DRAFT OF

UPDATED STRATEGY FOR THE MANAGEMENT OF SPENT NUCLEAR FUEL AND RADIOACTIVE WASTE IN BULGARIA - NATIONAL PROGRAMME IN CONFORMITY WITH DIRECTIVE 2011/70/EURATOM

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List of acronyms used	
NPP	Nuclear Power Plant
AM	Alternative manufacturer
NRA	Nuclear Regulatory Agency
BAS	Bulgarian Academy of Sciences
ECT	Evaporator Concentrate Tanks
SFP	Spent Fuel Pool
HLW	High level waste
WWER	Water cooled water moderated energy reactor
DGR	Deep Geological Repository
EIAR	Environmental Impact Assessment Report
SE RAW	State Enterprise “Radioactive Waste”
EAD	Single-owner shareholding company
EBRD	European Bank for Reconstruction and Development
EC	European Commission
EU	European Union
SUNEA	Safe Use of Nuclear Energy Act
D	Decommissioning
INRNE - BAS	Institute of Nuclear Research and Nuclear Energy - Bulgarian Academy of Sciences
(R)CA	(Radiologically) Controlled Area
Load Factor	Load Factor
EvC	Evaporator Concentrate
EF	Efficiency Factor
IAEA	International Atomic Energy Agency
ME	Ministry of Energy
TH	Turbine Hall
MEW	Ministry of environment and water
CoM	Council of Ministers
KIDSF	Kozloduy International Decommissioning Support Fund
NCRRP	National Centre of Radiobiology and Radiation Protection
NDF	National Disposal Facility for short-lived low and intermediate level waste
EIA	Environmental Impact Assessment
OECD	Organisation for Economic Co-operation and Development
CR	Control Rods of the reactor control and protection system
SNF	Spent Nuclear Fuel
RAW	Radioactive Waste
AB	Auxiliary building
SD	Specialized Division (of the State Enterprise “Radioactive Waste”)
PMF	Volume Reduction Factor Plasma Melting Facility of Waste
SD “D of Units 1-4”	Specialized Division “Decommissioning of Units 1-4”

SD "RAW-Kozloduy"	Specialised Division "Radioactive Waste - Kozloduy"
SD NDF	Specialized Division "National Disposal Facility"
SD "PRAWR - Novi Han"	Specialized Division "Permanent Repository for Radioactive Waste - Novi Han"
RCC	Reinforced concrete container
FNF	Fresh Nuclear Fuel
HM	Heavy Metal
NFDF	"Nuclear Facilities Decommissioning" Fund
RAWF	Radioactive Waste Fund
WSFSF	Wet Spent Nuclear Fuel Storage Facility
DSFSF	Dry Spent Fuel Storage Facility
SRDW	Size Reduction and Decontamination Workshop
RAWPW	Radioactive Waste Processing Workshop (at the SE "RAW – Kozloduy")
NFC	Nuclear Fuel Cycle
NF	Nuclear Facilities
AC	Actual Cost
CPI	Cost Performance Index
ESA	European Supply Agency
EV	Earned Value
NEA	Nuclear Energy Agency
PV	Planned Value
SPI	Schedule Performance Index

INTRODUCTION

This Strategy for Management of Radioactive Waste (RAW) and Spent Nuclear Fuel (SNF), (hereunder called "the Strategy"), represents the national programme of the Republic of Bulgaria for responsible and safe management of SNF and RAW within the meaning of Directive 2011/70/Euratom of the Council of the EU for establishing a Community framework for responsible and safe management of SNF and RAW (hereunder referred to as "Directive 2011/70/Euratom"). It has been drafted in pursuance of Article 74, paragraph 3 of the Safe Use of Nuclear Energy Act (SUNEA) and sublegislative normative documents.

The first version of the Strategy was adopted by the Council of Ministers (CoM) of the Republic of Bulgaria in 2004, and later updated in 2011 and 2015. The current update reflects the status in the sector as at 2022, and the changes made to the relevant international and national legislation since 2015. Due account has been taken, as appropriate, of the technical and scientific progress, analyses and self-assessments performed, recommendations made, lessons learned and good practices from the experience of other countries and peer reviews.

The Strategy for SNF and RAW Management is a basic document presenting the national policy, principles, goals and tasks related to the safe and responsible management of all stages of the management of SNF and all types of RAW - from their generation to disposal. The Strategy outlines the implemented and the planned practical solutions, their stages and completion dates, as well as the manner of funding. Information is presented on the condition and operation of the existing facilities, and the steps leading to the implementation of future ones.

This Strategy has considered the comments made by the European Commission on the infringement procedure launched against the Republic of Bulgaria No. 2018/2017 for nonperformance of obligations ensuing from Directive 2011/70/Euratom, as well as the recommendations of the IAEA ARTEMIS mission conducted in 2018, which constitutes an international peer review within the meaning of article 14 of Directive 2011/70/Euratom. The Strategy has also been underpinned by the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, in effect since 2001 (hereunder referred to as "the Joint Convention").

The Strategy has taken into account the occurrence of unfavourable geopolitical changes in the beginning of the year 2022, following the war initiated by the Russian Federation (RF) against the Ukraine and the emerging risks associated with the management of SNF and high level waste (HLW).

1. NUCLEAR PROGRAMME OF THE REPUBLIC OF BULGARIA

Nuclear energy is a key energy source for maintaining the power and energy balance of the Republic of Bulgaria. Electricity is generated with high production efficiency, low carbon dioxide emissions, competitive prices and maintaining a high level of nuclear safety and radiation protection.

Kozloduy NPP is a baseload power plant and plays a key role for keeping up the power system stability margin. With a share of up to 41% of the national electricity production in recent years, the nuclear power plant has been a guarantor of the energy security of Bulgaria.

The nuclear programme of the Republic of Bulgaria was launched in the early 1960s with the construction and commissioning of the IRT-2000 research reactor at the Institute for Nuclear Research and Nuclear Energy of the Bulgarian Academy of Sciences. The construction of Kozloduy NPP Unit 1 started in the late 1960s. Over the years, a total of six nuclear power units have been built on the plant site (four WWER-440 units and two WWER-1000 units), equipped with pressure water reactors, using low-enriched uranium fuel and light water as coolant and moderator.

In fulfillment of Bulgaria's commitments related to the country's accession to the European Union (EU), the operation of the first four power units was terminated before the expiration of their design lifetime. Presently, Units 5 and 6 are in operation, having a total output of about 2160 MWe (reached after the implementation of the foreseen modernisation measures on units). The Republic of Bulgaria has made a decision to continue developing its nuclear programme by maximizing the lifetime of Units 5 and 6 of Kozloduy Nuclear Power Plant, in strict compliance with the requirements for nuclear safety, radiation and physical protection and safe and responsible management of SNF and RAW. New nuclear capacities are planned to be built, according to the adopted by the Council of Ministers in January 2023 „Strategic vision for the sustainable development of the electricity sector with a horizon up to 2053", which foresees the construction of two nuclear units at the Belene site by 2035/2040 and two more units at the Kozloduy site by 2045.

Since 2004, the State Enterprise „Radioactive Waste" has been the national operator for safe management of RAW and decommissioning of nuclear facilities.

1.2. Nuclear Facilities

The Republic of Bulgaria has the following nuclear facilities:

- 2 power reactors (in operation);
- 4 power reactors (in decommissioning);
- 2 SF storage facilities (in operation);
- The National Disposal Facility for LLW and ILW (construction stage);
- Repository for RAW from nuclear applications (in operation);
- Facility for RAW processing and interim storage at Kozloduy NPP (in operation);
- Facility for RAW treatment and conditioning with high volume reduction factor (plasma melting facility, PMF) (at the stage of commissioning);

The SNF from the two operating power units is stored in the spent fuel pools, at the reactor, and in the wet storage facility (WSFSF) on the Kozloduy NPP site.

The spent fuel has been removed from the reactors of Units 1-4 and their spent fuel pools, and is stored in the storage facilities on the Kozloduy NPP site;

The construction of a National Disposal Facility for low- and intermediate level waste is under way.

The repository for RAW from nuclear applications in Novi Han has been accepting for interim storage all the RAW generated outside Kozloduy NPP, including orphan radioactive sources, investigative material and cargo detained during transit passage.

All the RAW generated by the operation of Kozloduy NPP is conditioned and stored in the SD "RAW - Kozloduy" that is a RAW management facility.

2. FUNDAMENTAL PRINCIPLES, POLICY AND OBJECTIVES

2.1. Fundamental principles in the regulation of SNF and RAW management

Internationally accepted basic principles:

- In SNF and RAW management, nuclear safety and radiation protection take priority over all other aspects of this activity;
- The licensees must observe the requirements, norms and rules of nuclear safety, radiation protection and physical protection in SNF and RAW management, also build and maintain an effective activity management system that prioritizes safety and ensures a high safety culture;
- SNF and RAW should be managed in such a way as to avoid undue burden on the future generations;
- Optimisation of protection against the ionising radiation from SNF and RAW;
- Application of the graded approach in determining the safety requirements;
- Taking account of the interfaces between all the stages related to RAW generation and management;
- Traceability of radioactive wastes at all the stages of their management;
- Minimisation of the generated SNF quantities and RAW volumes subject to disposal;
- Participation of all the stakeholders in the decision making on SNF and RAW management.

2.2. Policy

The nuclear programme of the Republic of Bulgaria has adopted the policy of implementing a nuclear fuel cycle in which once the nuclear fuel has depleted its lifetime in the reactor, it is then moved for initial and then interim storage on-site, after which it is transported for long-term storage and processing. This approach implemented so far has been based on long-term bilateral contracts for SNF processing in the Russian Federation. The applicable legislation provides that the fission material obtained from processing (i.e. plutonium and recycled uranium) shall become property of the EU. The vitrified high level waste (HLW) and other waste generated must be returned to the Republic of Bulgaria following a certain time period. To ensure their interim storage in the medium term an appropriate storage facility has to be constructed on the Kozloduy NPP site. In the long term (by 2050), the Republic of Bulgaria has to build and commission a deep geological repository (DGR) for the disposal of vitrified HLW, as well as other high level RAW from decommissioning activities.

The nuclear reactors operation results in the generation of RAW of different categories and types. In Bulgaria, nuclear energy RAW has been generated since the commissioning of Kozloduy NPP Unit 1 in 1974. These quantities of generated RAW undergo corresponding processing and then are moved for storage in appropriate facilities on the plant site. The subsequent stages of the process involve RAW treatment and conditioning in the SE RAW facilities, and final disposal in the NDF that is currently under construction. The long-lived intermediate level waste as well as HLW must be disposed in a DGR. Very low level radwaste (below the corresponding reference limits) shall be disposed in near surface depots. RAW conditioning and disposal shall be implemented in the shortest practicable time after its generation. A certain category of very low level RAW may be exempt from regulatory control.

In Bulgaria, radiation sources are used at about 2300 sites of the industry sector, medicine, agriculture and research institutes. The disused sources qualify as RAW and are, therefore, transferred to the Specialized Division "PRAWR - Novi Han", where they are subject to treatment and storage.

The policy of the Republic of Bulgaria regarding SNF and RAW management has been specified in the national legislation (mainly the SUNEA, Environment Protection Act, Health Protection Act and the regulations on their implementation) and includes the following main aspects:

- The SNF and RAW management has to be carried out in a way that may cause minimum negative effects on human health and the environment;
- The principal approach to the management of SNF and RAW consists in their concentration and isolation from the environment, including disposal using passive structures, components and systems to ensure safety;
- The SNF and RAW management is regulated by the Government, represented by legal persons that have obtained a permit or licence from the Chair of the National Regulatory Agency (NRA);
- Achievement and maintaining a high level of nuclear safety, radiation and physical protection at all the stages of SNF and RAW generation and management;
- Processing of the whole SNF quantity, interim storage in a specialised facility for all types of RAW shipped back to Bulgaria after processing, and final disposal in the DGR.
- The licensee bears the responsibility for observing the regulatory norms and requirements for safe management of RAW and its transfer to SE RAW, or exemption;
- SE RAW implements management of radwastes outside their generation sites;
- The state bears the final responsibility for the safe disposal of all types of radioactive waste generated from the operation of the nuclear reactors, and those resulting from SNF processing;
- The SNF generating organisations are obliged to bear the cost at all stages of its management, including the disposal of RAW generated from SNF processing, on the "polluter pays" principle, by paying the respective contributions to the specialised fund.
- The RAW generating organisations are obliged to transfer the waste to SE RAW and bear the cost at all stages of their management including disposal, on the "polluter pays" principle, by paying the respective contributions to the specialised fund.
- The state bears the responsibility for management of RAW with unknown owner;
- Import of RAW is prohibited except for the cases specified in the SUNEA;
- The principle of returning certain categories of radiation sources to their manufacturer after discontinuing their use, is applied;
- Radioactive wastes generated in the Republic of Bulgaria are disposed of on Bulgarian territory, unless an agreement has become effective for using a RAW disposal facility in another country;
- Application of the graded approach to RAW management, depending on the risks they pose;
- Taking account of the interfaces among all the stages related to SNF and RAW generation and management and requirements for safety:
    - minimisation of RAW volume and activity by taking all possible action to reduce their volume and activity during the generation process, and by applying suitable practices in their subsequent management, including recycling and reuse of the materials;
    - taking account of the requirements for RAW minimisation at the stages of design, construction, operation and decommissioning of the nuclear facility;
    - bringing RAW to a safe passive form fit for storage and disposal within the shortest achievable time after their generation;
- Possibility for declaring SNF to be radioactive waste in compliance with SUNEA;

Matrix for SNF and RAW management in the Republic of Bulgaria.

Type of responsibility	Long term policy	Funding	Current practices/facilities	Facilities planned
SNF	Processing abroad	Funded by the operator	Stored in wet and dry storage facilities on-site of Kozloduy NPP / Storage and processing abroad	
RAW obtained from the operation of nuclear reactors	Final Disposal	Funded by the operator. The RAW Fund, following transfer to SE RAW.	Treatment, conditioning and storage on the site of Kozloduy NPP	NDF - at the construction stage; A repository for interim long-term storage of HLW and longlived low- and intermediate level radwaste
RAW from nuclear applications	Final Disposal	Funded by the operator. The RAW Fund, following waste transfer to SE RAW.	Storage at SD "PRAWR - Novi Han"	NDF - at the construction stage; A repository for interim long-term storage of HLW and long-lived low- and intermediate level radwaste
RAW obtained during the decommissioning process of nuclear reactors	Continuous Dismantling Strategy	NFD Fund RAW Fund	Decommissioning of Kozloduy NPP Units 1 - 4	NDF - at the construction stage; Plasma Melting Facility - at the stage of commissioning
Sealed radiation sources, disused sources including orphan sources	Return to the manufacturer Final Disposal	Funded by the owners; Orphan RAW: RAW Fund	Storage at SD "PRAWR - Novi Han"	NDF - at the construction stage; A repository for interim long term storage of HLW and long-lived low- and intermediate level radwaste

2.3. Objectives

The strategy covers all the stages of the nuclear facilities life cycle, the application of the state-of-the-art technologies available for SNF and RAW management including their disposal, planning the necessary activities, implementation phases and financial and human resources required to achieve and maintain a high level of nuclear safety, radiation and physical protection. At this stage, the most important objectives compliant with the requirements of Council Directive 2011/70/Euratom are as follows:

- Minimising the time for SNF interim storage, taking into account that it is not an alternative to the final stage of SNF management;
- Processing of the entire amount of SNF generated from WWER-440 and WWER-1000 and disposal in the DGR of the vitrified HLW and other RAW generated during processing and returned to Bulgaria;

- Permanent reduction of the SNF quantities stored on the Kozloduy NPP site, through an average annual shipment of at least 77 t of heavy metal (HM) for long-term storage and processing abroad;
- Preparation of a long-term plan for construction of a repository for interim storage of returned vitrified HLW and other RAW from SNF processing;
- Commissioning of Stage 1 of the NDF by the end of 2025;
- Construction in the mid-term of Stages 2 and 3 of the NDF;
- In the long-term, design and construct a DGR;
- Providing financial resources for the construction of a DGR through the establishment of a new dedicated fund;
- Providing and maintaining sustainable financial and human resources for ensuring the necessary expertise and skills, including for carrying out the research and development required for the SNF and RAW management and regulation;
- Pursuing a policy of openness and transparency and involving the public in public hearings and decision-making on the SNF and RAW management.

3. LEGAL AND REGULATORY FRAMEWORK

The Republic of Bulgaria has established and maintains a national legislative, regulatory and organisational framework for spent nuclear fuel and radioactive waste management. This framework allocates responsibilities and provides for coordination between relevant competent bodies; establishes the infrastructure for safe and responsible SNF and RAW management and a mechanism for development of a national programme for spent fuel and radioactive waste management and a system of implementation control.

The national framework for RAW and SNF management takes into account the international conventions and treaties, the European and the national legislation.

The most significant international agreement in this field is the Joint Convention concluded under the auspices of the IAEA.

IAEA safety standards in the field of SNF and RAW management have been developed on an international level. Although they are not legally binding, the inclusion of the relevant requirements and standards in the national legislation is recommended. All EU member states are members of the IAEA and participate in the adoption of these standards. Regular peer reviews and missions are also carried out at the invitation of Bulgaria to independently review, analyse and assess the legal documents currently in force in the country.

The legal framework regarding SNF and RAW resulting from civil nuclear activities is laid down in the Euratom Treaty. Article 2(b) of the Euratom Treaty provides for the establishment of uniform safety standards to protect the health of workers and of the general public. Article 30 provides for the establishment of basic standards within the Community to protect the health of workers and the general public against the hazards arising from ionising radiations; and Article 37 requires each member state to provide the Commission with general data relating to any plan for the disposal of radioactive waste.

Council Directive 2011/70/Euratom provides binding legal effect to the main internationally recognised principles and requirements in this area. The Directive aims at ensuring high level of safety, avoiding undue burden on the future generations and increasing transparency. It supplements the basic standards laid down in the Euratom Treaty with regard to the safety of SNF and RAW. The Directive complies with the IAEA Fundamental Safety Principles and the Joint Convention.

Within the timeframe required, Bulgaria has reconciled the Directive requirements into the national legislation through the Regulation on Ensuring Safety in the Management of Spent Nuclear Fuel. However, there is incomplete and unclear wording of some of the provisions on specific milestones and timeframes for the implementation of the post-2030 SNF and RAW management projects, unclear language of key performance indicators for monitoring the progress on the programme implementation, lack of forecasts/estimates of expected post-2030 SNF and RAW quantities, incomplete assessment of the total financial costs, etc. For this reason, on 18 May 2018, infringement procedure No. 2018/2017 was launched by the EC against the Republic of Bulgaria for noncompliance with obligations under Directive 2011/70/Euratom. Due to late action on behalf of the Republic of Bulgaria, the EC initiated a second phase of the procedure in July 2020.

Action has been taken to eliminate the violations identified, including the development of this Strategy. Pursuant to Article 74 para.1 of the SUNEA, the Strategy shall be adopted by the Council of Ministers on the proposal of the Minister of Energy. Prior to the submission of the draft updated Strategy for consideration by the Council of Ministers, the document has undergone the relevant procedure required under national, European and international environmental legislation, namely: environmental assessment procedure, compatibility assessment (if necessary), assessment in a transboundary context, as well as public hearing and interdepartmental approval procedure.

