuclear Safety" No. 736/97-VR of 17 December 1997.
5. Convention on Environmental Impact Assessment in a Transboundary Context. Law of Ukraine "On Ratification of the Convention on Environmental Impact Assessment in a Transboundary Context:" No. 534-XIV of 19 March 1999.
6. Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters. Law of Ukraine "On Ratification of the Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters" No. 832-XIV of 6 July 1999.
7. Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. Law of Ukraine "On Ratification of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management" No. 1688-III of 20 April 2000.
8. Convention on the Physical Protection of Nuclear Material and Nuclear Facilities. Law of Ukraine "On Ratification of the Amendment to the Convention on the Physical Protection of Nuclear Material" No. 356-VI of 3 September 2008.
9. Treaty on the Non-Proliferation of Nuclear Weapons of 1 July 1968. Law of Ukraine "On Accession of Ukraine to the Treaty on the Non-Proliferation of Nuclear Weapons of 1 July 1968" No. 248/94-VR of 16 November 1994.
10. Implementing Agreement between the Cabinet of Ministers of Ukraine and the NATO Support and Procurement Agency (NSPA) for the Reburial of Radioactive Waste Resulting from Military Programs for the Former Soviet Union in Ukraine. Law of Ukraine No. 526-VIII of 17 June 2015.

Laws of Ukraine

11. Law of Ukraine "On Nuclear Energy Use and Radiation Safety" No. 39/95-VR of 8 February 1995.

12. Law of Ukraine “On Radioactive Waste Management” No. 255/95-VR of 30 June 1995.
13. Law of Ukraine “Uranium Ore Mining and Milling” No. 645 of 19 November 1997.
14. Law of Ukraine “On Human Protection against Ionizing Radiation” No. 15 of 14 January 1998.
15. Law of Ukraine “General Principles for Further Operation and Decommissioning of the Chornobyl NPP and Transformation of Destroyed Chornobyl NPP Unit 4 into an Environmentally Safe System” No. 309 of 11 December 1998.
16. Law of Ukraine “Authorizing Activity in Nuclear Energy” No. 1370-XIV of 11 January 2000.
17. Law of Ukraine “Physical Protection of Nuclear Facilities, Nuclear Materials, Radioactive Waste and Other Radiation Sources” No. 2064 of 19 October 2000.
18. Law of Ukraine “Civil Liability for Nuclear Damage and Its Financial Coverage” No. 2893 of 13 December 2001.
19. Law of Ukraine “Regulation of Nuclear Safety Issues” No. 1868-IV of 24 June 2004.
20. Law of Ukraine “Procedure for Making Decisions on Siting, Design and Construction of Nuclear Facilities and Radioactive Waste Management Facilities of National Importance” No. 2861-IV of 8 September 2005.
21. Law of Ukraine “On General Principles of State Oversight (Supervision) of Economic Activities” No. 877-V of 5 April 2007.
22. Law of Ukraine “National Target Environmental Program for Radioactive Waste Management” No. 516-VI of 17 September 2008.
23. Law of Ukraine “National Program for Chornobyl NPP Decommissioning and Shelter Transformation into an Environmentally Safe System” No. 886-VI of 15 January 2009.
24. Law of Ukraine “Management of Spent Nuclear Fuel Related to Siting, Design and Construction of the Centralized Storage Facility for VVER Spent Nuclear Fuel of National Nuclear Power Plants” No. 4384-VI of 9 February 2012.
25. Law of Ukraine “On Licensing of Economic Activities” No. 222-VIII of 2 March 2015.
26. Law of Ukraine “On Environmental Impact Assessment” No. 2059-VIII of 23 May 2017.
27. Law of Ukraine “On Amendment of Article 4 of the Law of Ukraine *On Radioactive Waste Management* to Improve the Funding Mechanism for Radioactive Waste Management” No. 2124-19 of 11 July 2017.
28. Law of Ukraine “On Amendment of the Budget Code of Ukraine to Improve the Funding Mechanism for Radioactive Waste Management” No. 2125-VIII of 11 July 2017.
29. Law of Ukraine “On Strategic Environmental Assessment” No. 2354-VIII of 20 March 2018.

30. Law of Ukraine “On Amendment of Some Laws of Ukraine to Improve Legislation for Radioactive Waste Management” No. 208-IX of 17 October 2019.
31. Law of Ukraine “On Amendment of Some Laws of Ukraine for the Safe Use of Nuclear Energy” No. 613-IX of 19 May 2020.