Other international treaties, directives, regulations and agreements applicable to the SNF and RAW management are given in Appendix 1.

The national legislative and regulatory framework for the safety of SNF and RAW management is established mainly through the SUNEA, the Environmental Protection Act, the Health Act and the regulations on their implementation.

SUNEA addresses the public interactions concerning the government regulation of the safe management of RAW and SNF, as well as the rights and obligations of those involved in these activities to ensure nuclear safety, radiation protection and physical protection. The state regulation of the safe use of RAW and SNF is effected by the NRA Chair that acts as an independent specialised authority of the executive power.

The Regulation on the Safe Management of Radioactive Waste enforces requirements to the Strategy form and content and introduces RAW classification. The types of RAW generated during the operation of nuclear reactors are liquid, gaseous and solid, with the latter constituting the major part.

The Regulation introduces a system that assigns solid RAW to categories and sub categories, in view of their safe long-term management and final disposal. Solid RAW are classified according to their activity and specific characteristics as follows:

- Category 1 - wastes containing low level radionuclides; they do not require radiation protection measures, or do not need high level of isolation (shielding) and containment; this category of RAW is further subdivided in:
    - Category 1a - wastes that meet the levels for exemption from regulatory control under the SUNEA (no restriction on their use);
    - Category 1b - very short lived wastes, containing predominantly radionuclides with short half life (not more than 100 days), whose activity falls below the the exemption levels provided in the SUNEA; They shall be managed by appropriate on-site storage for a limited period of time (usually no longer than a few years);
    - Category 1c - very low level wastes, with specific activity activity levels exceeding the minimum exemption levels (provided by SUNEA) only by a small margin, and having a very low content of long-lived radionuclides that pose a limited radiological hazard; this category of wastes does not necessitate the implementation of specific radiation protection measures, isolation (shielding) or containment;
- Category 2 - low- and intermediate level waste: RAW containing radionuclides in concentrations that require measures for reliable isolation and containment, but do not necessitate special measures for heat removal during storage and final disposal; such RAW are further subdivided in:
    - Category 2a: low- and intermediate level waste containing mainly short lived radionuclides (with half-life no longer than that of ^{137}Cs), as well as long lived radionuclides at significatly lower levels of activity concentration, limited for long lived alpha emitters to below 4.10^6 Bq/kg for any single package and a maximum average value of all packages in a given storage facility of 4.10^5 Bq/kg; such RAW require robust isolation and containment for periods of up to a few hundred years;
    - Category 2b: low- and intermediate level waste containing long lived radionuclides with levels of activity concentration of long lived alpha emitters exceeding the levels for category 2a;
- Category 3- High-level waste: RAW with such concentration of radionuclides, where the decay heat release need to be considered in their storage and disposal; this category requires a higher degree of isolation and containment than for low- and intermediate-level waste, which shall be ensured by disposing in stable, deep geological formations.

The above classification also applies to liquid and gaseous RAW depending on the characteristics and suitable for disposal form of the solid RAW that is expected to be achieved after conditioning of liquid and gaseous RAW. If no conditioning technology for liquid or gaseous RAW is available in the country, the classification shall be carried out taking into account the best current conditioning technologies.

The regulatory documents require that radioactive wastes shall be separated at the source of generation of the waste according to their radiological, physical and chemical characteristics.

(A list of national regulations in force in the field of SNF and RAW management is presented in Appendix 2.)

4. RESPONSIBILITIES REGARDING THE STRATEGY IMPLEMENTATION AND AUTHORITIES ENGAGED IN THE PROCESS OF SPENT FUEL AND RADIOACTIVE WASTE MANAGEMENT

4.1. Government authorities

4.1.1. Council of Ministers

The Council of Ministers (CoM) is the national body which adopts the National Strategy for Spent Nuclear Fuel and Radioactive Waste Management as well as legislative documents on the application the SUNEA, the Environmental Protection Act, and the Health Act.

4.1.2. Ministry of Energy

The Ministry of Energy (ME) implements the overall state policy in the field of radioactive waste and spent nuclear fuel management as well as nuclear infrastructure development. The ME is responsible for periodically reviewing and updating the Strategy and monitoring its implementation.

The ME is also responsible for organising and coordinating the activities on the preparation of a proposal for the construction of a national repository for the storage and/or disposal of RAW, as well as for monitoring the activities for its construction and operation.

4.1.3. Ministry of Environment and Water

The MEW performs procedures for environmental impact assessment (EIA) of RAW and SNF management facilities.

As regards the environmental assessment procedures, the Minister of Environment and Water is the competent authority responsible for the plans and programmes to be approved by the central executive authorities and the National Assembly. The spent nuclear fuel and radioactive waste management strategy is amongst the plans and programmes, for which an environmental assessment shall be conducted.

4.1.4. Ministry of Health

The Ministry of Health is a specialised body for implementing the government policy in the field of healthcare and, thus, it directly or through its subordinate bodies manages, coordinates and controls the activities related to protection, strengthening and restoration of public health.

The Ministry of Health through its Regional Health Inspectorates and the National Centre for Radiobiology and Radiation Protection imposes the state health and radiation control over the nuclear applications and nuclear facilities including during RAW and SNF management.

Through its specialised bodies, the Ministry of Health is involved in the revision and approval of designs for construction, expansion and refurbishment of sites with sources of ionising radiation, provides statements on the environmental assessment of plans and programmes and on the environmental impact assessments of investment proposals.

The specialised control bodies of the Ministry of Health exercise state health control on the compliance with the requirements for protection of the health of the occupationally exposed individuals and members of the public, and for prevention of hazards from the impact of ionising radiation that could result in each situation of planned exposure, existing exposure and emergency exposure.

4.1.5. Ministry of Interior

The Ministry of Interior provides for the security of the nuclear facilities and associated sites, identified as particularly important in terms of their physical protection. The Ministry of Interior, through its Fire Safety and Civil Protection Directorate General, coordinates the activities on the protection of the population and national economy in case of disasters and emergencies, including the conducting of risk assessment, preventive measures, rescue and urgent recovery works and providing international assistance.

4.1.6. Other institutions

The Ministry of Transport and Communications, Ministry of Defence, Ministry of

Regional Development and Public Works, and the State Agency for National Security have also specific functions as regards the use of nuclear energy and ionising radiation. The SUNEA provides that the coordination among the different authorities is within the responsibilities of the NRA Chair.

4.2. Regulatory body:

4.2.1. Bulgarian Nuclear Regulatory Agency

The NRA is an independent specialised body which through its chair carries out state regulation in the field of safe management of RAW and SNF and maintains the legislative framework and the regulation system in the field. It develops and proposes for approval by the Council of Ministers regulations on the SUNEA implementation and proposes amendments and supplements. NRA coordinates the activities on transposition of changes in EU regulations and for harmonisation of the national and European legislation on management of spent fuel and radioactive waste.

The NRA Chair issues licences and permits for activities related to RAW and SNF and controls nuclear safety, radiation protection and physical protection during management of spent nuclear fuel and radioactive waste. Permits and licences in the process of construction and operation of facilities for RAW and SNF management are issued for each stage in compliance with the Regulation on the procedure for issuing licences and permits for safe use of nuclear energy.

During the Strategy implementation process, NRA performs the following:

- Preventive, ongoing and follow-up control of compliance with the requirements and standards for safe management of RAW and SNF and compliance with the requirements set in the licences and permits issued under the SUNEA;
- Interaction and coordination with specialised control bodies in compliance with the SUNEA.

4.3. Licences/permits holders:

Holders of licences/permits for RAW and SNF management maintain records of inventory (quantities, characteristics, location) relevant to facilities they are responsible for. Every three years the inventory from the records is summarised in the national report on the Joint convention, national report on implementation of the requirements of the Directive 2011/70/EURATOM, national reports from ARTEMIS peer review mission, and during update of the strategy for RAW and SNF management.

4.3.1. Kozloduy NPP EAD

The nuclear operator is responsible for the management and operation of power units 5 and 6, WSNFS and DSNFS, including associated auxiliary facilities and process systems for collection, treatment and storage of RAW until their disposal. All the activities related to management of RAW and SNF at Kozloduy NPP EAD are subject to authorisation regime.

RAW generated during operation of nuclear facilities of Kozloduy NPP are managed jointly with SE RAW; activities and responsibilities of the two companies are regulated by comprehensive programmes and licences of both companies.

The activities related to RAW management are carried out based on the established administrative structures with specified status, defined functions and tasks and clear allocation of rights, duties and responsibilities. The operation of the facilities is carried out in compliance with the approved documents - procedures and instructions.

Each production unit exercises intra-departmental control over the compliance with the regulations, instructions, procedures, programmes, schedules, orders and directives in connection with the implementation of activities related to RAW management. Taking into consideration the design of the plant site facilities, applied technology and organisational structure established, the responsibilities of Kozloduy NPP, related to RAW management, are as follows:

- Optimisation of the responsibilities allocation between Kozloduy NPP and SE RAW;
- Safe storage of waste bottoms and unprocessed liquid RAW;

- Volume reduction and activity decrease of the liquid, solid and gaseous RAW generated;
- Establishment of appropriate connections between the different stages of RAW management;
- RAW transfer to SE RAW in compliance with the established acceptance criteria;
- Ensuring safe storage of SNF and evaluation of options for its future management.

4.3.2. State Enterprise for Radioactive Waste

State Enterprise Radioactive Waste (SE RAW) is a legal entity as per Art. 62, para 3 of the Commercial Act, established under Art. 78, para 1 of the SUNEA, with headquarters in Sofia and specialised divisions in the country. The principal activity of the company covers the follows:

- RAW management which includes all the activities related to handling, pre-treatment, processing, conditioning, storage and disposal of RAW, including decommissioning of RAW management facilities;
- Construction, operation, rehabilitation and reconstruction of RAW management facilities;
- Transportation of RAW outside the corresponding nuclear facility site complying with the requirements for ensuring physical protection in compliance with the defined category;
- Decommissioning of nuclear facilities.

The activities and funding of the company are financed from the Radioactive Waste Fund (RAW fund) and Decommissioning of Nuclear Facilities Fund (DNF Fund) under the Minister of Energy. The activities related to decommissioning of nuclear facilities are financed also from the Kozloduy International Decommissioning Support Fund (KIDSF) through the European Bank for Reconstruction and Development (EBRD). In case of an accident or emergency with a radioactive source in the country, SE RAW organises the transportation and acceptance of such sources as RAW under the terms and conditions specified by an order of the NRA Chair.

5. SPENT NUCLEAR FUEL AND RADIOACTIVE WASTE MANAGEMENT

There are no plants in the country for conversion, enrichment and fabrication of nuclear fuel and for SNF processing.

IRT-2000 research reactor was operated in the period 1961 - 1989 by INRNE-BAS. SNF from it has been transported to RF, RAW generated from the operation have been transferred to SE RAW.

5.1. SNF Management

5.1.1. Main characteristics of the spent nuclear fuel

After depletion of nuclear fuel energy potential, it is unloaded from the core and hereinafter for clarity is referred to as spent nuclear fuel. It is an inevitable technological product from the operation of nuclear reactors. It contains at least 95% of all radioisotopes generated during the NPP operation. The emitted radioactivity is partially absorbed by the nuclear fuel and converted into heat (decay heat) which leads to heating of the spent fuel assemblies and a necessity of its continuous cooling. For the same reason, when storing SNF, biological shielding should be provided against ionising radiation emitted from it. Due to the presence of fissile isotopes, specific measures should be taken during the storage in order to prevent criticality, and physical protection should be ensured, as well as prevention of unauthorised use of fissile material for other purposes.

SNF contains several groups of radioactive isotopes, including the following:

- Isotopes of uranium (which account for about 95 % of the fuel mass);
- Isotopes of plutonium - about 1 % of the fuel mass;
- Isotopes of neptunium, americium and curium;
- Products of the fission of the heavy uranium nuclei.

Radioactive isotopes accumulated in the fuel have different half-life (presented in Table 1) with some of them posing radiological risk for thousands of years. This requires their reliable isolation from the environment within this period, especially during the first 10,000 years.

Table 1. Long-lived man-induced isotopes in SNF

Radioactive isotope	Half life, years
Neptunium-237	2,140,000
Isotopes of neptunium (total amount of about 11 kg/t HM)	
Plutonium - 238	87.74
Plutonium - 239	24,100
Plutonium - 240	6,560
Plutonium - 241	14.35
Plutonium - 242	373,000
Isotopes heavier than plutonium (actinides)	
Americium-241	432.2
Amercoat 243	737
Curium-244	18.10
Long-lived fission products	
Strontium-90	28.78
Cesium-137	30.07
Technetium-99	211,000
Cerium-93	1,500,000
Cesium-135	2,300,000
Palladium-107	6,500,000
Iodine-129	15,700,000

During the SNF processing, the fissile materials are released (recycled uranium and plutonium). The fissile materials received so far are owned by the EU, but currently remain for permanent storage in RF. They can be used for fabrication of fresh nuclear fuel, REMIX fuel in particular, which is currently tested in WWER-1000 reactors.

The other radioactive isotopes are mixed with molten glass and sealed in leak-tight metal containers. They are qualified as high-level waste (HLW) and after a certain period of time are returned to Bulgaria. The metal parts of the FAs are compacted and enclosed in containers; other RAW are generated as well which are immobilised in cement matrices.

During the interim storage of the SNF, fuel pellets and fuel rod cladding are the main physical barriers against spreading the radioactive materials contained in the fuel in the environment. The interim storage facilities form additional engineering barriers and maintain their integrity.

Due to corrosion process (when stored in aquatic environment) or presence of thermal loads (when stored in gaseous environment), the period of SNF interim storage is limited. This is the reason the nuclear energy generating countries consider as a final stage either final disposal of spent fuel assemblies in DGR, or SNF processing and disposal of generated HLW in DGR.

The SNF storage facilities should ensure its reliable cooling, biological shielding against the ionising radiation and maintain deep subcriticality of the fissile elements stored in them. Another challenge is implementation of measures related to physical protection and security.

The main objectives for ensuring safety in the management of spent nuclear fuel are as follows:

- Prevention of harmful effect on the personnel, population, environment and future generations;
- Prevention of transfer of significant financial burden to the future generations;
- Provision of the required minimum free capacity for emergency core unloading from the Kozloduy NPP power units in operation;
- Introduction of new advanced nuclear fuel types which reduce the amount of SNF and RAW generated from its processing;
- Meeting safety requirements for management and storage of HLW generated from SNF processing.

5.1.2. SNF Management Practices

In Bulgaria, SNF is generated at Units 5 and 6 of Kozloduy NPP as well as at Units 1 to 4 in the past. The reactors of Units 5 and 6 are WWER-1000/B-320 commissioned in 1987 and 1991 respectively. In 2008, a large-scale modernisation programme was completed.

In 2016, the activities for justification of **Unit 5** plant life extension were completed. In 2017, the NRA renewed the Unit 5 Operating License for a period of 10 years. In 2019, the activities related to thermal power uprate to 3120 MW were completed. The implementation of an advanced fuel cycle is planned to begin in the period 2024-2025. According to the current TLAAs of the main equipment, it is possible to extend the unit safe operation until 2047.

In 2016, the Programme for thermal power uprate of **Unit 6** to 3120 MW was completed and an advanced fuel cycle with TVSA-12 fuel assemblies was implemented. As a result, the number of yearly generated SNF assemblies has been reduced from 48 to 42, which is in accordance with the basic principle of minimizing the quantities of RAW for disposal laid down in the Strategy. In 2018, the activities for justification of the unit plant life extension were completed. In 2019, the NRA renewed the Unit 6 Operating License for a period of 10 years. According to the current TLAAs of the main equipment, it is possible to extend the unit safe operation until 2051.

In 2019, in compliance with the European Energy Security Strategy (May 2014), Kozloduy NPP started analysing the options for diversification of supplies of fresh nuclear fuel.

It should be taken into account that any improvement of the fuel cycle (for example, introduction of a 5-year operating cycle of nuclear fuel), as well as the implementation of a project to diversify the supply of SNG, will reflect on the generation of SNG, respectively on its management and should be reflected in the Strategy.

The Units 5 and 6 SNF management covers **initial storage** of SNF in the spent fuel pools for a minimum period of 5 years.

The next stage is **intermediate storage** of SNF in a wet storage facility (WSNFS) on the site of Kozloduy NPP. Fuel from both WWER-440 and WWER-1000 is stored in the WSNFS (WWER-440 fuel is also stored in the dry storage facility – DSNFS). The intermediate storage enables the right choice to be made for the next stages of management, given that it is not an alternative to the final stage of SNF management. The term of intermediate storage should be minimized, taking into account the specific conditions.

In general, the long-term dry storage of spent nuclear fuel can lead to significant risks to the Bulgarian Nuclear Programme in the absence of options for transportation and/or processing of the spent nuclear fuel stored like this in the future. This may require its direct disposal, respectively a radical change to the Deep Geological Repository (DGR) Project in order to solve a number of complex technical issues. For these reasons, dry storage of SNF from WWER-440 and WWER-1000 should be considered only as a backup option (buffer) in case of unforeseen and insurmountable circumstances (for example, in case of impossibility to transport SNF due to complication of the international situation) which may lead to a shutdown of the units due to exhaustion of the SNF storage capacity of the existing storage facilities.

The practice of dry storage of WWER-440 SNF must be reconsidered as there are currently no plans for what will be done with this fuel upon expiry of its dry storage period. In this regard, until the possible options are clarified, the following activities shall be carried out:

- Discontinuing the practice of loading new CONSTOR 440/84 casks with WWER-440 SNF and storing them in the DSNFS;
- Analysing the options for returning a single cask to the WSNFS, testing the technology for opening it and checking the condition of the stored assemblies;
- Negotiating with the parties who possess technological capabilities and clarifying the possibilities of shipping for long-term storage and processing of SNF that has been dry stored for some time.

From the very beginning of its Nuclear Programme, the Republic of Bulgaria has chosen the practice of processing SNF. In this process, uranium and plutonium (one by one or together) are extracted, while the fission products and actinides are mixed with molten glass and sealed in metal containers.

As per the contracts for construction of the Kozloduy NPP Units 1 and 2, it is not required to return to Bulgaria the HLW and other RAW obtained from the processing of SNF. The shipment, long-term storage and processing of SNF from Units 3, 4, 5 and 6 can be done under a contract with other parties, with payment and return to Bulgaria of the HLW and other RAW from the processing.

The shipment of SNF from WWER-440 for technological storage and processing at FSUE "PA "MAYAK" in the USSR, now the Russian Federation, began in 1979. Due to the increasing challenges for the USSR to receive and store SNF from the former socialist countries, it was necessary to construct a facility for temporary storage of nuclear fuel on the site of Kozloduy NPP (WSNFS). In the period 1979-2017, a total of 7296 spent nuclear fuel assemblies from the WWER-440 reactors were shipped.

According to the existing practices developed later in the previous Strategies, in order to prevent overfilling of the WSNFS, in 2001, shipment of SNF from WWER-1000 for long-term storage and processing in the Russian Federation was started. By 2008, 959 spent nuclear fuel assemblies from the WWER-1000 reactors were shipped to FSUE "GKhK". The shipment of SNF from WWER-1000 was resumed in 2020 and, in 2020-2021, 288 assemblies were shipped to FSUE "PA "MAYAK".

In the previous Strategies, a requirement was included to ship at least 50 t of heavy metal (HM) in SNF per year for long-term storage and processing. Mainly due to objective difficulties with the transportation of SNF through third countries, but also due to underestimation of the importance of the task, in the period 2015 – 2019, instead of shipping at least 250 t of HM in SNF, only 26.5 t of HM in SNF were shipped. This led to an increase of about 154 t of HM in the mass of the SNF stored at the Kozloduy NPP site (at the end of 2015 – about 803 t of HM in SNF; at the end of 2022 – about 957 t of HM in SNF).

In 2019, all the activities for implementation of a scheme for shipment of SNF to the Russian Federation, which excludes transit through third countries, were completed. This makes it possible in 2020 to resume the shipment of SNF from WWER-1000 and perform one transport plus two more transports in 2021. It should be taken into account that, in general, shipment of spent nuclear fuel from WWER-1000 is possible after residual heat is reduced below a certain limit (10-11 years after its removal from the nuclear reactor).

In order to sustainably reduce the amount of SNF stored on the site of Kozloduy NPP, an average yearly shipment of a **minimum of 77 t of HM** in SNF must be carried out. In order to ship SNF from the WWER-1000 for long-term storage and processing, two transports must be carried out yearly.

When shipping SNF from WWER-440 for long-term storage and processing in two transports per year, no more than 56 t of HM in SNF can be shipped. When conditions are favourable, Kozloduy NPP EAD will ship three transports of SNF from WWER-440.

In 2023, it is planned to carry out one transport with 60 spent fuel assemblies and a second one with 58 spent fuel assemblies from WWER-1000 for reprocessing (if possible, the two transports will be combined into one). These are assemblies delivered and irradiated until 1 January 2007 (when the Republic of Bulgaria became a member of the EU). The contract for these 118 fuel assemblies in total has been approved by ESA.

Under favourable geopolitical conditions, negotiations with Euratom Supply Agency (ESA) on the transport of 379 WWER-1000 fuel assemblies for long-term storage and processing – these are assemblies delivered before 1 January 2007, but finally removed from the WWER-1000 cores later than 1 January 2007.

In 2022, a framework contract for the shipment of 1 268 WWER-440 SNF assemblies (approximately 146.5t of HM) in the period 2023 – 2028 for long-term storage and processing. Those are assemblies at the stage of intermediate storage in the Wet Spent Nuclear Fuel Storage Facility.

As per the commercial contracts for processing of spent nuclear fuel, Bulgaria has substantial stocks of fissile material stored on the territory of the Russian Federation. The fissile materials obtained from processing (recycled uranium and plutonium) are Community's property as stipulated in the Euratom Treaty.

The military actions of the Russian Federation against Ukraine which began in February 2022 created significant additional risks to the achievement of the Strategy main objective, namely "Processing of the entire amount of generated SNF, disposal in a deep geological repository of the vitrified HLW and other RAW generated during the processing and returned to Bulgaria". The current practice of SNF processing in the Russian Federation may become impossible or seriously threatened due to transport and logistics problems or sanctions imposed by both the EU and the Russian Federation. Therefore, this Strategy considers the options for SNF processing in France (see item 5.1.4).

5.1.3. Existing Facilities for SNF Management

5.1.3.1. Units 5 and 6 Spent Fuel Pools (SFPs)

The spent fuel and refuelling pools are located in the containment and serve to store spent nuclear fuel (until the residual heat is reduced to an acceptable level) and for temporary storage of other components irradiated in the core. The capacity of each pool is 612 fuel assemblies which provides for their storage for no less than five years. A certain capacity is meant for emergency removal of the reactor cores.

The SFPs consist of four sections (bays) physically separated by partition walls. Three bays are intended for storage of spent fuel assemblies, while the fourth one is intended for handling of fresh and spent fuel. Racks and airtight canisters for the storage of fuel assemblies with leaking rods have been installed in each spent fuel storage bay. By design, a certain distance between the assembly cells is ensured in order to guarantee the required subcriticality in the SFPs. The pools are designed to perform their intended functions under the seismic impact of a safe shutdown earthquake.

5.1.3.2. Wet Spent Nuclear Fuel Storage Facility (WSNFS)

The SNF storage facility is a separate building located on the site of Kozloduy NPP which houses equipment and systems ensuring SNF subcriticality, residual heat removal and biological protection. It is a "wet" type storage facility, i.e. the SNF is stored under water, in pools. The storage facility was commissioned in 1991. It is intended for long-term (not less than fifty years) storage of spent nuclear fuel from the WWER-440 and WWER-1000 reactors after initial storage of at least five years in the spent fuel pools at the reactors.

The facility is equipped with four SNF storage pools physically separated by partition walls. In three of them, the spent fuel assemblies are stored in special transport baskets. The fourth pool is intended for emergency operations. The WSNFS design capacity is 168 baskets. The storage facility has been licensed for a period of 10 years, until 2024.

5.1.3.3. Dry Spent Nuclear Fuel Storage Facility (DSNFS)

The storage facility is intended for long-term dry storage (not less than fifty years) of spent nuclear fuel from the Kozloduy NPP WWER-440 reactors. The DSNFS is equipped with systems intended for reception, storage and shipment of SNF. It was licensed in 2016 for a period of 10 years. Initially, it was planned for storage of a total of 2856 WWER-440 assemblies in 34 CONSTOR 440/84 casks for a period of 50 years.

The main characteristics of the DSNFS are as follows:

- The DSNFS is an independent structure consisting of a one-story hall divided into two main operational areas: reception area and cask storage hall. The two areas are separated by a security door;
- The SNF is stored in CONSTOR 440/84 casks;
- The DSNFS capacity is 72 casks. The cask consists of a body and double lid system. The body and double lid system ensure the cask airtightness during normal operation and emergencies;
- The cask internal space containing the spent fuel is dried, then filled with helium. The inert atmosphere inside the cask prevents corrosion of the fuel rods throughout their long-term storage;
- The DSNFS natural air convection passive cooling system and cask design ensure not exceeding the fuel rod cladding temperature limits and prevention of ageing of the fuel assembly and cask structures.

5.1.4. Planned tasks and activities related to spent nuclear fuel management

The planned tasks and activities related to SNF management are specified by the main objective of the Strategy in the field - processing of the whole SNF quantity from WWER-440 and WWER-1000 reactors, interim storage of vitrified HLW and other RAW generated from on-site processing and their consequent disposal in DGR. In connection with the unfavourable geopolitical changes that took place at the beginning of 2022 after the Russian Federation (RF) started a war against Ukraine, these tasks and activities are as follows:

- Inter-governmental negotiations between Bulgaria and France and signature of an agreement on potential processing in France of SNF from current and future operation of WWER-1000 reactors, as well as from the possible new nuclear unit;
- Exploration of technological options for processing of SNF from WWER-1000 reactors at processing plants in France, clarification of the required expenditures for adapting the processing lines for processing of SNF from WWER reactors, clarification of the price for processing HM t, the quantities of high- and intermediate-level RAW obtained and the parameters of the packages they are sealed and transported in, as well as obtained fissile materials, methods of their isolation, conditions for their storage and return to Bulgaria, etc.
- Development of a transportation scheme for regular shipment of SNF from WWER-1000 reactors for processing at processing plants in France and return of RAW obtained;

- Development of measures to adapt and test the existing transportation scheme for shipment of SNF from WWER-1000 reactors for the purpose of transportation of SNF from WWER-1000 reactors for long-term storage and processing. Taking into consideration the quantities of SNF from WWER-1000 reactors stored on-site (2864 FAs, 330.9 t HM) and under favourable geopolitical conditions after 2023, from the financial and economic point of view it is expedient that the processing continue to be carried out in RF in view of current practice and existing contracts. This means that 12 shipments of SNF from WWER-1000 reactors for processing are required, which will ensure additional free capacity of 43 baskets for interim storage of FAs from WWER-1000 reactors in the WSNFS (or 516 FAs with SNF) for the period of negotiations and preparation for processing in France, without building a buffer capacity for dry storage of SNF from WWER-1000 reactors;
- Update of Kozloduy NPP EAD programme for SNF management in compliance with the objectives specified in the Strategy;
- Under favourable geopolitical conditions, regular shipment of SNF from WWER-1000 reactors according to the established practice;
- Reaching an agreement between the Republic of Bulgaria and EC on processing according to the established practice of the considered number of FAs from WWER-1000 delivered to Kozloduy NPP after 01.01.2007 and considered for transportation after 2024;
- Maintaining preparedness for shipment of SNF for long-term storage and processing through third countries according to the transport scheme.

Clarification on implementation of the idea to reprocess SNF from WWER-1000 reactors at SNF processing plants in France.

Clarification and solving of a number of issues is required, the most important of which are in the following areas:

- The design differences in the dimensions and the shape of the FAs used in WWER reactors (hexagonal) and PWR rectors (square) require redesigning and retrofitting of the existing process lines at the plants for processing of SNF from WWER-1000 reactors. This involves significant financial resources and requires technological time;
- A transportation scheme for shipment from Kozloduy NPP to the processing plant should be developed and tested. This means designing of transport containers and vehicles for SNF from WWER reactors or modification of existing ones for FAs for PWR reactors. Compatibility should be achieved with infrastructure and lifting equipment existing at Kozloduy NPP and used for transport and handling operations. Safety of the containers and vehicles should be justified and permits and licences should be obtained from the relevant competent authorities for their use during SNF shipment. Depending on the scheme, licences should also be obtained for relevant infrastructure facilities and lifting equipment outside the Kozloduy NPP site used for reloading operations with containers with SNF;
- It is necessary to clarify the types of RAW and their quantities generated during the processing, as well as the method of their immobilisation and packaging, the type of metal containers used, initial storage period, etc. The same applies to the fissile materials obtained;
- It is necessary to agree the conditions for storage in France of obtained quantities of fissile materials and their possible reuse;
- A transportation scheme shall be developed for the return of vitrified HLW and other RAW generated from the processing of SNF in France, and in short term a construction of interim storage facility at Kozloduy NPP is planned;

Under the most favourable assumptions, the development of transportation scheme and preparation of processing plants for SNF from WWER reactors, clarification of the issues related to the quantities and method of returning of the RAW obtained from processing as well as other waste, will take no less than 5 years.

It should be taken into consideration that the processing of SNF from WWER-1000 reactors at UP2 and UP3 plants in France will require greater financial resources compared to the current processing of SNF in RF. According to an analysis performed by

HARVARD Kennedy School, with 40 years operating life of the units with 62% load factor, by the year 2016, the price for processing (optimistic) is $1100/kg HM.

Considering the modest, from the point of view of the processing plants, amount of t HM in SNF from WWER-440 reactors stored at the Kozloduy NPP site (330.9 t HM), it is expedient to continue the established practice.

If the total amount of SNF from WWER-440 reactors stored in the WSNFS is transported for processing until 2030, this will give **5 years grace time** for construction and extension of the WSNFS and will facilitate the achievement of the Strategy main objective - gradual removal of all SNF from the site.

Taking into consideration the new issues caused by the changed geopolitical situation, in view of effective and safe management of SNF from WWER-1000 reactors, it is possible that a buffer space for SNF storage will be required.

Assuming the most unfavourable scenario, namely failure of shipment of SNF from WWER-1000 reactors in the long run and taking into consideration the unit refuelling mode, it is expected that the usable space of the WSNFS will be **filled in 2032.** This implies the need for obtaining a licence for extension of the DSNFS with a space for 38 casks for dry storage of 722 spent fuel assemblies from WWER-1000 reactors not later than in 2030. The extension of DSNFS will provide an additional buffer capacity for operation of Units 5 and 6 for 8 more years after 2032.

Activities facilitating the safe operation of the WSNFS and DSNFS

Activities have been implemented and new ones are planned for maintaining the safe operational condition of the WSNFS and periodic renewal of its licence until 2060-2064.

Measures are planned for maintaining the safe operational condition of the DSNFS and renewal of its licence.

It is necessary to study the experience of other countries regarding dry storage of SNF, and based on this experience to make a conclusion about the safe storage period and options for unpacking the CONSTOR 440/84 casks in the WSNFS, unloading the spent fuel assemblies from WWER-440 reactors and their transportation to another country for long-term storage and processing.

In the long run, it is necessary to perform an analysis of the possibility to use the DSNFS for interim storage of vitrified RAW and other RAW generated from the SNF processing after their return to Bulgaria.

5.1.5. Analysis of the options for long-term management of SNF

The SNF generation, its transportation for processing and the quantity of the SNF stored on the site is analysed, provided that from 2024 onwards Unit 5 is loaded with FNF produced by Westinghouse and Unit 6 continues operation with the FNF provided by the original manufacturer in the coming years, and then with FNF supplied by Framatom France until the end of their service life.

The deployment of fuel from another manufacturer shall be justified by a full range of safety analyses, their verification and licensing, especially when performing mixed core loading.

According to the available information, Westinghouse provides only the opportunity for dry interim storage of SNF (Westinghouse) but does not offer an option for its processing. This means that the processing of the generated quantities of SNF must be planned and performed in another country.

Even under favourable geopolitical conditions, the SNF (Westinghouse) processing in the Russian Federation seems unrealistic. As a result, there shall be an increasingly pressing need for choosing the option for WWER-1000 SNF processing in the processing plants of France. If this option is not implemented, the only option for SNF (Westinghouse) management shall be to extend the time for its interim storage and further direct disposal in the DGR. This will result in serious technical and financial difficulties during the design, construction and operation of the DGR, the emergence of a series of technical issues that are difficult to solve, and a significant financial burden for posterity.

The following three scenarios for processing SNF are considered, under normal operation of Units 5 and 6 and annual generation of SNF that contains about 38 t HM.

Realistic scenario

As a result of the unfavourable geopolitical changes that took place at the beginning of 2022 after the Russian Federation (RF) started a war against Ukraine, a series of risks related to the management of SNF and HLW arise. The realistic scenario is based on the following preconditions:

- continuing the established practice of processing WWER-1000 SNF may not be possible or may be greatly impeded as a result of transportation and logistics issues or sanctions imposed by the EU and the RF;
- developing the idea for processing WWER-1000 SNF, incl. SNF (W) in the processing plants of France;
- transporting WWER-440 SNF for processing in compliance with the current practice;
- achieving the set objective - an average annual shipment of 77 t HM as SNF from the site (for a period of 10 years).

This includes implementation of the following activities until the end of 2029:

- 2023 - sending two shipments, as per contract, of 118 fuel assemblies with SNF from WWER-1000 (around 45.3 t HM), with signed contracts and approved by the ESA (if possible the two transports will be merged into one).
- 2024 – 2029 – clearing the site of all the SNF from WWER-440 that is now stored in the SFS storage facility and the DSFSF (a total of 2864 fuel assemblies containing 330.9 t HM). This means sending two/three SNF shipments from WWER-440 per year, each with 240 fuel assemblies containing 27.7 t HM, or about 55.4/83.1 t HM. The fuel assemblies stored in the SFSF are transported first. The activities for moving the fuel assemblies from the DSFSF to the SFSF are synchronised with the schedule for their subsequent shipment.

Thus, by the end of 2029, the site will be cleared of a total about 376.2 t HM, which means an average of 47 t HM per year. The quantity of SNF generated for these 7 years will be about 274 t HM, i.e. the amount of SNF stored on site will have decreased by about 102 t HM to about 855 t HM by the end of 2029.

- 2030 - start of the SNF shipping from WWER-1000 to the processing plants in France;
- after 2030 - performing two/three shipments per year, each with 96 WWER-1000 spent fuel assemblies to be reprocessed in the plants of France (9 shipments in total of about 347 t HM).

In this way, a sustainable reduction in the amount of SNF stored at the site will be achieved in the coming years, with the ultimate goal of decontaminating the site by 2060 (Figures 1a and 1b).

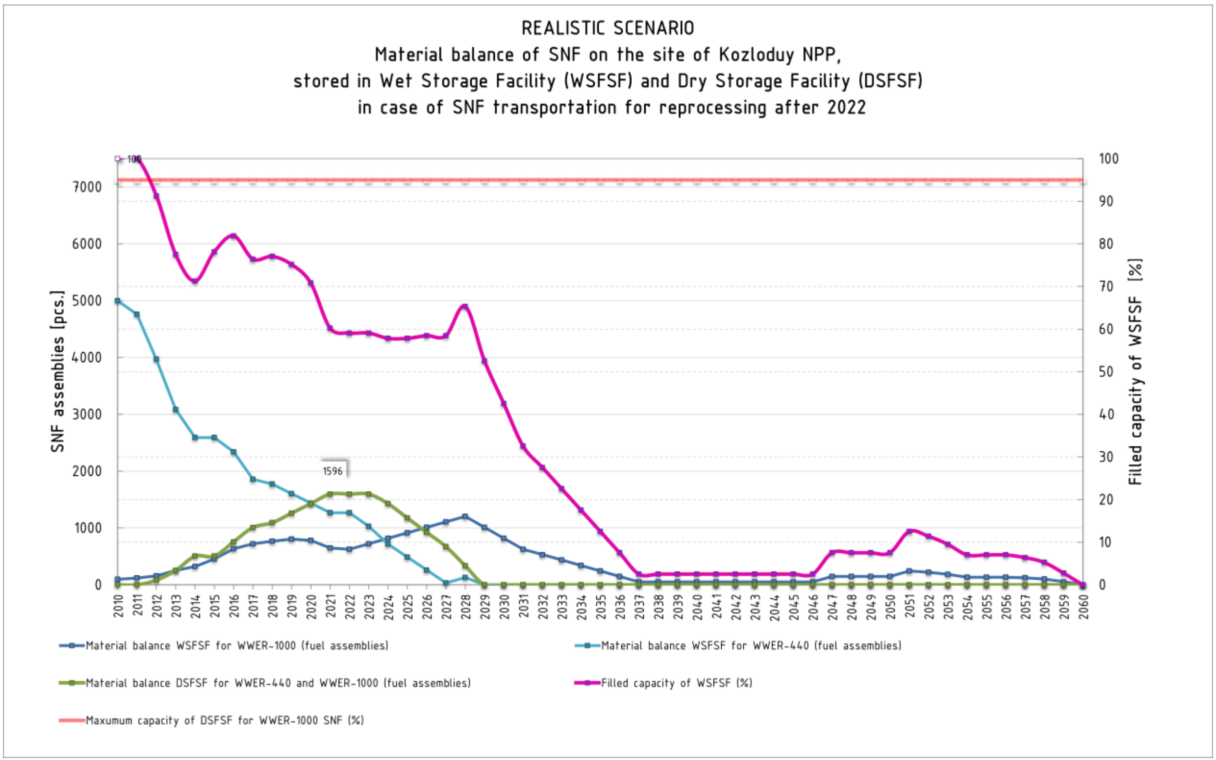


Figure 1a. Material balance of SNF stored in SFSF and DSFSF in the Realistic scenario.