Decrees, Resolutions and Ordinances

32. Presidential Decree “Additional Measures to Transform the Shelter into an Environmentally Safe System and Rehabilitate the Territories Affected by Radioactive Contamination Caused by the Chornobyl Accident” No. 141 of 13 April 2016.
33. Cabinet Resolution “On Approval of the Feasibility Study of Investments to Construction of the Centralized Storage Facility for VVER Spent Nuclear Fuel of National Nuclear Power Plants” No. 131-r of 4 February 2009.
34. Cabinet Resolution “Approval of the Strategy for Radioactive Waste Management in Ukraine” No. 990-r of 19 August 2009.
35. Cabinet Resolution “On Granting Authorization to Develop a Land Management Project for the Allocation of Land” No. 399-r of 23 April 2014.
36. Cabinet Resolution “On Withdrawal and Provision of Lands for Permanent Use with Change of Original Purpose” No. 721-r of 5 October 2016.
37. Cabinet Resolution “On Approval of Construction Project *Zaporizhzhya NPP. Development of Radioactive Waste Treatment Plant. Reconstruction* (Revision)” No. 239-r of 5 April 2017.
38. Cabinet Resolution “On Approval of Construction Project *Energoatom KhNPP Radioactive Waste Treatment Plant*” No. 240-r of 5 April 2017.
39. Cabinet Resolution “On Approval of Construction Project *Centralized Storage Facility for VVER Spent Nuclear Fuel of National Nuclear Power Plants*” No. 380-r of 7 June 2017.
40. Cabinet Resolution “On Approval of the Energy Strategy of Ukraine until 2035 *Safety, Energy Efficiency, Competitiveness*” No. 605-r of 18 August 2017.
41. Cabinet Resolution “On Closure of the Ukrainian State Association *Radon*” No. 233-r of 10 April 2019.
42. Cabinet Resolution “On Approval of the Concept for State Economic Program for Management of Spent Nuclear Fuel from National Nuclear Power Plants until 2024” No. 385-r of 5 June 2019.
43. Cabinet Ordinance “On Approval of the Procedure for Public Hearings on Nuclear Energy Use and Radiation Safety” No. 1122 of 18 July 1998.
44. Cabinet Ordinance “On Emergency Measures to Improve the Safety and Reliability of Nuclear Energy” No. 1553 of 12 October 2000.

45. Cabinet Ordinance “On Approval of Lists with Positions and Specialties of Personnel for Operation of Nuclear Facilities Whose Training Is Subject to Licensing and Positions of Personnel Directly Involved into Reactor Control” No. 1683 of 8 November 2000.
46. Cabinet Ordinance “On Some Issues of Radioactive Material Transport” No. 1196 of 3 October 2007.
47. Cabinet Ordinance “On Approval of Provisions for the Unified State Civil Protection System” No. 11 of 9 January 2014.
48. Cabinet Ordinance “On Supervisory Board to Monitor the Use and Investment of Financial Reserve Funds Intended for Future Decommissioning of Operating Nuclear Power Plant Units” No. 21 of 22 January 2014.
49. Cabinet Ordinance “On Amendment of Cabinet Ordinance No. 1570 of 2 October 2003” No. 336 of 13 August 2014.
50. Cabinet Ordinance “On Approval of the Statute on the State Nuclear Regulatory Inspectorate of Ukraine” No. 363 of 20 August 2014.
51. Cabinet Ordinance “On Amendment of Cabinet Ordinance No. 594 of 27 April 2006” No. 280 of 19 April 2017.
52. Cabinet Ordinance “On Implementation of the Association Agreement between Ukraine, on the one hand, and the European Union, European Atomic Energy Community and Their Member States, on the other hand” No. 1106 of 25 October 2017.
53. Cabinet Ordinance “On Approval of the National Emergency Response Plan” No. 223 of 14 March 2018.
54. Cabinet Ordinance “On Approval of the Procedure for Using the State Fund for Radioactive Waste Management” No. 330 of 25 April 2018.
55. Cabinet Ordinance “On Approval of the Technical Regulation of Packaging for Storage and Disposal of Radioactive Waste” No. 884 of 17 October 2018.
56. Cabinet Ordinance “On Approval of the National Target Environmental Program of Priority Measures to Bring the Facilities and Site of the Former Uranium Enrichment Association “Prydniprovsk Chemical Plant” into Safe State for 2019-2023” No. 756 of 21 August 2019.
57. Cabinet Ordinance “On Approval of the Procedure for Using Funds Allocate in the State Budget to Cover Priority Measures to Bring the Facilities and Site of the Former Uranium Enrichment Association “Prydniprovsk Chemical Plant” into Safe State” No. 912 of 23 October 2019.
58. Cabinet Ordinance “On Amendment of Some Cabinet Ordinances” No. 916 of 6 November 2019.