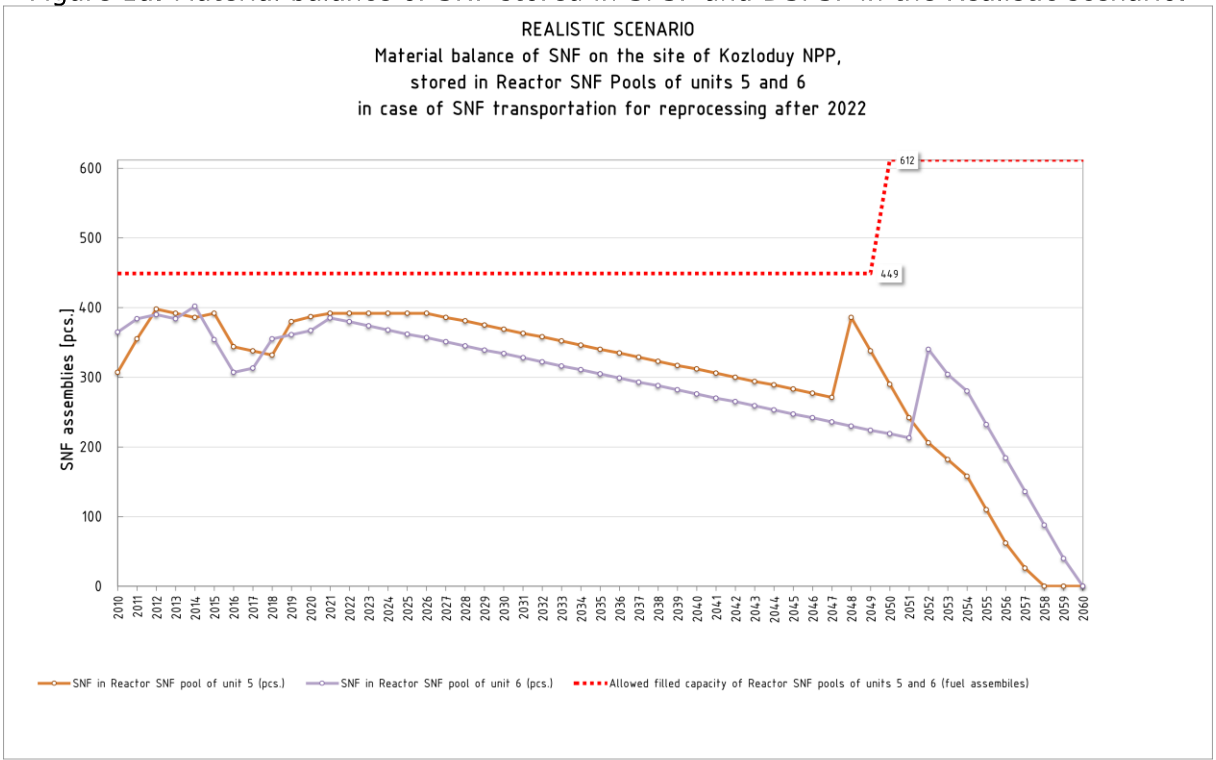


Figure 1b. Material balance of SNF stored in SFP-5 and SFP-6 in the Realistic scenario.

Optimistic scenario

All activities considered in the realistic scenario are implemented. In addition, it is supposed that, at a certain stage, shipment of WWER-1000 SNF, supplied by TVEL for processing in compliance with the established practice, shall begin, starting with the transport of 379 spent fuel assemblies from VVER-1000, subject to European Commission approval (see Section 5.1.2.). Sending WWER-1000 SNF for processing in the plants in France remains an option, however, primarily for SNF (Westinghouse и Framatom).

In this scenario, all goals are met, just as in the realistic scenario, but at a lower cost.

Pessimistic scenario

Shipment of SNF from WWER-440 and WWER-1000 for processing is not carried out according to the established practice.

This means that the overriding priority of this Strategy is to reprocess WWER-1000 SNF and, preferably, WWER-440 SNF in the plants in France. From 2029 onwards two/three shipments shall be sent annually for processing in France.

In this scenario, the goal of this Strategy - a steady decrease in the amount of SNF stored on site - cannot be achieved in the next 7 years, and its implementation in the long-term is under risk as well. A buffer capacity for dry storage of WWER-1000 SNF has to be constructed (Figures 2a and 2b).

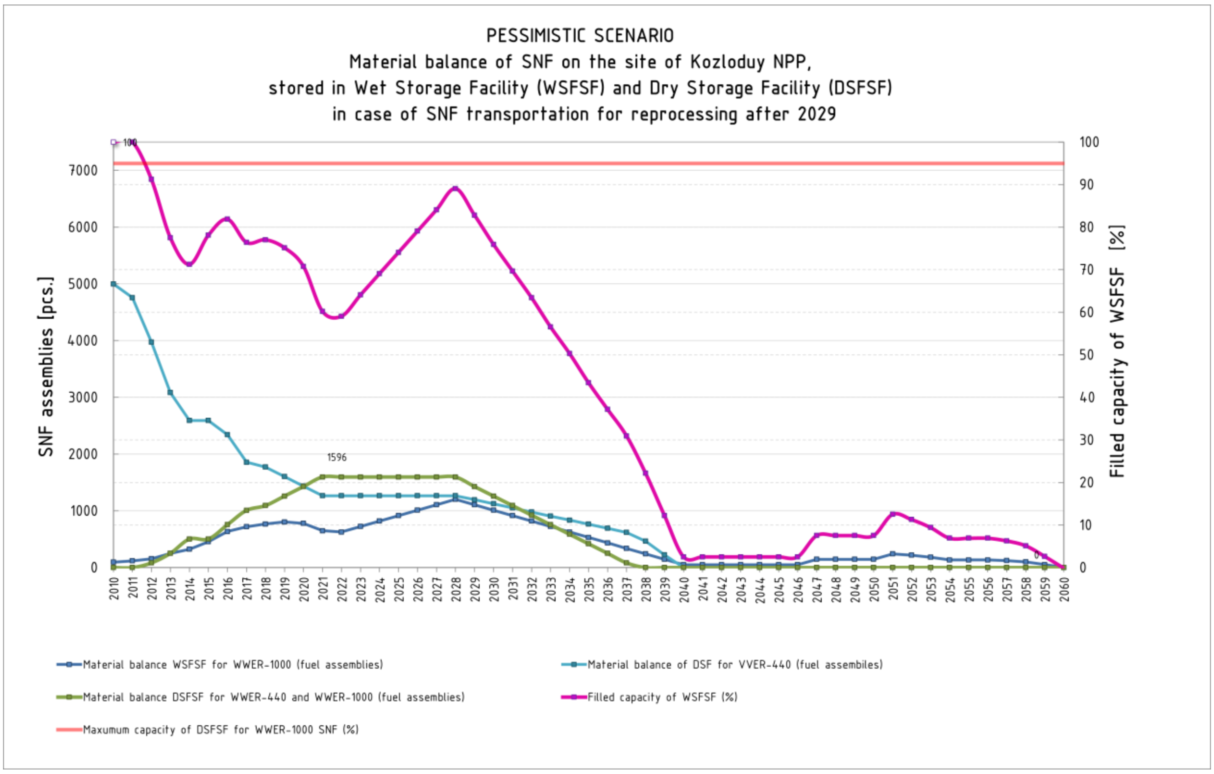


Figure 2a. Material balance of SNF stored in SFSF and DSFSF in the Pessimistic scenario.

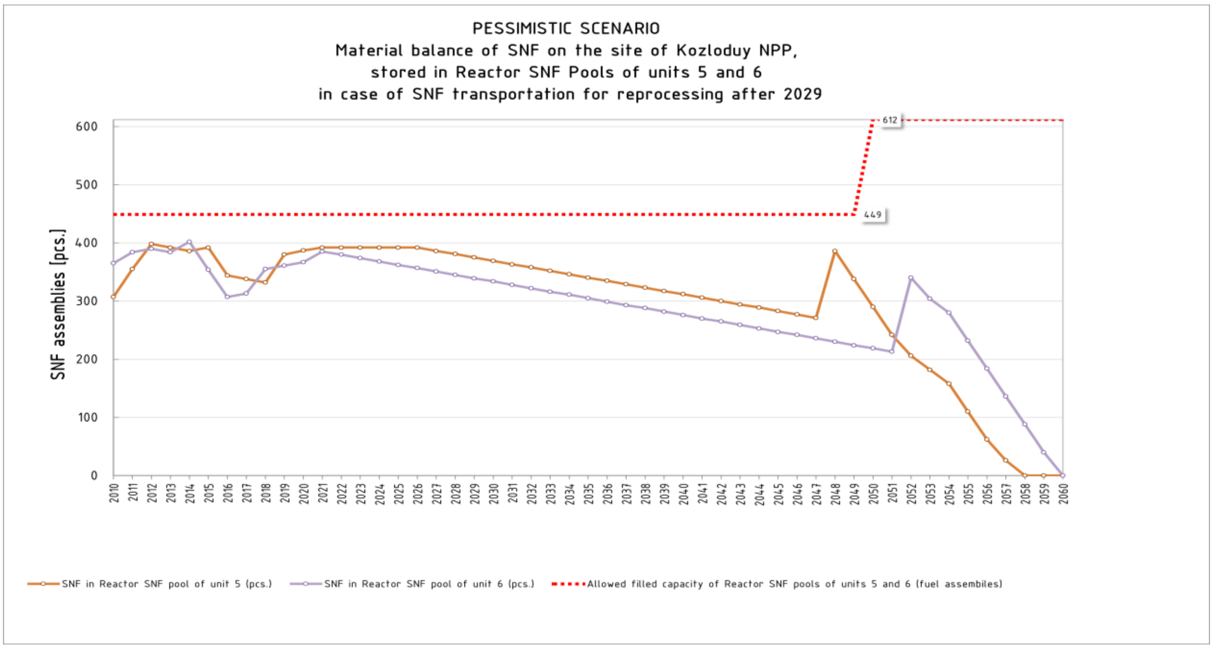


Figure 2b. Material balance of SNF stored in SFP-5 and SFP-6 in the Pessimistic scenario.

In the present conditions making long-term estimations could entail a great degree of uncertainty, so this will not be done at this stage. This shall be done when updating the Strategy after the geopolitical situation in Europe, the opportunities for interaction with the RF, France, the EC, and other factors, become clearer. The goal of the next Strategy must remain the same, namely, to ship no less than 770 t HM as SNF every 10 years and to remove any SNF from the site of the plant by 2060.

5.1.6. Report on the quantities of SNF on the site

In the period 1979 -2022, the total quantity of SNF generated from the operation of Units 1 to 6 is about 2470 t HM. For the same period, about 1368 t HM (about 55%) of this quantity was shipped for long-term storage and processing.

High-level waste (HLW) generated from the processing of SNF shipped until 1989, is not eligible for shipping back to Bulgaria.

Eligible for sending back to the country is HLW and other RAW from the processing of about 1006 t HM as WWER-440 and WWER-1000 SNF, shipped between 1998-2021.

By the end of 2022, the accumulated SNF on site of Kozloduy NPP, stored in the SFP, SFSF and DSFSF, amounts to 957 t HM. This amount is distributed in 2864 WWER-440 FAs and 1527 WWER-1000 FAs, or a total of 4391 FAs. As a result of objective difficulties and subjective factors, the maximum amount of SNF stored on the site is increased with 154 t HM compared to 2015.

At the end of 2022, 1268 WWER-440 and 804 WWER-1000 FAs are stored in the SFSF, or 2072 fuel assemblies in total (470 t HM as SNF), and 112 out of 160 spaces for baskets in total are filled.

In the DSFSF, 19 CONSTOR 440/84 contain 1596 WWER-440 SNF assemblies (184 t HM as SNF).

The total quantity of SNF stored in the SFP is the following:

- Unit 5 - 368 FAs or 151.7 t HM;
- Unit 6 - 355 FAs or 151.0 t HM.

/A report for the quantities of SNF in the SFP, SFSF, and DSFSF, as of 31 December 2022, is provided in Appendix 3/

5.1.7. Kozloduy NPP's estimates and assessment of expected amounts of SNF

The estimate for the quantities of SNF to be generated in the future is made on condition that each of the units will be operational for 60 years, i.e. that Unit 5 will operate until 2047 and Unit 6 - until 2051. Taking into account the existing loading patterns of Kozloduy NPP Units 5 and 6, 84 fuel assemblies will be generated annually. Considering the accepted deadlines for operation of the units, it is expected that about 2530 SNF assemblies will be generated (about 1218 t HM as SNF) by 2051.

5.1.8. Estimates and assessment of expected amounts of SNF generated by a new nuclear installation

The development of the nuclear programme of the Republic of Bulgaria presupposes the construction of a new nuclear installation. In all events, the use of a high pressure LWR that operates with low enriched uranium fuel and has electrical output of about 1000 MW is envisaged.

According to the specifications issued by the manufacturer, the average annual generation of SNF by such a reactor is of about 21 – 22 t HM as SNF. When the operating lifetime of the nuclear facility is 60 years, a total of 1300 t HM will be generated in the SNF. If two nuclear reactors are constructed - about 2600 t HM in the SNF, respectively and if four nuclear reactors are built - respectively about 5200 t TM in SNF.

If a project with higher electrical output is chosen, the SNF generation must be specified in advance.

The SNF generated from a new nuclear installation is first stored in the reactor pools. The next stage of the interim storage can be defined after a specific project for a NPP is chosen. In all events, when choosing the project, maximum compatibility of the concept for management of SNF suggested in the project for SNF management with the main goal of this Strategy has to be pursued - processing and subsequent disposal of HLW in the DGR.

When a decision is taken to construct new nuclear facilities under Art. 45 of the SUNEA, the Strategy must be updated to take into account the expected quantities of SNF that will be generated from them.

5.2. RAW management

Management of low and intermediate level short-lived RAW

The main volume of low and intermediate level RAW is generated from the operation of the nuclear reactors, the first of which was commissioned in 1974. The first four units of Kozloduy NPP were designed and constructed without RAW processing facilities in compliance with the concept for their storage and decommissioning. This practice has led to a gradual filling of the capacity of the facilities, the need for concentrating liquid RAW and the formation of masses that have turned into crystals in tanks, the development of new temporary facilities for storage of RAW, and other negative consequences.

In the 90s, the construction of a complex of facilities for processing, conditioning and interim storage of RAW began, managed by SE RAW.

The processing and disposal of RAW, under the regulations issued by the SUNEA, was assigned to SE RAW, an enterprise established in 2004. These activities include primarily processing and storage of RAW, generated as a result of the operation of Kozloduy NPP, and radioactive sources which are used for economic purposes in various fields (medicine, industry, agriculture, and scientific research).

Kozloduy NPP and the license holders for use of radioactive sources reprocess radioactive sources and ensure the interim storage of all generated RAW on their sites until their handover to SE RAW.

At the SE RAW, processing and intermediate storage of the conditioned RAW for disposal in the NDF is performed following its commissioning.

The radioactive sources used for economic purposes are another source of radioactive waste. About 2300 sites in Bulgaria use radiation sources in the field of industry, agriculture, medicine and the institutes for scientific research. The disused sources qualify as RAW and are, therefore, transferred to the SE RAW Specialized Division Permanent Storage Facility - Novi Han ("PRAWR - Novi Han") where they are subject to treatment and storage.

After processing, conditioning and interim storage, low and intermediate level short-lived radioactive waste must be disposed of in the National Disposal Facility for Radioactive Waste (NDF).

The first strategy (2004) plans the first stage of the NDF to be commissioned in **2015** In July 2005, the Council of Ministers assigns the construction of the first stage of the SE RAW repository (Decree No. 683). The initial deadline for its commissioning (2015) was not met and a new deadline was set, **2021,** which was also extended.

The last approved deadline for the first stage of construction of the NDF (with a total capacity of 46 000 m^3) is the end of **2023.** What follows after completion of the construction is a stage of defect elimination, issuing safety reports and other documents, and licensing. Considering this, the commissioning of the NDF is expected to take place in **2025.**

The results of the commissioning programme for the Plasma Melting Facility (PMF) show a multiple reduction in the volume of the RAW for further sealing. As a result, the delay in the NDF construction does not lead to difficulties in the conditioning and interim storage of RAW and the process of decommissioning of Units 1-4.

It should be noted that in the absence of a licensed NDF, any proposal for the construction of a new nuclear unit cannot be recognised as a sustainable investment project according to the complementary delegated act project, which has been developed in compliance with Regulation (EU) 2020/852 on the establishment of a framework to facilitate sustainable investment and amending (Taxonomy Regulation).

The construction of the NDF Stage II has to be finished 20 years following the commissioning of Stage I, and Stage III - 20 years following the completion of Stage II, respectively.

The NDF will be in operation from 2025 to 2085 and the closure period will continue until 2100, and the institutional control and the period after it will continue to about 2400.

Management of RAW that contain very low level radionuclides

Such waste is generated during the operation of nuclear reactors and their decommissioning, and as a result of the use of radioactive sources for economic purposes. In accordance with the Regulation for Safe management of Radioactive Waste, it is a Category 1 and no actions are needed for radiation protection and high level of isolation and confinement.

If the waste conforms to the criteria specified in the Regulation on Radiation Protection, it can be exempted. The exemption of materials is another important aspect of minimising the quantities of RAW, something that the licensees pay increasingly greater attention to. Meanwhile, the legislation requires from the licensees to take action in order to prevent any uncontrolled environmental release of radioactive materials. The intentional mixing and dilution of radioactive material in order to obtain clearance is forbidden.

Management of long-lived radioactive ILW and HLW

This RAW consists primarily of several by-products from the processing of SNF as well as of some RAW obtained during the operation and decommissioning of the nuclear reactors at Kozloduy NPP. The legislation requires that, after its conditioning and interim storage, this RAW be sent for disposal in a DGR.

Assessment of the generated HLW as a result of the processing of SNF

Processing the SNF consists of separating the uranium from the plutonium and the fission products from the metal components of the FAs that contain SNF.

The resulting fission products are property of the EU. At this stage their future use in the nuclear fuel cycle is unclear.

The separated fission products (which contain about 1% of uranium and plutonium) are mixed with molten glass and the resulting mass is encapsulated in primary metal containers that are sealed by means of welding the lid. Their volume is about 150-200 l and the vitreous mass of it can reach up to 500 kg. The end product has a very high total activity (in the order of $5{,}55 \times 10^{12}$ Bq/kg) and considerable heat release (about 2 kW/m^3) For these reasons, such waste materials fall under Category 3 (HLW) and require constant cooling and biological protection during their storage.

When processing SNF at the PT-1 plant, two or three containers are put one on top of the other in a vertical metal container (a transport module with a diameter of about 60 cm and height 3,4 m when three containers are inside it) that is sealed by welding the lid. The transport module is moved for storage in a storage facility where it is provided with air cooling.

The SNF processing technology in other countries is similar and applicable.

In the processing process, the metal elements of the FAs are crushed, compacted and sealed in similar containers. This method leads to a reduction of their volume many times. Depending on the initial enrichment of the nuclear fuel and its burnup, they can be Category 2b or Category 3 RAW. Other RAW are generated as well, mostly chemical solutions that are cemented and sealed in metal containers.

The radioactive waste from the processing of the shipped SNF quantities to 1989 incl. are not subject to shipping back to Bulgaria. For the quantities of SNF shipped after 1989 (transportation was resumed in 1998), any matters related to shipping back the reprocessed RAW are settled within the signed framework contracts.

As stipulated in the contract for technological storage and processing of WWER-440 SNF in FSUE Mayak PA, the vitrified HLW and other RAW will be returned under the conditions of a separate contract. The same approach will be used for the radioactive waste generated from the processing of WWER-1000 SNF in the same plant. The return of the vitrified HLW and the other RAW is planned to take place at least 10 years after reaching an agreement on the Methodology for determining the quality and the characteristics of the returned HLW generated from WWER-440 and WWER-1000.