Regulatory Documents

59. General Safety Provisions for Decommissioning of Nuclear Power Plants and Research Reactors, approved by Order of the Ministry for Environmental Protection and Nuclear Safety No. 2 of 9 January 1998.
60. Safety Conditions and Requirements (Licensing Terms) for Radioactive Waste Management Activities, approved by SNRIU Order No. 110 of 22 October 2002.
61. Procedure for State Inventory of Radioactive Waste, approved by SNRIU Order No. 27 of 11 February 2003.
62. Requirements for the Procedure and Scope of Activities for Lifetime Extension of Instrumentation and Control Systems Important to Safety of Nuclear Power Plants, approved by SNRIU Order No. 42 of 18 March 2003.
63. Procedure for State Safety Oversight of Nuclear Energy Use, approved by SNRIU Order No. 141 of 19 November 2003.
64. Recommendations on Establishing Criteria for Acceptance of Conditioned Radioactive Waste for Disposal in Near-Surface Facilities, approved by SNRIU Order No. 160 of 25 October 2004.
65. General Requirements for Long-Term Operation of Nuclear Power Plants Based on Periodic Safety Review, approved by SNRIU Order No. 181 of 26 November 2004.
66. General Safety Provisions for Dry Interim Spent Fuel Storage Facilities, approved by SNRIU Order No. 198 of 29 December 2004.
67. Procedure for State Review on Nuclear and Radiation Safety, approved by SNRIU Order No. 21 of 21 February 2005.
68. Requirements for Certification of Systems for Nondestructive Inservice Inspection of Equipment and Piping of Nuclear Power Plants, approved by SNRIU Order No. 115 of 10 October 2005.
69. Rules on Nuclear and Radiation Safety of Radioactive Material Transport, approved by SNRIU Order No. 132 of 30 August 2006.
70. Requirements for the Frequency and Contents of Reports Submitted by Licensees in Use of Nuclear Energy, approved by SNRIU Order No. 162 of 16 October 2006.
71. Conditions and Procedure for Granting Individual Written Permits for Activities at Stages of Operation and Closure of Radioactive Waste Disposal Facilities, approved by SNRIU Order No. 161 of 19 November 2007.
72. General Safety Provisions for Nuclear Power Plants, approved by SNRIU Order No. 162 of 19 November 2007.
73. Requirements for the Structure and Contents of Safety Analysis Reports for Radioactive Waste Storage Facilities, approved by SNRIU Order No. 168 of 7 December 2007.
74. Requirements and Rules for Long-Term Storage of Long-Lived and High-Level Radioactive Waste before Disposal in Deep Geological Formations, approved by SNRIU Order No. 169 of 7 December 2007.
75. Nuclear Safety Rules for Pressurized Water Reactors of Nuclear Power Plants, approved by SNRIU Order No. 73 of 15 April 2008.
76. Requirements for Siting of a Radioactive Waste Disposal Facility, approved by SNRIU Order No. 188 of 14 November 2008.
77. Requirements for Packages for Long-Term Storage and Disposal of High-Level Waste Resulting from Spent Nuclear Fuel Reprocessing, approved by SNRIU Order No. 34 of 16 February 2009.
78. Requirements for Safety Assessment of Nuclear Power Plants, approved by SNRIU Order No. 124 of 22 September 2010.

79. Procedure for Release of Radioactive Materials from Regulatory Control within Practices, approved by SNRIU Order No. 84 of 1 July 2010.
80. General Requirements for the Management System for Activities in Use of Nuclear Energy, approved by SNRIU Order No. 190 of 19 December 2011.
81. Conditions and Procedure for Granting Licenses for Activities of Operating Organization Officials, approved by SNRIU Order No. 195 of 28 December 2011.
82. Requirements for the Management System for Activities of the Operating Organization (Operator), approved by SNRIU Order No. 51 of 2 March 2012.
83. General Safety Rules for Medical Radiation Sources, approved by SNRIU/Ministry of Health Order No. 51/151 of 16 February 2017.
84. Requirements for Periodic Safety Review of Nuclear Power Plants, approved by SNRIU Order No. 313 of 30 August 2017.
85. Rules for Design and Safe Operation of Containment Safety Systems, approved by SNRIU Order No. 140 of 3 April 2018.
86. General Safety Provisions for Predisposal Management of Radioactive Waste, approved by SNRIU Order No. 79 of 1 August 2017.
87. Requirements for Periodic Safety Review of Nuclear Power Plants, approved by SNRIU Order No. 13 of 30 August 2017.
88. Requirements for Risk-Informed Decision-Making on Safety of Nuclear Power Plants, approved by SNRIU Order No. 443 of 1 December 2017.
89. Requirements for Seismic Design and Seismic Safety Assessment of Nuclear Power Plants, approved by SNRIU Order No. 265 of 25 June 2018.
90. General Safety Provisions for Disposal of Radioactive Waste, approved by SNRIU Order No. 331 of 13 August 2018.
91. Safety Requirements for Nuclear Fuel Management, approved by SNRIU Order No. 269 of 21 June 2019.
92. Requirements for the Structure and Contents of Safety Analysis Reports on Surface and Near-Surface Disposal Facilities for Radioactive Waste, approved by SNRIU Order No. 520 of 2 December 2019.
93. Provisions on the Functional Subsystems on Nuclear and Radiation Safety of the Unified State Civil Protection System, approved by SNRIU Order No. 57 of 14 February 2020.
94. Requirements for the Structure and Contents of Safety Analysis Reports on Radioactive Waste Treatment Facilities, approved by SNRIU Order No. 249 of 10 June 2020.

Standards and Rules

95. NRBU-97. Radiation Safety Standards of Ukraine. State Health and Safety Standards, approved by Order of the Chief Medical Doctor of Ukraine No. 62 of 1 December 1997.
96. NRBU-97/D-2000. Radiation Safety Standards of Ukraine: Supplement. Radiation Protection against Potential Exposure Sources. State Health and Safety Standards, approved by Order of the Chief Medical Doctor of Ukraine No. 116 of 12 July 2000.
97. Basic Health and Radiation Safety Rules of Ukraine (OSPU-2005), approved by Order of the Ministry of Health of Ukraine No. 54 of 2 February 2005.

Annex 7. National and International Safety Reports Issued in the Reporting Period

1. National Report of Ukraine on Compliance with Obligations under the Convention on Nuclear Safety (2019).
2. Analytical Report on Technology-Related and Natural Safety in Ukraine in 2017.
3. Analytical Report on Technology-Related and Natural Safety in Ukraine in 2018.
4. Annual Report on Nuclear and Radiation Safety in Ukraine for 2017.
5. Annual Report on Nuclear and Radiation Safety in Ukraine for 2018.
6. Annual Report on Nuclear and Radiation Safety in Ukraine for 2019.

Annex 8. Radiation Protection of Personnel

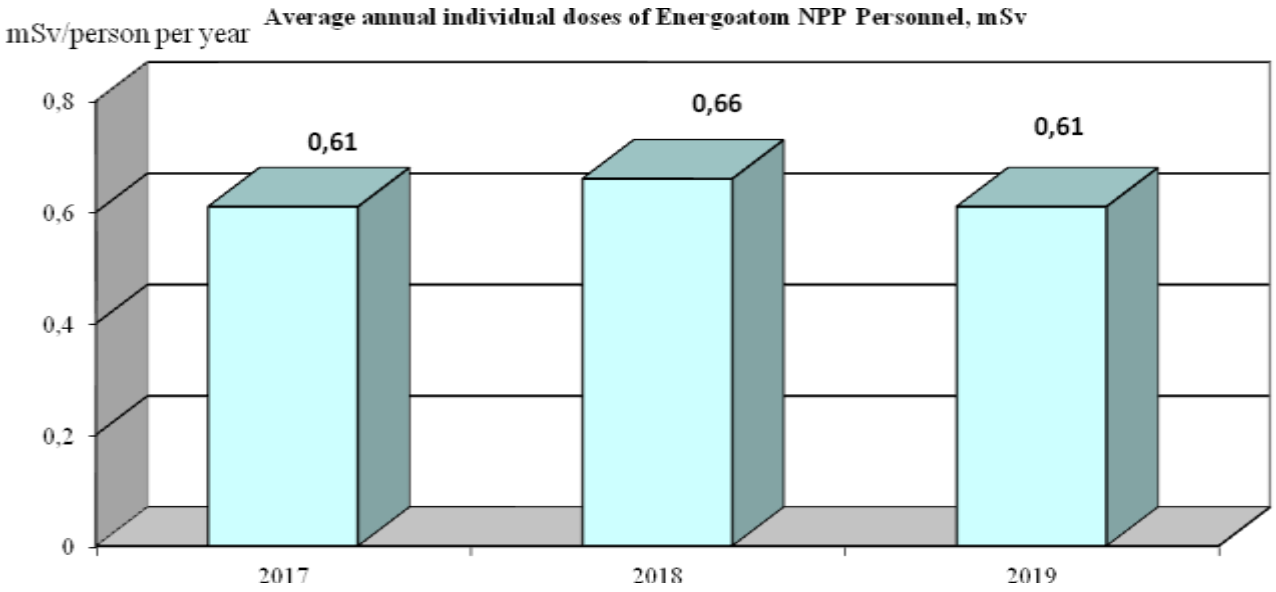


Figure L.8.1. Average Annual Individual Doses of Energoatom NPP Personnel in 2017–2019