The return of the vitrified HLW and the other RAW from the processing of WWER-1000 SNF in FSUE MCC (Mining & Chemical Combine), Zheleznogorsk, shall be performed under a separate contract that has to be signed after 25 years of storage of SNF at the processing plant. The SNF specific volume and characteristics will be determined and coordinated between the two parties according to a Methodology for determining the quality and the characteristics of the returned HLW that conforms to the international practice that has to be agreed on by 2030.

So far there has been no reliable data to determine the dimensions, volume, radiation and other parameters of RAW packages. Since they are unavailable, an assessment of the total quantity for interim storage and disposal cannot be made at this stage.

This strategy presents activities and tasks for processing SNF in other countries which have the required technological capabilities. The results of a conducted research show that in Europe there are facilities only in France (the UP1 and UP2 plants at La Hague) that have the capacity to reprocess up to 1700 t HM in SNF for a year.

As a **basic scenario** for making estimates, data issued by NEA can be used that during the processing (PUREX method) of 1 t HM, around /more than 115 l vitrified HLW, about/above 350 l long-lived intermediate-level RAW plus the compacted metal parts are generated in SNF. This estimate is subject to update.

According to the report for the present quantities of SNF and the estimates up to 2051, the total amount of SNF generated from Units 1 to 6 and subject to processing is about **3179 t HM**. During the processing of this quantity of SNF, it was estimated (based on the data provided by NEA) that the amount of the vitrified HLW for shipping back to Bulgaria is around 366 m^3 (or approximately 1005 t). The containers with the vitrified HLW are hermetically sealed in transport modules, each with HWL weighing around 270 kg.

The basic assessment of the quantity of HLW subject to return is around 3722 transport modules, each with three containers.

When using a vitrified HLW generation coefficient of 0.385, typical for borosilicate glass, the mass of the HLW for shipping back to Bulgaria is approximately 1224 t (4533 transport modules).

This estimate is subject to update.

5.2.1. Radioactive Waste Management at Kozloduy NPP

The responsibilities for RAW management on behalf of Kozloduy NPP are allocated between the plant (as a licensee) and SD "RAW-Kozloduy". Kozloduy NPP is responsible for collecting, sorting, processing and the interim storage of the generated waste. SD "RAW-Kozloduy" is responsible for the processing and interim storage of the conditioned and sealed RAW and their further disposal. The RAW management activities are stipulated with a Complex RAW Management Programme issued by Kozloduy NPP.

The facilities for interim storage of RAW generated from Units 5 and 6 that are currently in operation are located in AB-3 and include:

- A spent fuel storage facility for low-level and intermediate-level RAW (category 2a) with dose rate below 10 mSv/h – cell type underground vaults: 18, with a capacity of 2486 m^3;
- A spent fuel storage facility for low-level and intermediate-level RAW (category 2a) with dose rate above 10 mSv/h – cell type underground vaults: 3, with a capacity of 224 m^3;
- A liquid radioactive concentrate storage facility: 7 stainless steel tanks with a total capacity of 3584 m^3;
- Spent Sorbents Storage Facility: 2 stainless steel tanks, each with a capacity of 100 m^3.

Information on the condition of the storage facilities at the end of 2022 is presented in Appendix 4, Item 1.

Despite the comparatively big capacity of the storage facilities, to prevent burdening the future generations and facilitating the decommissioning of Units 5 and 6, the adopted approach for the management of RAW generated by Kozloduy NPP is aimed at:

- Minimisation of the quantities of generated RAW.
- Sending for disposal all solid radioactive waste generated in the process of operation.
- Retrieval of legacy waste (solid and liquid) from the RAW repositories and shipping it for processing.

The policy for minimisation of the generated RAW is implemented by applying organisational and technical measures in the following main directions: preliminary planning and control of the generated quantities of RAW; improving the operation and maintenance of equipment; preventing the spread of radioactive contamination; separation and sorting of radioactive materials by type and radiation characteristics; providing for a connection between the activities that generate RAW and the subsequent stages of RAW management; exemption.

Depending on its state at the time of generation, waste can be solid and liquid.

Solid RAW

The average annual generation of solid RAW from Kozloduy NPP includes:

- Radioactive waste of Category 2a with dose rate above 10 mSv/h - around 1 m^3, that is stored in the AB-3 storage facility.
- Nonmetal radioactive waste of Category 2a with dose rate below 10 mSv/h – from 400 to 600 m^3, sent for processing immediately after its generation.
- Metal RAW - between 20 t и 70 t, either shipped for disposal or decontaminated.

Similar information on the generated RAW is presented in Appendix 4, Item 2:

Considering that the subsequent methods for processing are based on reduction of the capacity by means of compaction located at the generation source, the solid RAW is subject to preliminary sorting into: compactible (textile, wool, plastic, etc.), noncompactible (construction waste, wood) and metal.

Prior to sending solid RAW to SD "RAW-Kozloduy", waste is checked for compliance with the acceptance criteria for processing.

Waste with dose rate lower than 1 µSv/h is managed as very low-level RAW and is considered candidate for exemption. According to the requirements defined in the NRA regulations, these types of RAW are subject to additional measurements and assessments to define their compliance with the criteria for exemption, specified in the Regulation for Radiation Protection.

Liquid RAW

As a result of the operation of Units 5 and 6, between 15 000 and 30 000 m^3 of radioactive wastewater is generated annually. Mechanical impurities in the wastewater are removed by means of sedimentation and mechanical filtration, then water is further processed by means of evaporation. As a result of this evaporation, a radioactive and distilled concentrate is produced. The resulting concentrate is additionally filtered through ion exchange resins, it is collected in tanks and following radiation monitoring and control for the presence of borates, it is discharged into the environment.

The radioactive concentrate (still bottoms, SB), which is obtained after wastewater processing by means of evaporation, is stored in tanks located in Auxiliary Building-3. The annual concentrate generation is between 150 and 250 m^3. After commissioning of the liquid RAW processing line in SD "RAW-Kozloduy" in 2003, the concentrate is regularly pumped out of the tanks and then channeled through a pipeline for processing and conditioning. Before the concentrate is transferred to SD "RAW-Kozloduy", its compliance with the acceptance criteria for processing is assessed. Over time, part of the stored concentrate crystallises and the content of the tanks is of solid and liquid phase.

In the last few years, approximately 220 m^3 of the liquid phase is pumped out and channeled for processing in SD "RAW-Kozloduy". To be extracted and channeled for processing, the solid phase has to be dissolved.

The spent sorbents (ion exchange resins and activated charcoal) used to remove radionuclides from wastewater, are stored in Auxiliary Building-3 in two tanks, each with a capacity of 100 m^3 . The annual generation of spent sorbents varies between 0,5 and 6 m^3. A new method for their extraction, treatment and conditioning is under development.

The sludges deposited on the technological systems are estimated to be approximately 50 m^3. A new method for their extraction, treatment and conditioning by cementing is under development. This method has successfully passed laboratory tests and currently an installation for its industrial implementation is under construction.

Estimates and assessments for RAW generation

The activities related to reconstruction and modernisation of Units 5 and 6, connected with the thermal power uprate of the reactors to 104 % and the lifetime extension carried out in the last ten years, did not cause a significant change in the rate of generation of liquid and solid nonmetal (compactible and noncompactible) RAW. On this basis, it is reasonable to assume that in the last 30-year operating period of Units 5 and 6, the average generation and processing rates of solid RAW and liquid concentrate will remain the same.

The estimated quantities of solid and liquid RAW expected to be generated in the next 30-year operating period of Kozloduy NPP and the justification for the assessments made are specified in Appendix 4, Item 2.

5.2.2. Radioactive Waste Management in SE RAW

The State Enterprise "Radioactive Waste" is the national operator for RAW management outside the facilities in which they are generated. The main commitments of the enterprise are related to the collection, handling, pre treatment, processing, conditioning, storage and disposal of radioactive waste. SE RAW is also responsible for the Kozloduy NPP Units 1-4 decommissioning activities. The enterprise consists of Headquarters and four specialised divisions according to the location of the nuclear facilities:

- Specialised Division - "Decommissioning - Units 1-4, regulates the decommissioning activity, dismantling and follow-up activities for Kozloduy NPP Units 1-4, while managing and operating the rest of the process systems, facilities and equipment remaining in operation in compliance with the safety requirements.
- Specialised Division "Radioactive Waste - Kozloduy" (SE "RAW - Kozloduy") carries out the collection, sorting, transportation, processing and storage of RAW generated from the operation of the nuclear power plant;
- Specialised Division "National Disposal Facility" (SD "NDF"). The activity of the division is related to the design, commissioning and operation of a repository for long-term storage of low and intermediate level radioactive waste;
- Specialised Division "Permanent Radioactive Waste Repository – Novi Han" (SD "PRAWR - Novi Han") was designed for storage of radioactive waste resulting from the application of radioactive sources in medicine, industry, science and education.

The inventory and quantities of RAW, managed by SE RAW (as of 31 December 2022), are presented in Appendix 5.

5.2.3. High-level Waste (HLW) Management

It is internationally accepted that the only reliable way to isolate the long-lived radionuclides of RAW Category 2b and Category 3 from the environment is through their disposal in stable, deep geological formations.

5.2.3.1. General Notes

The construction of a deep geological repository (DGR) in Bulgaria (not excluding the possibility to participate in international projects) has been clearly defined as a requirement in the Strategy revisions in effect so far.

A plan for the establishment of a national DGR is described in the Strategy of 2004, in which the key stages are defined and a decision for its establishment was scheduled to be accepted by the Council of Ministers in 2015. This objective has not been achieved. The development of a "National progamme for the geological disposal of category 2b HLW and ILW (intermediate level waste) until 2013" was defined as an objective in the Strategy of 2011, which had to be adopted by the Council of Ministers. This objective has not been achieved either. The development of this programme was also required in the 2015 Strategy. A plan for the construction of a DGR until 2050 has been developed in the current Strategy (Appendix 7).

It should be noted that in the absence of a plan with clearly defined stages, deadlines and funding for the construction of a DGR until 2050, any proposal for the construction of a new nuclear unit cannot be recognised as a sustainable investment project according to the complementary delegated act project which has been developed in compliance with Regulation (EU) 2020/852 on the establishment of a framework to facilitate sustainable investment (Taxonomy Regulation).

5.2.3.2. Past Activities

Analyses on the "Investigation of the possibilities for construction of a geological repository for high-level waste from SNF processing and other nuclear applications in Bulgaria" have been conducted by "MINPROEKT EAD" - Geological Institute - BAS.

A pre-feasibility study on the opportunities for the construction of a geological repository for high-level and long-lived radioactive waste in Bulgaria has been carried out in order to clarify the practicability and the conditions required for construction. A concept for the construction of a geological repository and paths for its implementation has been developed.

Three areas of interest have been defined as part of the performed zoning of the Bulgarian territory, tentatively called: North Western, Central North and Eastern areas of interest.

Five prospective areas have been localised. For each one of the prospective areas, namely "Lower Cretaceous Marls - Sumer Formation", "Neogenic Clay", "Lower Cretaceous Marls - Trambesh Formation", "Lower Cretaceous Marls - Gorna Oryahovitsa Formation" and "Sakar", analysis has been performed of the geotectonic, geomorphologic, neotectonic, seismic, hydrogeological and geoengineering conditions, hydro-meteorological and socio-economic specifics.

The potential geological blocks which should be further investigated have been localized. The potential host rocks are lower cretaceous dense and clay marls, neogenic clay and granites.

Reports of the BAS Geological Institute geofund, the National geofund of the Ministry of Economy and Industry, have been included into the preparation of the project documents, while establishing a data base of initial graphical applications - reports with results from deep sounding, petrol and gas exploration activities, geophysical cuts and geoseismic profiles of probing for the preliminary characterisation of the potential geological blocks. A conceptual description of the geological repository has been developed.

Information has been collected and analysed for these geological blocks and adjoining sites from existing sources (publications, geofund reports, relevant thematic maps, etc.) in order to provide data on: location, geotectonic conditions, seismic and neotectonic conditions, geomorphological, geoengineering, hydrogeological conditions, hazardous geological processes and phenomena, meteorological and hydrological conditions, characteristics of the infrastructure, certain socio-economic factors, etc.

Preliminary characterisation of the potential geological blocks has been conducted, with the next stage being the identification of 2 to 3 blocks on which preliminary studies and research shall be carried out with regard to the potential construction of an underground research laboratory and a DGR.

The conclusion from the preliminary studies is that Bulgaria has the appropriate geological conditions (especially in the Moesina plates' marl rocks in Northern Bulgaria) for the construction of a deep geological repository.

Narrowing down of the potential sites need to be accelerated and the sites have to be completely investigated in order to identify the most suitable one of them. SE RAW has developed an indicative time-schedule with a deadline until 2050 (Appendix 7) for implementing the activities on the licensing process for studies and for shortlisting the potential sites, conducting detailed investigations, site selection and licensing for the construction of a DGR with clearly defined stages, dates and the necessary financial and human resources. The plan also defines the subsequent activities - design, construction (potential construction of an underground laboratory), commissioning, operation, decommissioning, regulatory control period following closure, etc.

Prior to the submission of a draft Decision to the Council of Ministers for the construction of a DGR it is necessary to introduce amendments and supplements in the SUNEA. The results from the past activities are not sufficient for the preparation of such a Decision.

5.2.3.3. Initial costs estimation for the construction of a DGR

Initial costs estimations performed so far by SE RAW for the construction of a DGR in Bulgaria vary significantly. On account of this, the following approach has been adopted - the initial estimation of these costs has to be based upon data comparison of countries which have already performed similar analyses.

According to the publicly available EL SWD (2019) 436 working document which is an accompanying part of the Commission Report to the Council and the European Parliament on the implementation of Directive 2011/70 and an inventory of radioactive waste and spent fuel present on the Community’s territory and future prospects *(https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52019SC0436&rid=7)*, assessments of the countries with nuclear programmes that are similar to the Bulgarian programme are:

- Czech Republic - costs associated with the construction of a DGR - around EUR 4 billion;
- Slovakia - costs estimated to EUR 2,7-3,6 billion;
- Finland - initial costs - around EUR 3,5 billion.
- Lithuania - initial costs - around EUR 2,5 billion.

France plans to develop a DGR (initial costs - around EURO 25 billion) in a giant clay bedrock at a depth of approximately 500 metres underground and to use it for the disposal of conditioned HLW generated from the processing of SNF and from the operation and decommissioning of the NPP. These two conditions most closely resemble the objectives of Bulgaria for the complete processing of SNF and disposal, most likely also in a clay bedrock, of RAW generated from it. If the difference in the scale of the nuclear programmes (approximately 12 times) is considered, the loss from the economies of scale and other factors, the estimation result will approximate EUR 2.5 billion.

At present, taking into account the above facts, **the sum of BGN 5 billion**, subject to periodical updating, is assumed as the baseline estimate for the construction of a DGR in the Republic of Bulgaria. It should be borne in mind that following the construction of the repository, significant financial resources will be required for its operating expenses, as well as for its closure.

6. DECOMMISSIONING ACTIVITIES FOR KOZLODUY NPP UNITS 1-4

Units 1 and 2 with WWER-440 type of reactors were shut down for decommissioning at the end of 2002. Units 3 and 4 with WWER-440 type of reactors were then shut down for decommissioning at the end of 2006.

The decommissioning activities are executed in three main phases:

1. Phase 1 - the preparatory activities for decommissioning and the removal of SNF are performed with a licence for the operation of the units;
2. Phase 2 - a licence for RAW management applies to the activities for removal of the historical RAW from the units, and the initiation of decommissioning infrastructure building;
3. Phase 3 – the decommissioning activities are performed with a licence according to the SUNEA;

Until 2010, the operator for the decommissioning activities was Kozloduy NPP EAD and since 2010, SE RAW has taken up this role.

Licences for the decommissioning of Units 1 and 2 were issued in 2014, while for Units 3 and 4 the licences were issued in 2016. All units are currently at Phase 3.

The equipment dismantling activities commenced from Units 1-4 Turbine Hall (TH) where the secondary circuit non radioactively contaminated equipment is located, followed by dismantling in the controlled area (CA).

As at the end of 2019, all activities related to the dismantling of the equipment to elevation 0 in TH (turbines generators, condensers, pumps, heaters, etc.) have been completed. Currently, there are pipelines and cable routes at elevation –3.60 ensuring the operation of safety important systems which will be dismantled at a later stage.

Table 3 presents the quantity of dismantled metal in the TH.

Years	2011	2012	2013	2014	2015	2016	2017	2018	2019
Dismantled metal (tonnes)	345	2,314	5,055	9,909	15,956	21,752	27,050	29,825	31,843

Table 3. Quantity of metal dismantled in the TH (with accumulation).

As at the end of 2019, performance of all the decommissioning activities in the CA proceeded in accordance with the plans approved by the NRA and agreed by the EC and EBRD. Some major projects that have been completed: radiological inventory of the entire Units 1-4 equipment; commissioning of outdoor storage sites for materials exempt from regulatory control; commissioning of the Size Reduction and Decontamination Workshop; procurement and commissioning of loading and transport equipment to support the decommissioning activities; the Plasma Melting Facility (PMF) commissioning programme has been successfully completed and the documentation for the issuance of an operating licence from the NRA has been prepared; completion of the activities related to laboratory testing and the NRA verification of the polymer matrix properties for liquid RAW conditioning (conditioning of sludges, sorbents and solid phase in the AB-1 and AB-2 evaporator concentrate tanks), and installation of the equipment supplied from the manufacturer; Activities associated with the decontamination of the primary circuit have been commenced with a completion deadline in September, 2022; a project for the complete dismantling of the equipment in the controlled area is being developed, etc. No progress has been achieved with regards to the treatment of the evaporator concentrate stored in AB-1 and AB-2.

"Brown field" was selected as the final state of the site. It involves dismantling of the equipment and clearing of buildings and facilities that are not designed for further use, processing and removal of all the RAW from the site and adapting the site to the needs of the nuclear energy sector or other business activities. The deadline for completing the decommissioning activities is 2030.

After 2030, the following facilities will remain in operation at the Kozloduy NPP site for Units 1-4: the Size Reduction and Decontamination Workshop; the Plasma Melting Facility; Units 3 and 4 reactor building which houses a site for the storage of activated equipment (in canisters that are specifically designed for this purpose); as well as auxiliary equipment which ensures the operation of the listed facilities.

7. HUMAN RESOURCES MANAGEMENT ACTIVITIES

Setting up and maintaining an up-to-date system for training of qualified staff is a defining condition for the reliable and safe operation of nuclear facilities, as well as for the management of SNF and RAW activities. The training of specialists for the nuclear industry in secondary schools and higher education institutions, as well as in the afterwards additional training in the nuclear sector first hand, is an important task for the nuclear energy industry.

The system of nuclear staff training and qualification in the Republic of Bulgaria follows a multistage approach and includes:

7.1. Secondary vocational education

- **Igor Kurchatov Technical Vocational School, Kozloduy**

The school was established in 1974 in order to train secondary education staff for the needs of the Bulgarian nuclear energy. There are five specialities for the pupils: "Computer equipment and technology", "Heating engineering - heating, air conditioning, refrigeration and ventilation", "Electrical power generation", "Nuclear energy", and since 2019 - "RAW management" The vocational school graduates can work as executive staff in the nuclear energy sector, including in the field of safe management of SNF and RAW generated by NPPs and sources of radioactivity used in medicine, industry, science and education, or they can continue further their education in higher institutions on specialities relevant to the sector they have chosen to work in.