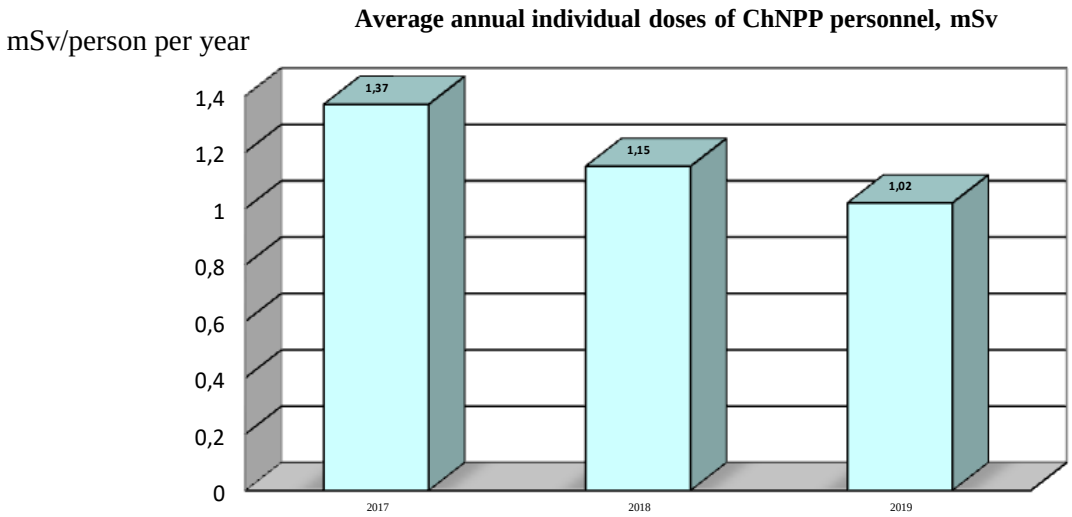


Figure L.8.2. Average Annual Individual Doses of ChNPP Personnel

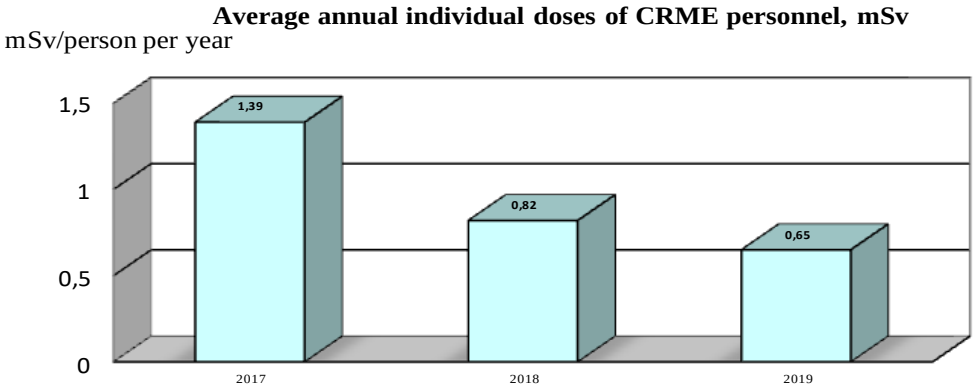


Figure L.8.3. Average Annual Individual Doses of CRME Personnel

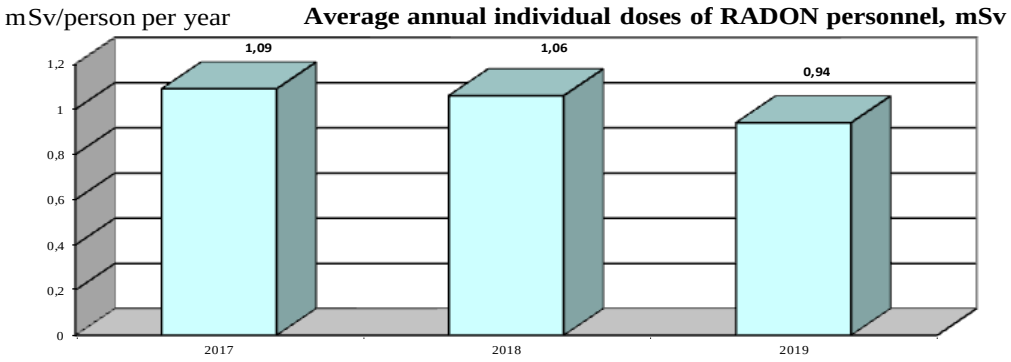


Figure L.8.4. Average Annual Individual Doses of RADON Personnel

Annex 9. Shelter

Construction of New Safe Confinement (NSC) for Shelter

Construction of the New Safe Confinement is the main project within Shelter transformation into environmentally safe system.

The confinement is a protective structure including process equipment for dismantling of unstable Shelter structures and retrieval of fuel-containing materials from the destroyed ChNPP Unit 4, radwaste management and other systems and is intended to transform this unit into an environmentally safe system and ensure the safety of personnel, the public and the environment.

The envisaged period of NSC operation is 100 years.

The NSC project is divided into two startup stages (SS):

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

The French Company Joint Venture *Novarka* (which included V*INCI Construction Grands Projects* and *Bouygues Travaux Publics* Companies) was NSC SS-1 contractor. Other foreign companies, as well as Ukrainian design, research and construction organizations, were involved in the activities as subcontractors.

Detailed information on the Shelter is presented in NRU-2017 (Annex 9).

Implementation of NSC SS-1 was completed in 2019. The State Architecture and Construction Inspectorate of Ukraine issued a certificate on compliance of completed NSC SS-1 with design documents, which confirms the readiness of NSC SS-1 for operation, on 20 November 2019.

According to the terms of operating license (EO No. 000033 issued by the SNRIU on 30 December 2001), ChNPP shall receive an individual permit for commissioning/trial commissioning of NSC SS-1.

In pursuance of the specified condition, ChNPP submitted an application and a package of documents for obtaining relevant permit to the SNRIU. According to the state review of nuclear and radiation safety of submitted documents and inspection, the SNRIU issued an individual permit to ChNPP for trial and commercial operation of NSC SS-1 on 24 July 2020.

The planned term of NSC SS-1 trial and commercial operation is one year. After its completion, ChNPP shall receive a license for operation of the complex of NSC and the Shelter (licenses for processing, storage of radioactive waste existing and generated during Shelter transformation into an environmentally safe system within NSC operation including the Shelter)

The main task after NSC SS-1 commissioning in the coming years is the implementation of NSC SS-2, dismantling of unstable Shelter structures, radioactive waste management, and retrieval/transfer of fuel containing materials into controlled state in future.

Annex 10. Information on Safe Management of Uranium Ore Processing Waste

Information on Safe Management of Uranium Ore Processing Waste and Impact of *SkhidGZK* Uranium Mines on the Environment and the Public

Uranium ore mining and processing in Ukraine began in the late 1940s. These activities were carried out in conditions of secrecy and confidentiality of information on compliance with radiation and environmental safety by the State Enterprise *Eastern Ore Mining and Processing Plant* (*SkhidGZK*) and the Industrial Association *Prydniprovsk Chemical Plant* (*PChP*) located on the territory of the Dnipropetrovsk region.

In 1991, *PChP* ceased its uranium ore processing activities.

At present, *SkhidGZK* is the only enterprise in Ukraine that carries out a full cycle of uranium and ore mining and processing. Uranium ore is mined underground at the Vatutinsky (Smolinska mine), Michurinsky and Central (Ingulska mine) and Novokostiantynivsky (Novokostiantynivska mine) deposits in the Kirovohrad region. Processing of uranium ores and production of uranium oxide concentrate (U_3O_8) are carried out at the hydrometallurgical plant (Zhovti Vody in the Dnipropetrovsk region), as well as at Smolinska mine by the technology of heap leaching.

According to the World Nuclear Association, Ukraine ranked 7th in the world in terms of nuclear power generation in 2019. The share of electricity generated by nuclear energy in the energy balance of Ukraine is about 55 %.

The nuclear energy needs of Ukraine amount to 2,480 tons of uranium per year, while *SkhidGZK* ensures about 40 % of Ukraine's needs.

The strategic objective of *SkhidGZK* is to increase the production of uranium oxide concentrate to volumes that will meet 100 % of the needs of Ukrainian NPPs to achieve energy independence of the country, which meets the provisions of the Energy Strategy of Ukraine until 2035 "Safety, Energy Efficiency, Competitiveness" approved by Resolution of the Cabinet of Ministers of Ukraine No. 605-r on 18 August 2017.

In uranium ore processing, waste of uranium ore processing (tails) with a high content of natural origin radionuclides is generated. It is transported by pulp pipeline and placed in specially equipped tailing pit "Scherbakivska" located at a distance of 1.5 km south of Zhovti Vody. As of 01 July 2020, $46.1 \cdot 10^6$ tons of uranium production waste with a total activity of $0.46 \cdot 10^{15}$ Bq is stored in the tailing pit.

Uranium ore processing waste is constantly under a layer of water to minimize the impact of the tailing pit on the environment.

In addition, uranium ore processing waste is stored in the brown iron ore quarry located 2 km from the north-western outskirts of Zhovti Vody. The total amount of waste from uranium ore processing placed in the tailing pit from the beginning of its operation since 1964 is $15.94 \cdot 10^6$ tons with a total activity of $0.93 \cdot 10^{14}$ Bq. Since 01 January 1996, the tailing pit has not been operated and is now closed.

Waste from the uranium ore processing by means of heap leaching is used to fill spent underground mine workings at Smolinska mine.

In order to prevent emergencies (dust emission, loss of integrity of dams, slurry pipelines, etc.), *SkhidGZK* experts constantly monitor the technical condition of hydraulic structure of tailing pits and heap leaching facilities and perform radiation monitoring of the environment in the territory of uranium facilities, and dosimeteric monitoring of personnel is carried out in their control areas and observation areas.