- **Maria Skłodowska Curie Technical Vocational School, Belene**

The school was established in 1986 and specialises in training of executive staff in the nuclear energy. The school specialities provide a good base to further one's education in higher institutions with a focus on power engineering and nuclear energy. The secondary school educates pupils in full-time and mixed form in total of seven specialities.

7.2. Higher Education

The higher education in Bulgaria offers the opportunity to gain Bachelor's and Master's degree in natural and technical science, as well as PhD degree.

- **Technical University of Sofia (TU-Sofia)**

At TU-Sofia higher education is offered in nuclear specialities for all three degrees of education: BA, MA and PhD. The BA degree is a general one "Thermal and Nuclear Power Engineering" where the fundamental disciplines - the technology basis - are explored. The MA speciality "Nuclear Power Engineering" has a focus on narrowly specialised disciplines related to nuclear facilities operation, nuclear safety, nuclear fuels and nuclear fuel cycles. Particular attention is paid to up-to-date designs of nuclear reactors, simulator training and use of specialised software products. Both the BA and MA degrees are aimed at training highly qualified staff which possesses the necessary knowledge, skills and capabilities to work in the thermal and nuclear energy sector. The university is accredited for two PhD specialities in the field of nuclear energy: "Nuclear Power Systems and Installations" and "Thermal and Nuclear Power Stations".

- **Sofia University "St. Kliment Ohridski"**

The students at the University are trained in speciality "Nuclear Engineering" and are trained in two main directions - applied nuclear physics and nuclear engineering. Both the BA and MA speciality degrees are aimed at training highly qualified specialists in the field of reactor analysis (calculation model of the neutron-physics processes), nuclear safety, nuclear spectroscopy, dosimetry and radiation protection, physics and operation of nuclear reactors, management of nuclear fuel cycles and applications of nuclear and physics methods in different fields of science, medicine and practice. The University is accredited for two PhD specialities in the field of nuclear energy: "Nuclear Physics" and "Neutron Physics and Nuclear Reactors Physics".

- **University of National and World Economy (UNWE)**

Students at the UNWE are trained in an international MA programme for economy of protection and security in English, specializing in "Nuclear Security". The programme has come up as a result of an agreement for cooperation in the field of education and scientific research between UNWE and IAEA. The MA programme provides for solid knowledge in fundamental areas such as law, nuclear technologies and application, radiation protection, as well as in-depth research in the main fields of nuclear security; it aims to train qualified management staff for the needs of nuclear security.

7.3. Scientific Research Institutes

7.3.1. Bulgarian Academy of Sciences (BAS)

The BAS scientists provide scientific and expertise support for institutions and organisations in the nuclear sector. Leading institutions in the field are the following:

Institute for Nuclear Research and Nuclear Energy – BAS (INRNE - BAS)

The INRNE-BAS is a leading comprehensive centre in Bulgaria for research in the field of nuclear technologies. The Institute coordinates a number of activities of scientific organisations in the nuclear research field.

The Institute has gained significant experience in gamma spectroscopy of nuclear fuel (fresh and spent) in order to calculate its isotope composition and fuel burnup. Training and specialisations are delivered at the Institute to highly qualified staff for the needs of nuclear science, nuclear engineering, radiochemistry, environmental radioactivity and thereof scientific directions.

The INRNE-BAS has laboratories that set up the national base for research in the fields of radiochemistry, RAW management, radiopharmacy, production of radioisotopes, environmental radioactivity researches and environmental protection. The laboratories are well equipped for analysis of nuclear materials, for production, fission and concentration of radioactive isotopes.

The Institute has a long-term international experience in researching the process of transmutation of some radioactive fission products, which is expected to shorten the time for their safe storage.

The INRNE-BAS traditionally takes part in the training of highly qualified staff for nuclear science and technologies. The Institute is accredited for four PhD programmes related to nuclear energy: "Nuclear Physics‟, „Neutron Physics and Nuclear Reactors Physics‟, „Nuclear Reactors‟ and „Radiochemistry‟. Many PhD graduates, including some working in Kozloduy NPP, have successfully written their thesis in these programmes.

Institute of Metal Science, Equipment and Technologies with Centre for Hyrdo- and Aerodynamics "Acad. A. Balevski" at the BAS – (IMSETHC-BAS)

The mission of the IMSETHC-BAS is to contribute to the progress of scientific and research activities and education in the country by delivering fundamental and applied scientific research and training in the field of: metal science, heat treatment, casting, crystallization process, structure and properties of metals and alloys, composites and nanomaterials, plasticity modelling, destruction of materials, functionality and reliability of construction, ship hydrodynamics, aerodynamics, water transport, ocean and coastal engineering, marine and river disasters and crisis, national security and defence of the country. The activity of the Institute is at service to society by accelerating the development in the fields of social and economic life at which the efforts of the IMSETHC-BAS scientists are aimed.

Geological Institute - BAS

Ever since its establishment (1947), the Geological Institute plays the role of a comprehensive scientific and research centre in the field of geology and has proved itself to be an institute of national significance where the scientific foundations are laid for comprehensive research and studying of geology in Bulgaria in all the major areas - paleontology, stratigraphy, tectonics, mineralogy, geochemistry, petrology, hydrogeology and engineering geology.

7.3.2. International scientific organisations

Joint Institute for Nuclear Research, Dubna (JINR)

The Republic of Bulgaria (prior to 1992 - People's Republic of Bulgaria) has been part of the Joint Institute for Nuclear Research since its establishment after an Agreement signed in March 1956 in Moscow.

Ever since Bulgaria has been an active participant in the Institute activities. Throughout the years a number of Bulgarian specialists have worked and still do in the JINR laboratories by taking part in a number of the Institute projects, including in the implementation of the mega project NICA - a complex for the study of properties of dense baryonic matter, built on the basis of superconductivity cyclic accelerator of protons and heavy nuclei. The cooperation is carried out in all aspects of scientific activity of JINR, including the access to developments of safe management of SNF and RAW.

European Organization for Nuclear Research (CERN)

The European Organization for Nuclear Research, known as CERN, is the biggest laboratory for particle physics. In 1999 Bulgaria became a CERN Member State and this marked the beginning of a joint cooperation in an array of fields in science and scientific applicability (astronomy, archaeology, astrophysics, computational chemistry, high energy physics, and others alike).

7.4. Initial and continuing specialised training

According to the SUNEA, the RAW and SNF management shall be performed only after obtaining a permit and/or licence from the BNRA Chair to safely perform such activities. The licence holders carry full responsibility for ensuring the safety of facilities and activities. Pursuant to these SUNEA requirements, the licence holders should have available a system established and in force for recruitment and qualification of the personnel.

The BNRA has developed and approved Regulation on the Terms and Procedure for Obtaining Vocational Qualification and on the Procedure for Issuing Licenses for Specialised Training and Individual Licenses for Work Activities involving Nuclear Power. The Regulation sets out the general requirements for the recruitment and qualification system for personnel of the licence holders, the terms and procedures for acquiring professional qualification, the terms for issuance, amendment, renewal, termination, and revocation of licences for specialised training for activities involving nuclear facilities and handling sources of ionizing radiation (specialised training) and others.

A Certifying Examination Board functions at the BNRA which is assigned by the BNRA Chair and can include representatives of the Agency, Ministry of Health, as well as other persons selected by the BNRA Chair who conform with certain requirements. The Board conducts examination for certain positions of the licence holders, which are directly related to complying with the requirements for safe operation of the relevant facilities, and the Board issues certificates of competence.

For ensuring a qualified and competent personnel a recruitment system is applied, requiring the following:

- Examination of the health status and permit to work in an ionizing radiation environment;
- Conduct of psychophysiological examination for compliance of the personal qualities of the candidate for operational personnel, operating with RAW and SNF, with the necessary requirements for holding such position and issuance of conclusion for fitness - this is performed by qualified psychologists. The Ministry of Health provides methodological guidance over this process;
- Conduct of professional recruitment - compliance verification of the candidates with the job description requirements for the degree of education, acquired speciality guaranteeing the minimum knowledge, and the necessary professional experience.

The specialised initial and continuing training for RAW and SNF management and maintaining the qualification of the personnel is carried out by the Training Centre at Kozloduy NPP. Specialists from Kozloduy NPP, SE RAW, as well as specialists handling sources of ionizing radiation, are trained at the Centre.

The Training Centre holds licence from BNRA for:

- Conduct of specialised training in activities performed at nuclear facilities and with sources of ionizing radiation with impact on safety;
- Issuance of certificates of competence for persons professionally engaged in activities in nuclear facilities and with sources of ionizing radiation.

The activities of RAW and SNF management are provided for with sufficient number of qualified personnel in compliance with the licences and permits issued. The specific positions, the number and the required minimum degree of education for holding the position are determined in the staff establishment plan of the licence holders.

7.5. Knowledge management

In technology-intensive industries, knowledge is a key resource required for successful work. In the nuclear industry, as well as in the SNF and RAW management activities in particular, the availability of sufficient knowledge and experience is essential for the safe, effective and efficient operation of facilities.

Knowledge management involves planning, organizing, motivating and monitoring people, processes and systems in order to improve and effectively use existing knowledge assets. Knowledge assets include all documented information and data, in the form of licenses, regulations, instructions, procedures, databases, project documentation, etc. (explicit knowledge), as well as personal or group competencies acquired as a result of professional and life experience to employees that are not documented and not accessible through standard distribution channels or through formal training (tacit knowledge).

The process of knowledge management includes its identification, retrieval, processing, storage, provision of access, sharing and use. The main goal of the process is to provide access to the necessary information and data for the performance of work at any time and at any workplace, on the one hand, and to prevent the loss of unique and specialized knowledge of experts with extensive professional experience, on the other.

In order to ensure sufficient, motivated, competent and qualified personnel and create an organizational culture with an emphasis on safety, a knowledge management system has been implemented at Kozloduy NPP. A main goal of the process is the perception of information and knowledge as a corporate asset that can generate value and whose management requires a high level of commitment and investment in terms of time and resources.

Two main approaches to knowledge management are used:

- Codification of knowledge - formalization of knowledge and information that is important for enterprises. In accordance with the current procedures, employees formalize part of their knowledge (by writing reports, procedures, instructions, statements, etc.) and place them in the current databases to fill in the corporate memory;
- Personalization of knowledge - sharing of knowledge and experience directly between collaborators in a group. It takes place in the form of formal training, participation in seminars, working groups, new projects, exchange of operating experience, mentoring, implementation of techniques for extracting, storing and disseminating tacit knowledge.

The general framework of the system, guaranteeing the achievement of the goals of the of Kozloduy NPP EAD’s management for application of knowledge management methods and tools for developing and preserving corporate knowledge, is described in the "Knowledge Management Strategy".

The development of the system requires the effective work of specialized operational teams in the structural units for the implementation of the activities, periodic training of the teams, maintaining up-to-date working documents, assessment of the risk of knowledge loss, planning of measures to extract and store knowledge, development of the used specialized software products.

In order to achieve operational coherence in the implementation of process activities and to ensure conditions for effective operation of the system in accordance with the expectations of the management, a specialized subdivision - Knowledge Management and Preservation Section was created within the structure of the Training Centre.

A similar approach to management and storage of knowledge is also applied in SE RAW.

In order to create and maintain a sustainable system for the development and improvement of the human resources, which would guarantee the effective functioning of the nuclear sector, a National Strategy for the Development of Human Resources in the Nuclear Sector 2022-2032 has been prepared.

'Centre for Nuclear Competences - Kozloduy' Association

Co-founders of the Association are Kozloduy NPP EAD, Kozloduy NPP - New Builds EAD and SE RAW. The centre was created to maintain and develop highly qualified personnel for the Bulgarian nuclear sector, manage nuclear knowledge, promote the advantages of nuclear energy among adolescents, pupils and students, as well as to establish real cooperation between scientific and educational fields and the industry. The activity of the Association is aimed at active participation in international and pan-European networks and projects, stimulating qualification, applied research and the exchange of experience and good practices in the field of nuclear energy and RAW management.

7.6. Scientific research, development and demonstration activities necessary for the implementation of SNF and RAW management solutions

The Republic of Bulgaria has more than 45 years of experience in nuclear energy and more than 75 years of scientific experience in nuclear research. There are a number of organizations engaged in scientific research, development and demonstration activities, which are necessary for the implementation of SNF and RAW management solutions, such as the Sofia University St. Kliment Ohridski, St. Ivan Rilski University of Mining and Geology, Bulgarian Academy of Sciences (BAS) with the Institute for Nuclear Research and Nuclear Energy (INRNE), the Institute of Geology and the Institute of Metallurgy.

The cooperation between scientific and engineering organizations, both within the Republic of Bulgaria and internationally, is an essential element in the process of exchanging knowledge, scientific infrastructure and personnel. Such cooperation allows the joining of efforts to solve specific tasks in the field of science and new technologies and is carried out between operators of nuclear facilities, national and international organizations on a project-type basis. In this regard, the following projects can be mentioned:

- Activities related to a preliminary study of the possibilities for the construction of a deep geological repository and suitable geological formations for a borehole repository for decommissioned radioactive sources. It is implemented jointly by the SE RAW and the Geological Institute of the BAS;
- Investigations, sampling and monitoring carried out in connection with the assessments of the long-term safe operation of the National RAW Repository (NRRAW). Assessments of the geological and geomorphological conditions of the Danube Plain in the Quaternary. It is implemented jointly by the SE RAW and the Geological Institute of the BAS;
- Technical solutions to minimize RAW from contaminated and activated metals. It is implemented jointly by the SE RAW and the Institute of Metallurgy, Facilities and Technologies of the BAS;
- Cooperation between SE RAW, TRACTEBEL ENGINEERING SA, Brussels, BELGIUM and the Institute of Geology of the Bulgarian Academy of Sciences in the field of disposal of RAW in geological formations, packaging of RAW and intermediate storage of RAW after processing.

Considering that the safe management of SNF and RAW is a complex and difficult problem and that international cooperation can significantly improve it, and eventually - provide a final solution, our country actively participates in the international efforts to improve the management of SNF and RAW. An important element of the international cooperation is the exchange of information, experience and technologies on the basis of the Euratom Treaty, the Code of Practice on the International Transboundary Movement of Radioactive Waste and the Joint Convention. Examples of the participation of the Republic of Bulgaria in international and regional initiatives and projects of the IAEA and the EU are presented below:

- INPRO (International Project on Innovative Nuclear Reactors and Fuel Cycles) International project on innovative nuclear reactors and nuclear fuel cycle under the initiative of the IAEA;

- WENRA (Western European Nuclear Regulators Association). NRA has been a member of WENRA since March 2003 and participates in the harmonization activities;
- Committee to support the decommissioning of nuclear facilities at the EC (NDAPC) and the Kozloduy International Decommissioning Support Fund (KIDSF). Monitoring Committee for acceptance of the planned decommissioning activities, which are financed by the KIDSF, administered by the EBRD;
- IFNEC - International framework for nuclear energy cooperation. The main tasks of IFNEC are the development and use of modern technologies in the nuclear fuel cycle with the aim of significantly reducing RAW, simplifying their storage and disposal and reducing the quantities of spent nuclear fuel from civil applications in a safe and secure manner protected from any illegal proliferation of nuclear materials;
- HERCA (Heads of the European Radiological Protection Competent Authorities) Association of European radiation protection authorities, established in 2007 under the initiative of the French Nuclear Safety Authority (ASN). The NRA has been involved in the work of HERCA since its inception;
- European Radioactive Waste Management Agencies Club of Agencies.
- International Low-Level Waste Disposal Network (DISPONET). An international network to support the activities of the IAEA member countries in the field of disposal of low and medium radioactive waste;
- International Decommissioning Network (IDN). An international network to support the activities of IAEA member countries in the field of decommissioning of nuclear facilities and safe management of low- and medium-level radioactive waste generated by these activities;
- NEA/OECD Committees and Working Groups in the field of Nuclear Safety and Decommissioning.

Areas for future research

- Minimization of RAW from the operation of the NPP;
- Minimization of RAW from the decommissioning of the NPP;
- Optimization of the technologies for decontamination during decommissioning of NPP;
- Assessment of the condition of the ground foundation and the structures, systems and components of buildings at the site of units 1-4, with a view of the future use of these buildings;
- Periodic assessment of the condition of the ground foundation and of the structures, systems and components of the Spent Fuel Storage Facility (SFS) and the Dry Spent Fuel Storage Facility (DSFS);
- Assessment of the insulating and protective properties of the multi-barrier coating of the NRRAW;
- Post-operational monitoring of the NRRAW;
- Development of methodologies for the characterization of historical RAW;
- Development of technologies for extracting historical RAW from the underground storage facilities of the SD RAW-PSF of Novi Han.
- Development of HLW acceptance criteria;
- Studies of the characteristics of the potential sites for borehole disposal and deep geological disposal (DGD);
- Feasibility studies of HLW disposal technology (underground demonstration laboratory);
- Safety assessments, methodologies and modelling programs for demonstrating the safety of DGD.

The scientific research, development and demonstration activities, which are expected to be carried out on a national level, will be included in the business programmes of Kozloduy NPP and SE RAW and financed with own funds and resources from the national funds.

8. ECONOMIC AND FINANCIAL ASPECTS

8.1. Estimate of the costs for the management of Spent Nuclear Fuel (SNF) and Radioactive Waste (RAW), including decommissioning activities

8.1.1. Costs of Kozloduy NPP

Kozloduy NPP costs for management of SNF and RAW are a part of the process for long-term and operational planning taking into account all aspects of their safe management - safety, environment, national and international requirements, etc., in an integrated manner. The established system for planning and budgeting, approval, implementation and control of the costs associated with SNF and RAW management ensures that the funds planned and spent on these activities are adequate in terms of amount and are provided when required.

Monitoring of the results of the planned SNF and RAW management activities is performed periodically, the areas of risk and concern are identified. A system of internal rules and procedures for preliminary, ongoing and follow-up control has been established in order to provide for the necessary resources in accordance with the planned activities.

Spent nuclear fuel (SNF) management costs

The estimate of the costs for SNF management in Kozloduy NPP includes the SNF management for the whole operating lifetime and after the shutdown of the units until the complete complete removal of the spent nuclear fuel from the site.

The annual funding of the activities for storing SNF in the storage facilities at the plant site (Spent Fuel Pools of Units 5 and 6, Spent Fuel Storage Facility(SFSF), Dry Spent Fuel Storage Facility (DSFSF)) and activities connected with the shipment of SNF abroad for technological storage and processing, is performed with own resources, based on the approved budget.

The strategy chosen for transportation of 77 t of HM SNF on average per year for long-term storage and processing allows a rhythmic allocation of funds over time when the units are in operation and generate income. This creates predictability in the formation of the prime cost of electricity, respectively better planning and management of the costs in the long term, and reduces the risk of transferring the responsibility for additional funding of the SNF management activities to future generations.

The Kozloduy NPP EAD costs for SNF shipment for technological storage and processing are currently recognised as costs for the licensed activity forming the prime cost of electricity. In the event that shipment of spent fuel is not possible, provisions are accrued for the respective year in accordance with the internal rules and accounting policies.

The estimate of the costs for SNF management is based on the long-term operation of Units 5 and 6 and the planned transportation scheme for shipment of SNF from WWER-440 and WWER-1000 reactors in accordance with the goals set in the Strategy.