According to the results of dosimetric monitoring in 2019, individual radiation doses of the personnel of *SkhidGZK* involved into uranium ore processing activities were from

1.53 to 4.12 mSv/year, which does not exceed the established control levels of *SkhidGZK* personnel exposure. At the same time, the problem of the enterprise remains the creation of a modern system of dosimetric control of personnel, which will ensure the receipt of the most comprehensive and accurate data on individual radiation doses of *SkhidGZK* personnel.

In order to introduce individual dosimetry of radon and its daughter decay products, uranium and long-lived alpha-nuclides using personal dosimeters, the company has developed a project "Organization of Individual Dosimetry of Radon and Its Daughter Decay Products at Uranium Mining and Processing Facilities".

According to the results of radiation monitoring, there was no deterioration of the radiation state of the environment in the area of impact of *SkhidGZK* uranium facilities (mines, hydrometallurgical plants, tailing pits) in 2019.

Information on Safe Management of Uranium Ore Processing Waste and Impact of *Baryer* Uranium Mines on the Environment and the Public

Uranium facilities of the Industrial Association *Prydniprovsk Chemical Plant* (*PChP*) are located in Kamianske (former Dniprodzerzhynsk) of the Dnipropetrovsk region. *PChP* was one of the most powerful mining and processing enterprises of the former USSR, which from 1949 to 1991 processed uranium ores from various deposits in the Soviet Union and Eastern Europe to obtain uranium concentrate.

As a result of these activities, about 42 million tons of radioactively contaminated waste of uranium ore processing, residues of uranium raw materials and production waste with a total activity of $3.14 \cdot 10^{15}$ Bq were generated. This waste is located in nine tailing pits and repositories with a total area of 2.68 million m^2.

The cessation of uranium concentrate production in 1991-1992 led to the shutdown of most uranium facilities of *PChP*, which due to economic circumstances were not decommissioned in accordance with the requirements of the legislation that was in force at that time. This led to a situation that currently a significant part of the facilities and territory of *PChP* are radioactively contaminated as a result of the destruction of production facilities and the spread of contaminated materials and dust.

The restructuring of *PChP* performed after the cessation of its activities resulted in the current situation where several dozen enterprises, most of which have nothing to do with activities in the field of nuclear energy use are located on its territory.

State Enterprise *Baryer* was established by Order of the Ministry of Fuel and Coal Industry of Ukraine No. 562 dated 13 December 2000 to implement systemic remediation measures on the territory of the former *PChP*.

The main activities of *Baryer* are remediation efforts on radioactively contaminated territories; operation and decommissioning of tailing pits with uranium ore processing waste; decontamination of radioactively contaminated buildings, structures, equipment, territories contaminated by naturally occurring radionuclides; radiation monitoring, etc.

At present, *Baryer* owns all tailing pits and facilities with uranium ore waste, as well as some industrial buildings and other buildings of *PChP* with radioactively contaminated equipment and pipelines.

Baryer has SNRIU License No. OB001063 to provide activities on uranium ore processing with regard to liquidation, shutdown or conversion of uranium facilities valid until 19 February 2021.

The characteristics of uranium facilities of former *PChP* belonging to *Baryer* are presented in Table 1.

The National Target Environmental Program of Priority Measures to Transform Facilities and Site of the Former Industrial Association *Prydniprovsk Chemical Plant* for 2019-2023 (the Program) was approved by Resolution of the Cabinet of Ministers of Ukraine No. 756 dated 21 August 2019 in order to ensure safe state of *PChP* territories and facilities. There are funds in the amount of 247,948.79 thousand UAH to implement tasks and measures of the Program. In 2019, it was planned to perform design and estimate activities on the liquidation of building No. 104, conversion of Sukhachivske tailing pit (section II) and construction of waste decontamination site; provide services on the technical support of European Commission project measures for safe maintenance of uranium facilities, observation of their impact on the environment and radiation and dosimetric monitoring. Unfortunately, the lack of adequate funding did not allow implementation of measures envisaged by the Program for 2019.

In current conditions, personnel exposure dose on the territory of the former *PChP* and in the area of its impact is estimated at approximately 0.6 mSv/year, which does not exceed the appropriate dose limit set by NRBU-97. This dose is mainly formed by external exposure and inhalation of ^{222}Rn. Exposure doses to personnel living in Kamianske at a distance of about 800 m from the perimeter of the fence of the former PChP as a result of atmospheric dispersion of ^{222}Rn from tailing pits are very small (about 10^{-4} mSv/year) and do not pose a significant risk.

The most contaminated buildings No. 103 and No. 104 that were part of the uranium ore processing cycle and the area around them pose the greatest danger both to the personnel of *Baryer* and personnel working on *PChP* site.

Increased dose rates of gamma radiation (on average up to 100 μSv/year and higher) and dispersed materials containing uranium extraction residues with a relatively high concentration of Ra-226 also create an area with increased emanation of Rn-222. The average concentrations of Rn-222 activity in the adjacent areas around Building No. 103 vary from 90 to 200 Bq/m^3 exceeding the established permissible concentrations.