Together with the shipment of SNF following the above-mentioned scheme, an alternative scenario for licensing of the DSFSF Extension for dry storage of SNF from WWER-1000 is being considered as a buffer solution.

The WWER-440 SNF assemblies shipped in the period 1979-1988 (362 t HM), for which Bulgaria will not receive HLW and funds will not be paid, are excluded from the prepared estimation of the SNF and HLW management costs.

The funds for the WWER-440 and WWER-1000 assemblies shipped from 1998 to 2022 amount to BGN 1138 million and account for about 33 % of the total estimate of the funds required for SNF shipment calculated for the period 1998-2060, including shipment of SNF from WWER-440 reactors. In compliance with a signed framework Annex to a long-term contract with FSUE "Production Association Mayak", in agreement with Euratom Supply Agency, in 2023 two shipments of SNF are projected to be completed (total of 118 WWER-1000 assemblies, if possible the two transports will be combined into one).

The estimated cost for transport, long-term storage and processing of the SNF from WWER-1000, stored at the Kozloduy Nuclear Power Plant site at the end of 2022 (including the remaining 118 not transported assemblies under the signed Addendum to the contract) and the amount of SNF that will be generated in the operation of units 5 and 6 between 2023 and 2051 (around 4000 assemblies) is expected to be around **BGN 1,876 million** (without price escalation). The estimate is based on agreed prices for technological storage and processing service under the current Agreement and includes all transport costs, license fees, expenses for permits, insurances and other costs incidental to transportation.

The estimate of the costs for transport, long-term storage and processing of the WWER-440 SNF quantities is around **BGN 361 million**.

At this stage an estimate of the costs can not be made if the SNF is reprocessed in France.

The estimates prepared for the financing of the costs for long-term SNF management (at conservative market prices of electricity compared to the current price rates and Units 5 and 6 operation with Load Factor not less than 86%) show that Kozloduy NPP can cover the regular costs for shipment and processing of SNF during the whole operating lifetime of units 5 and 6 with own resources. The financing of the costs for an average annual shipment of 77 t HM SNF for long-term storage and processing during the Units 5 and 6 operating lifetime will ensure removal of the accumulated nuclear fuel from the Kozloduy NPP site without transferring financial burdens to future generations.

Radioactive waste (RAW) management costs

Kozloduy NPP EAD, in its capacity of an operator of nuclear facilities, generating about 95% of the RAW in the country, has the obligation to provide for the availability of sufficient financial resources for its management from the stage of its generation to its disposal. As part of this commitment, priority is given to funding all activities related to RAW management which include:

- Activities performed by Kozloduy NPP covering all stages before transferring it to SE RAW (collection, separation, pretreatment, internal transportation and temporary storage) and compliance with national and internal documents;
- Investment activities for maintenance and renovation of the facilities associated with RAW management;
- Funding of the activities associated with RAW management after transferring the RAW to SE RAW by monthly instalments to the RAW Fund.

The total nominal estimate of RAW management costs until 2051 amounts to more than **BGN 250 million**. The contributions to the RAW Fund in the period 2023-2051 are estimated at **BGN 2159 million** (at 3 % contributions from the revenues from electricity sales).

8.1.2. Costs for the management of RAW by SE RAW

The costs for RAW management activities performed at the specialised divisions of SE RAW are funded by the RAW state fund particularly established for this purpose. The annual funding of the activities is carried out according to annual programmes approved by the Management Board of the fund. The three-year budget estimates for the SE RAW activities provide for costs based on the production programme for annual RAW quantities, submitted to SE RAW facilities, including operational waste from Kozloduy NPP and institutional waste from nuclear applications, as well as for activities for the management of RAW management facilities. The last budget estimate for the SE RAW activities amounts to ~ **BGN 25 million** per year.

The activity of SE RAW related to RAW management for the respective year is planned on a programme basis, in accordance with the requirements of the SUNEA and in pursuance of the Company’s obligations under the Strategy.

The main programmes include production, maintenance and investment activities, as well as personnel costs.

Decommissioning costs

Costs for the decommissioning of Units 1-4

The total estimate of the required financial resources providing for the activities related to the decommissioning of Units 1-4 of Kozloduy NPP for the period from 2003 to 2030 (completion of the process) has been developed based on an approach using cost organisation according to a work breakdown by activities (International Structure for

Decommissioning Costing (ISDC) of Nuclear Installations, Nuclear Energy Agency, OECD, 2012).

The total indicative costs for Units 1-4 of Kozloduy NPP for the period from 2003 to 2030 are estimated to around **EUR 1357.71 million.** In the Strategy from 2015, these costs were estimated to **EUR 1107.439 million**. The indicative estimate of the required financial resources for the decommissioning of Units 1-4 of Kozloduy NPP has been prepared on the basis of a developed plan and an updated strategy for decommissioning of the four units by "continuous dismantling".

Table 4 presents the allocation of costs (EUR million) for decommissioning by categories:

Labour costs (MEUR)	**Investment costs** (MEUR)	**Expenses** (MEUR)	**Contingencies** (MEUR)	**Total** (MEUR)
459.200	**514.225**	**288.279**	**96.011**	**1357.714**

Table 4. Allocation of costs for Kozloduy NPP Units 1-4 decommissioning by categories.

Estimated costs for Kozloduy NPP Units 5 and 6 decommissioning

Currently, a preliminary Concept has been developed for the decommissioning of the Kozloduy NPP Units 5 and 6, with continuous dismantling and a stage of safe storage of the equipment in the Controlled area. The activities to be implemented, their sequence and duration have been determined.

The determination of the financial resources required for decommissioning is only possible after the completion of a detailed planning of the decommissioning activities. Different pre-calculation models are used also based on comparison with similar estimates for other nuclear power plants. Regardless of the method, some unpredictability is inevitable in all estimates of future costs. The differences in the NPP designs, the final goal of the decommissioning, standards of living in the different countries, the calculation methodologies also lead to large differences in the required financial resources.

The forecast costs for decommissioning of Units 5 and 6 have been estimated on the basis of an alternative estimation of the costs for decommissioning of 1 GW(e) which is based on comparative analyses of the IAEA and OECD and existing global practices in this area. The calculations are based on the most recent data published by international nuclear agencies in the source "Costs of Decommissioning Nuclear Power Plants" NEA No.7201, OECD 2016, according to which the estimated cost of decommissioning of nuclear reactors under the option of immediate dismantling in European countries ranges from EUR 230 million to EUR 1 300 million per 1 GW(e). Taking into account these data and the updated financial cost estimates for decommissioning of units which are in the process of decommissioning in Bulgaria, Lithuania and Slovakia, the baseline costs for the decommissioning of Units 5 and 6 structured according to the ISDC are estimated at ~ **EUR 620 million** per 1 GW(e). A 10% contingency (**EUR 62 million** per 1 GW(e)) and resources to the amount of 15% (**EUR 97 million** per 1 GW(e)) are added to these for costs arising from uncertainties and risk events in the future. Based on the above assumptions, the total financial estimate of the required costs for Units 5 and 6 decommissioning amounts to ~ **EUR 1 600 million** (without costs escalation and discounting).

Since the fund-raising processes and the implementation of the activities related to Units 5 and 6 decommissioning have a long-term horizon, in order to assess the adequacy of the contributions raised in the DNF Fund in relation to future costs for decommissioning in the period 2050-2080, their values have been compared using the economic valuation method "net present value", i.e. their values have been recalculated to the present moment, taking into account the time factor and the depreciation of the funds raised in the DNF Fund in the long term. Calculations show the amount (contributions) that is required to be invested in the DNF Fund and at what investment (financial) conditions in order to cover the decommissioning costs until 2080. The assumptions are the following: For the implementation of the option for decommissioning with continuous dismantling, with a duration of the decommissioning activities until 2080, an annual decommissioning costs escalation of 2% and a discount factor of 3%, the present value of the costs for the decommissioning of Units 5 and 6 is estimated at **EUR 440 million**. Applying an identical approach to the accumulation of resources in the DNF Fund and the planned spending of the resources from the Fund until 2080, an expected return on assets in the funds of 3% per year, the present value of the financial resources to be accumulated in the DNF Fund is estimated at **EUR 604 million.**

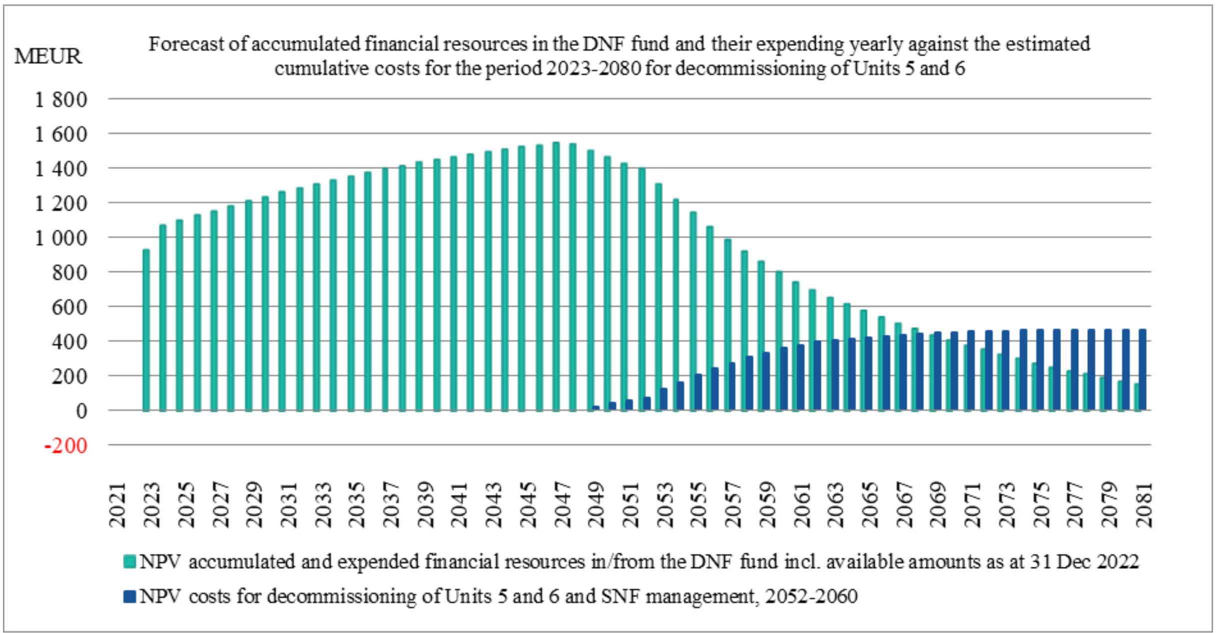


Figure 3. Forecast of funds raised in the DNF Fund and their spending against the estimated costs for the decommissioning of Units 5 and 6.

The comparison of discounted funding and estimated costs per year, does not predict a shortage of funding to cover decommissioning and SNF management activities. Given the long-term horizon for the project implementation, the occurrence of a financial deficit should not be excluded, since economic, technological or other types of modifications, changes in the market environment, etc. are likely to deviate significantly from the current evaluation parameters. Funding shortages may occur when a final decision to opt for long-term SNF and HLW management takes place, as well as in case of significant long-term changes in price escalation and inflation compared to those used in the forecast.

Based on the selected preliminary concept for decommissioning of Units 5 and 6 with continuous dismantling in the short term there should be a move towards:

- Development of a preliminary Decommissioning Plan;
- Development of a methodology for determination of the costs/necessary funds to finance the process of decommissioning of nuclear facilities.

Based on the updated preliminary decommissioning plan and after application of the methodology for estimation of the costs for the decommissioning of Units 5 and 6, a revaluation will be made of the total costs and the adequacy of the set annual contributions to the state funds, attributable to the operating lifetime of the units, in order to ensure sufficient financial resources for the decommissioning activities after shutdown of the last reactor.

8.2. Current financing schemes

8.2.1. General

Kozloduy NPP EAD fulfils the requirements of the licenses issued under the SUNEA and the Energy Act to ensure sufficient financial resources for the safe and responsible management of SNF and RAW. The financing of all activities, including contributions to the RAW and DNF funds, is provided with own resources, which are part of the current operating costs of Kozloduy NPP EAD. These are planned in the company's operational and long-term business programmes and the resources required for them are provided on a priority basis. Contributions to the funds are recognised for tax purposes as current operating expenses and are part of the prime cost of electricity.

The DNF Fund and the RAW Fund are the main financial instruments for the implementation of the State policy for safe management of RAW, including its disposal, and for the activities associated with decommissioning of nuclear facilities. The Funds are dedicated, established to ensure the implementation of specific long-term activities in the field, and are managed in accordance with the regulations in force in a way that ensures:

- Sufficient funds to be available at all times, when needed, to avoid transferring an excessive burden to future generations;
- Effectiveness of the costs for RAW management and decommissioning;
- Transparency in the financial management of funds.

8.2.2. Decommissioning of Nuclear Facilities (DNF) Fund

The proceeds to the DNF Fund are collected from contributions from the entities operating nuclear facilities, from the state budget, interest on the management of the amounts raised in the Fund and on late payments of contributions, as well as from donations and other revenues received as a result of the management of the resources in the Fund.

The amount of the contributions to the DNF Fund are determined in such a way that at the end of the operating period the necessary funds are collected to cover the costs for the decommissioning of the nuclear facilities. Their amount is set out in the Regulation on the procedure for assessment, collection, spending and control as well as definition of the amount of contributions to the Decommissioning of Nuclear Facilities Fund.

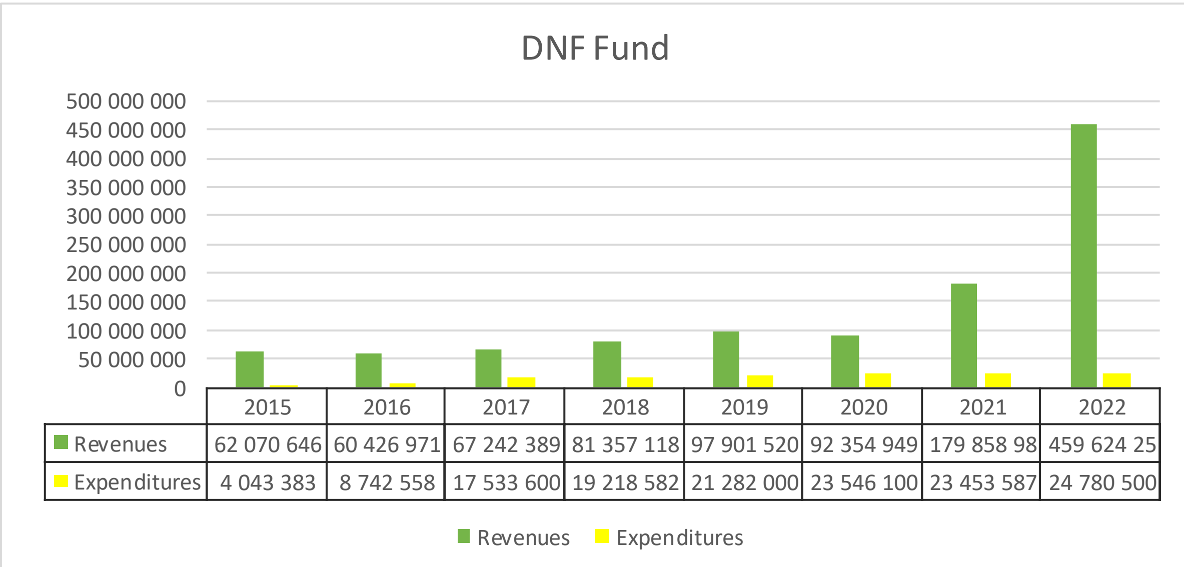
Currently, the due contributions of Kozloduy NPP EAD amount to 7.5 % of the revenue from electricity sales.

The amounts in the Fund are purposefully expended solely to finance the activities related to decommissioning of nuclear facilities, including:

- Annual programme of the decommissioning licence holder;
- Costs associated with storage and disposal of RAW generated from activities related to decommissioning of nuclear facilities;
- Management of the fund, including administrative and financial costs;
- Other, including preparatory activities foreseen by the SUNEA, related to safe decommissioning, including of nuclear power plants declared as facilities for the management of RAW pursuant to the Act.

Where the implementation of the decommissioning project proves to be more costly than the cost estimates approved by the Management Board of the Fund, the necessary additional costs are borne by the person who last operated the nuclear facility, in accordance with an issued operating licence.

The annual revenues and expenditures in the DNF Fund for the period 2015-2022 are presented in Figure 4.



	2015	2016	2017	2018	2019	2020	2021	2022
Revenues	62 070 646	60 426 971	67 242 389	81 357 118	97 901 520	92 354 949	179 858 98	459 624 25
Expenditures	4 043 383	8 742 558	17 533 600	19 218 582	21 282 000	23 546 100	23 453 587	24 780 500

Figure. 4. Revenues and expenditures in the DNF Fund for the period 2015-2022

8.2.3. Radioactive Waste (RAW) Fund

The revenues of the RAW Fund are collected from contributions of legal and natural persons that generate RAW as a result of their activities, funds from the state budget, interest on the management of the funds raised in the Fund and on late payments of contributions, other revenues received as a result of the management of the resources in the Fund. Currently, the due contributions of Kozloduy NPP EAD amount to 3 % of the revenue from electricity sales. The procedure for assessment, collection, spending and control of the amount in the Fund is stipulated with a regulation adopted by the Council of Ministers.

The amount of the contribution of legal and natural persons that generate RAW from nuclear applications is determined using a methodology developed by SE RAW and approved by the Management Board of the RAW Fund based on the costs for acceptance of RAW from nuclear applications for the previous year, the RAW volumes and radioactivity .

The amounts in the Fund are purposefully expended to finance:

- The activity and funding of SE RAW;
- Other activities associated with RAW management apart from those of the specialised state enterprise, including research and scientific developments;
- Decommissioning of RAW management facilities;
- Management of the fund, including administrative and financial costs;
- The municipalities and residential areas in the area of which a facility for RAW management is operated or the construction of a RAW management facility is approved or permitted under the provisions of the Spatial Development Act (SDA) and the SUNEA. They can receive funding for spatial planning and development projects and activities up to a total of 2 per cent of the SE RAW annual budget per year;
- Expropriation of privately owned properties and parts of properties for the construction of national repositories for the disposal of RAW;
- Financing of research and scientific developments related to RAW management.

The annual revenues and expenditures in the RAW Fund for the period 2015-2022 are presented in Figure 5.