The specified buildings are in poor technical condition, however, access to the buildings is controlled.

Operating period	**Tailing pit**	**Area, ha**	**Volume of tailing, mln.t / mln. m^3**	**Total activity, 10^{12} Bq**	**Uranium content, mg/kg**
Tailing pits of *SkhidGZK*					
1959-1970	Scherbakivska (old basin)	614.9	7.640/7.119	79.318	5 - 10
1979-until present	Scherbakivska (new basin)		46.120/41.410	462.464	6 - 8
1964-until June 1990 1991-1996 (occasional)	Iron ore quarry	55.0	15.94/12.40	93.300	10
***PChP* tailing pits registered on *Baryer* Books**					
1949-1954	Western	4.0	0.77/0.35	180	700
1951-1954	Central Yar	2.4	0.22/0.10	104	630

1956-1990	South Eastern	3.6	0.33/0.15	67	22
1968-1983	Sukhachivske Section 1	90.6	19.0/8.60	710	80
1983-present time	Sukhachivske Section 2	70.0	9.60/5.50	270	80
1960-1991	Base C	34.0	0.3/0.10	440	1000
1954-1968	Dniprovske	73.0	12.0/5.84	1400	230
1982	Blast Furnace 6	0.2	0.04/0.02	11	-
1965-1988	Lanthanum Fraction Building No. 602	0.6	0.007/0.003	0.86	-

In 2019, with the support of the European Commission, technical assistance project U4.02/16 "Emergency Measures to Eliminate Emergency Situation with the Industrial Association *Prydniprovsky Chemical Plant* in Kamianske in Ukraine (former Dniprodzerzhynsk)" was implemented on the site of the former *PChP*. In particular, three projects were developed and subject to nuclear and radiation safety review: on construction of control areas and a site for storage of radioactively contaminated materials on the industrial site of the former *PChP*, activities on stabilization of buildings and activities on transfer of freely located and easily moved facilities of radiological risk from the territory of *PChP* for temporary storage, implementation of which is planned for 2020.

An important project for remediation of the former *PChP* territory is the project "Risk Reduction, Monitoring of Radioactive Contamination and Improvement of Environmental Monitoring System at *PChP*" launched by the Government of Norway in the fourth quarter of 2019 and which will be implemented to 2022 and within which the following activities and efforts will be implemented:

- Radiological characterization of the former *PChP* territory, which will allow clearing of the northern part of *PChP* site and return it to economic use;
- arrangement of the groundwater monitoring network to define the impact of *PChP* and *Baryer* uranium facilities on its state.

Table 1

No.	Facility name	Area, ha	Volume of waste, mln. t/ mln. m^3	Max thickness of waste layer, m	Total activity Bq	Gamma radiation dose rate (μSv/h)	Activity concentration of Rn-222 Bq/m3
1	Western	4.02	0.77/0.35	18.0	$1.8 \cdot 10^{14}$	to 1.0	25 – 240.0
2	Dniprovske	73.0	12.0/5.9	12.0	$1.4 \cdot 10^{15}$	0.5 – 4.5	to 60
3	Central Yar	2.4	0.22/0.10	10.8	$1.04 \cdot 10^{14}$	0.3 – 50.0	70 - 620
4	South Eastern	3.6	0.33/0.15	19.2	$6.7 \cdot 10^{13}$	to 0.3	to 93
5	Base C	25.0	0.3/0.15	no data	$4.4 \cdot 10^{14}$	0.14 – 24.2	80 - 386
6	Blast Furnace 6	1.8	0.4/not defined	no data	$3.3 \cdot 10^{14}$	to 0.3	no data
7	Sukhachivske Section I	90.6	19.06/8.6	27.0	$7.1 \cdot 10^{14}$	0.3 – 5.39	to 850
8	Sukhachivske Section II	70.0	9.6/4.4 29.9/14.7 (reserve)	no data	$2.7 \cdot 10^{14}$	to 0.3	to 25
9	Lanthanum Fraction (Building No. 602)	0.6	0.007/0.003	no data	$8.6 \cdot 10^{11}$	to 0.3	no data
Total		271,02	42.33/19.65		$3.14 \cdot 10^{15}$		
10	Building No. 103	1759 m^2				0.75 – 300.0	90 - 200
11	Building No. 104	4620 m^2				0.5 – 75.0	90 - 200

Notes:
- background value of gamma radiation dose rate in the region – to 0.3 μSv/h;
- background value of activity concentration of ^{222}Rn in the region – 25.0 Bq/m^3;
- permissible concentration for drinking water (Bq/l): ^{238}U – 10.0; ^{210}Po – 0.2; ^{210}Pb – 0.5; ^{226}Ra – 1.0.

Annex 11. Organizational Structure of the State Nuclear Regulatory Inspectorate of Ukraine (as of 1 July 2020)