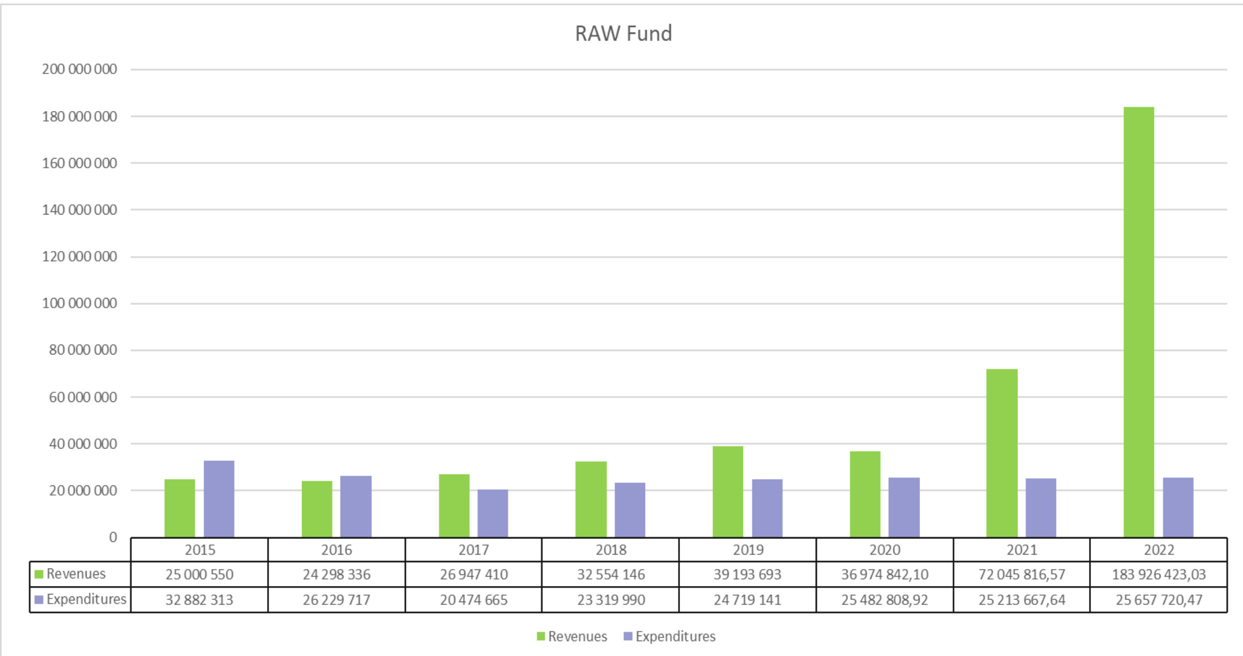


Figure 5. Revenues and expenditures in the RAW Fund for the period 2015-2022

8.2.4. Kozloduy International Decommissioning Support Fund

The Kozloduy International Decommissioning Support Fund (KIDSF) has been established in order to support the decommissioning of Units 1-4 under the Framework Agreement between the European Bank for Reconstruction and Development (EBRD) and the Republic of Bulgaria. The Fund was set up to manage grants awarded by the

European Commission and other donors to reduce the consequences of the early decommissioning of the Kozloduy NPP units.

A grant from the EU amounting to **EUR 866,032 million** was awarded for decommissioning activities and RAW management until 2027.

Taking into account the EU grant, the shortage of resources for the decommissioning of Units 1-4 for the period until 2030 has been estimated to about **EUR 33,620 million**. Taking this assessment into account, it will probably be necessary to adjust the contributions due of Kozloduy NPP to the DNF Fund, as well as steps may be undertaken to provide funding from external sources, including European programmes.

Bulgaria will seek opportunities to provide the necessary funding after completion of the assessment of the resources necessary for the decommissioning of units 5 and 6 of Kozloduy NPP taking into account the plans to extend their operating lifetime.

8.2.5. Establishment of a new fund to generate financial resources associated with the DGR Project

The establishment of the Fund requires that relevant amendments be made to the SUNEA. The Fund is envisaged to be a dedicated one, under the Minister of Energy. It is intended to generate the resources required for the activities related to the DGR project which will ensure the required resources for the implementation of the project. Contributions to the Fund are to be provided from the current operating costs of Kozloduy NPP EAD, and their amount will be set out in a specially established regulation to the SUNEA. The amount of the contributions will be reviewed periodically.

8.3. General assessment of the costs and adequacy of financial schemes

The general assessment of the costs is based on estimated financial resources for the implementation of all stages of SNF and RAW management, from their generation to disposal, including decommissioning activities, taking into account projects and activities currently being implemented or planned for the future.

The financial resources for the management of facilities and activities at the Kozldoduy NPP site have been assessed in perspective till 2100 when all facilities at the site should be provisionally released from regulatory control. Should new nuclear installations be constructed at the site, this perspective may change in the future.

The activities on decommissioning and management of all kinds of RAW, outside the generators sites, are performed by SE RAW with financing from the two specialised funds. The establishment of a new fund for dedicated generation of financial resources for the construction a DGR presented in 8.2.5. is envisaged.

The current financial assessments have been prepared excluding costs for activities related to the management of RAW or decommissioning of a future new nuclear power.

The general assessment is based on:

- Units 5 and 6 long-term operation;
- Plans for the Kozloduy NPP Units 1-4 decommissioning;
- Indicative estimation of the costs for decommissioning of the Kozloduy NPP Units 5 and 6;
- Estimation of the costs of decommissioning of other nuclear installations on the basis of preliminary studies and application of analogies with the activities of the nuclear units;
- Estimation of costs for construction, operation and closure of the NDF based on design documentation and detailed analyses with consideration of reserves;
- Estimated costs for construction, operation, monitoring and closure of the DGR;
- Estimation of costs for construction and operation of a borehole repository based on data from the IAEA reference studies;
- Estimation of costs for construction, operation and closure of HLW and SNF interim storage facilities.

Based on the current financing schemes and market conditions, Kozloduy NPP forecasts that by 2051, the accumulated financial resources in the funds are expected to be in the amount of BGN 9,900 million, including: DNF fund – BGN 7,383 million and RAW fund – BGN 2,517 million (the available amounts reported as at 31.12.2022 are:

BGN 2,293 million in the DNF fund and BGN 359 million in the RAW fund as shown in Figure 6). The assumptions about the financial resources accumulated in the funds are based on estimated revenues from sale of electricity formed on the basis of estimated amounts of electricity and historically reached power exchange prices on the IBEX EAD 'Day Ahead' market segment for the period 20 February 2016 – 30 March 2023.

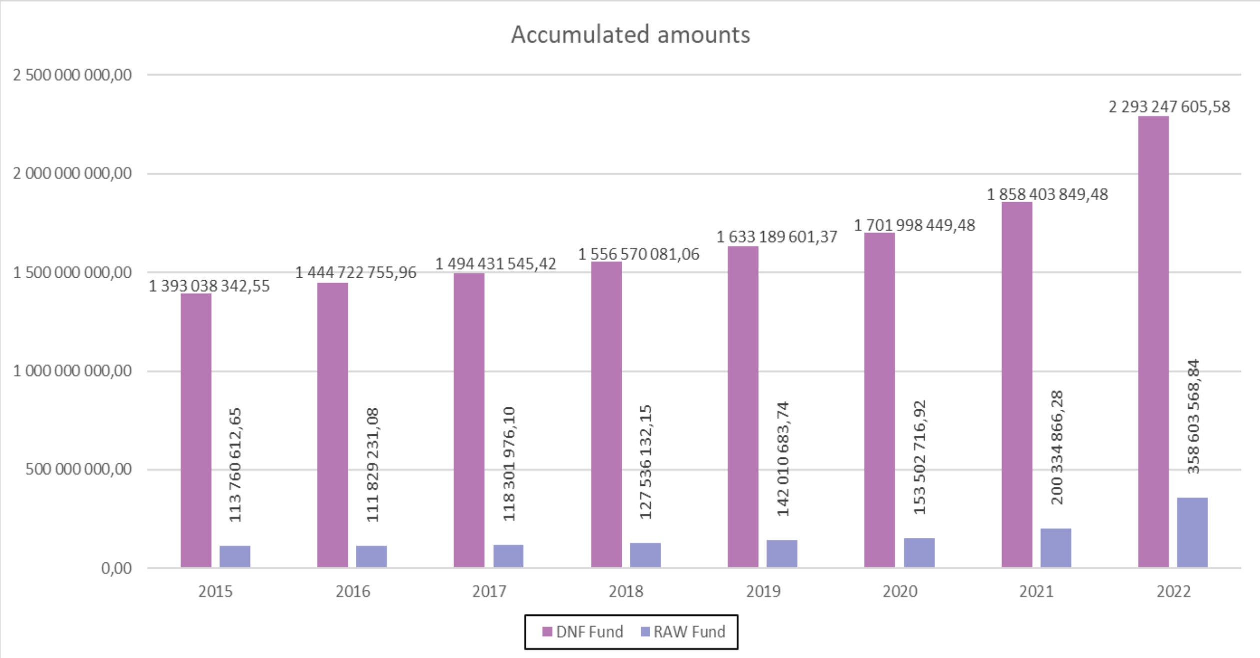


Figure 6. Accumulated amounts in the RAW Fund and the DNF Fund as at 31 December 2022

According to the estimated calculations there is a certain deficit in funding for the costs for activities, including:

- For activities associated with the Units 1-4 decommissioning (EUR 33,620 million);
- For interim storage of HLW (no estimates have been made yet);
- Costs for decommissioning and disposal of RAW from other nuclear installations (apart from Kozloduy NPP Units 5 and 6);
- Costs incurred by SE RAW for the construction and maintenance of support infrastructure for the decommissioning of nuclear facilities, including monitoring, consumables and fees.

In order to provide financial resources for the long-term investment plans for the construction of the DGR, a new dedicated fund needs to be established through an amendment of the SUNEA and the respective regulations. The baseline estimation of the start-up costs for the construction of the DGR is BGN 5 billion. The funds must be available in the newly established fund before the final shutdown of the units.

It is foreseen that, in accordance with the Regulations on the contributions due to the DNF Fund and the RAW Fund, the amounts raised in the funds will bear interest at a fixed and agreed interest rate between the Minister of Finance and the Minister of Energy. At present, the amounts raised are not used for investment purposes and do not provide additional yield/interest.

An essential condition for the management of the amounts in the funds is to apply an appropriate investment strategy, ensuring a return (interest) on the amounts that are accumulated in the DNF Fund, the RAW Fund and the new dedicated fund that is to be established to generate financial resources for the construction of a DGR, that covers at least the annual inflation index so that sufficient amounts are accumulated at the end of the period. The investment of the financial resources in such funds, or part of them, is a practice in a number of European countries in a portfolio of low-risk assets - low-risk cash equivalents, government securities, etc. - in order to accumulate additional funds from the profits of the funds' investment activities. Not investing/not providing positive returns to cover the depreciation of the amounts over the long term is a negative factor in the reduction of the amounts in the state funds in real terms. An additional funding from the state budget after the shutdown of Units 5 and 6 and imposing financial burdens on future generations may be required if the necessary actions for raising sufficient amounts during Units 5 and 6 commercial operation, including additional revenues from financial management of the funds (bearing an interest, investment) have not been undertaken.

Where there is a policy adopted to provide profitability, financial revenue (interest) will continue to accrue after 2051 which will be of a significant amount given the value of the financial assets accumulated. In order to ensure adequate financial resources in the long term, there is a proposition to prepare an Investment strategy for the Funds, which is set out for development in Appendix 6 - Action Plan according to the Strategy. The long-term investment policy of the DNF Fund, the RAW Fund and the dedicated fund that is to be established to generate resources for the construction of a DGR, as well as the specific mechanisms and conditions for managing their financial assets will be set out in the Investment Strategy.

9. MONITORING. IMPLEMENTATION PROGRESS ASSESSMENT. RISKS.

9.1. Strategy implementation monitoring

The overall Strategy implementation monitoring will be carried out by an interdepartamental task force assigned by an order of the Minister of Energy. Pursuant to the Action plan of the Strategy (Appendix 6), the responsibility for the execution of each specific activity is clearly assigned to the relevant competent authority. The currently outlined framework including strategic priorities shall be subject to periodic update in the event of a significant change in the political vision, the national legislative base or the global innovative solutions in the technological development.

9.2. Performance indicators for Strategy Implementation Progress Assessment

Quantitative and qualitative monitoring performance indicators shall be used for the Strategy Implementation Progress Assessment. The planned projects and activities have major contribution to the achievement of the strategic objectives and they are periodically assessed. These projects and activities are assessed using the Earned Value Management methodology, which integrates the scope, schedule and resources for objective implementation progress assessment and monitors the progress made with the implementation of these projects.

The schedule performance indicators (SPI) and respectively the cost performance indicators (CPI) shall be periodically reported and controlled for the major projects, with signed contractual agreements financed under the Kozloduy International Decommissioning Support Fund (KIDSF). When implementing the project according to the plan, the ideal values of these performance indicators equals to one. The performance indicator related to the assessment of the schedule performance indicator (SPI) is determined by the ratio of the actual earned value (EV) to the planned value (PV), and respectively the cost performance indicator (CPI) - the ratio of the actual earned value (EV) to actual cost (AC).

The Action Plan (Appendix 6) includes the set measures and tasks to be carried out in the specific directions. The deadlines, necessary funding with possible sources of resources, responsible authorities, as well as the success criteria for achievement of the objectives set are specified in the plan.

The best practices acquired in the course of the joint work with the EC and EBRD peer organisations shall be used in future to develop performance indicators and monitoring planning.

The assessments of achieving compliance with the best international practices must consider the conclusions of international missions, EC statements and directives, and justified positions of public organisations.

The periodic reviews of the policies and the SNF, RAW and decommissioning management activities are carried out within the framework of the preparation of the National reports on the Convention on nuclear safety, Joint convention, of the Directive 2011/70/EURATOM, as well as within the periodic update of the Strategy.

The planned periodic reviews of different levels and scopes allow current assessment of measures and tasks implementation, as well as an update of the risk assessments related to the plans and programmes implementation to be performed. In case of indicators of a change, the mechanisms for introduction of compensatory financial, organisational and technical measures are activated.

9.3. Risks of a delay or failure to implement the Strategy

Based on the uncertainty factor analysis, the following risks in terms of the Strategy implementation are identified:

- **Risk**: Shift in the geopolitical landscape and/or impossibility to transport SNF for long-term storage and processing. **Negative consequences**: Increase in the amount of SNF stored at the Kozloduy NPP site, decrease in the capacity of the intermediate SNF storage facilities, need for change of the overall concept of the Strategy; increase in the radiological risk for the public and the environment, as well as other negative consequences. **Risk management measures** – planning the possibility for dry storage at the NPP site; negotiating the details on the processing, the conditions of the return of HLW in the country and the conditions for use of fissile material; development of a plan for SNF processing in France, including planning of short-term plan for construction of a temporary storage facility for the returned vitrified HLW and other RAW from the SNF processing; active communication with the EC in terms of SNF management and providing for support regarding the national plans.

- **Risk**: Negative result from the negotiations regarding SNF processing in France. **Negative consequences**: Increase in the amount of SNF stored at the Kozloduy NPP site, decrease in the capacity of the intermediate SNF storage facilities, need for change of the overall concept of the Strategy; increase in the radiological risk for the public and the environment, as well as other negative consequences. **Risk management measures** - Strategy update.
- **Risk:** An imposed decision for long-term interim dry storage of SNF **Negative consequences**: Increase in the amount of SNF stored at the Kozloduy NPP site, decrease in the capacity of the intermediate SNF storage facilities, need for change of the overall concept of the Strategy; increase in the radiological risk for the public and the environment, as well as other negative consequences; need for change of the overall concept of the Strategy - impose a decision for direct disposal of SNF assemblies, respectively a radical change to the Deep Geological Repository (DGR) design related to making a decision on a number of complex technical issues. **Risk management measures** - Investigating the possibilities for the shipment of SNF after long-term dry storage, active communication with the EC for risk reduction.
- **Risk**: Impossibility to transport SNF due to issues related to obtaining approval from the EC for the shipment of SNF that had been delivered to Kozloduy NPP after 01 January 2007 **Negative consequences:** Increase in the amount of SNF stored at the Kozloduy NPP site, decrease in the capacity of the intermediate SNF storage facilities, need for change of the overall concept of the Strategy; increase in the radiological risk for the public and the environment, as well as other negative consequences. **Risk management measures** - it is necessary to clarify the legal grounds for such obstacles and conduct negotiations at a high state level with the EC to reach a clear agreement on the transportation of the planned quantities of SNF.
- **Risk**: Assuming an incident or accident during SNF transportation. **Negative consequences**: Delay in the schedule for SNF processing and increase in the amount of the SNF stored at the Kozloduy NPP site, decrease in the capacity of the intermediate SNF storage facilities, need for change of the overall concept of the Strategy; increase in the radiological risk for the public and the environment, as well as other negative consequences. **Risk management measures** - timely investigation of the event and identifying the root cause and the relevant corrective actions for safety improvement.
- **Risk**: Introduction of a payment scheme for storing the quantities of fissile materials separated during the SNF processing. **Negative consequences**: Adverse effect on the financial indicators of Kozloduy NPP. **Risk management measures** - negotiations to achieve a minimum price for storing fissile materials; negotiations for their long-term storage on the territory of the EU. Construction of a specialised fissile materials storage facility at the Kozloduy NPP site.
- **Risk**: Failure to implement key decommissioning projects for Units 1-4 in a timely manner. **Negative consequences**: Delay in the process and possible revision of the overall decommissioning programme for Kozloduy NPP Units 1-4. **Risk management measures** - regular reviews of the implementation of the schedules and planned activities by the SE RAW management bodies; communication with the partners in the course of EU funds management; holding the guilty person liable.
- **Risk**: Changed conditions for the FNF delivery, which require a change to the SNF management policies. **Negative consequences**: Need for change of the SNF management plans and planning of additional infrastructure at the NPP site. **Risk management measures** - long-term planning of the FNF deliveries; maintaining FNF reserves and active communication with the EC on these issues.

- **Risk**: Delay in the commissioning of the NDF. **Negative consequences**: Delayed/blocked process of processing and conditioning of RAW generated from the Kozloduy NPP operation and decommissioning; suspension/extension of the decommissioning process, etc. **Risk management measures** - regular reviews of the implementation of the schedules and planned activities by the SE RAW management authorities, communication with the governmental institutions, and holding the guilty person liable.
- **Risk**: Shortage/ lack of qualified staff employed by the governmental institutions and licensees. **Negative consequences**: Problems with safe operation of Kozloduy NPP, construction of new nuclear units and new RAW and SNF storage facilities, delay in the decommissioning processes and SNF and RAW management. **Risk management measures** - adoption of the proposed National Strategy for Human Resource Development in the nuclear field 2022 - 2023 and implementation of the measures thereof; update of the long-term planning of the activities and development of employment, qualification and qualification maintenance programmes.
- **Risk**: Insufficient financial resources under the existing national funds. **Negative consequences**: Delay or suspension of the implementation of key decommissioning or SNF and RAW management programmes. **Risk management measures** - conducting a periodic audit and re-evaluation of the amounts available in the funds by their management boards and the Public Financial Inspection Agency;
- **Risk**: Delay in the activities related to the planning and construction of the DGR. **Negative consequences**: Failure to implement the Strategy objectives; increase in the radiological risk to the public and the environment; creating significant technical difficulties and transferring a significant financial burden to the future generations. **Risk management measures** - periodic audit of the activities; holding the guilty person liable.
- **Risk**: Lack of financial resources for the construction of the DGR. **Negative consequences**: Failure to fulfil the objectives set in the Strategy; postpone the DGR commissioning; necessary extension of the deadline for interim storage of HLW; increase in the radiological risk for the public and the environment. **Risk management measures** - establish a dedicated fund 'DGR Construction' to cover the costs related to all stages of the DGR construction work; development and approval of a methodology for determining the annual contributions of Kozloduy NPP to the fund; periodic audit of the fund financial resources; periodic re-evaluation and update of the amounts needed and the annual contributions.
- **Risk**: Impairment of the financial resources raised in the KIDSF and RAW funds due to the inflation processes in a long-term aspect. **Negative consequences**: Insufficient amount of raised resources for funding the future costs for SNF and RAW management, and the decommissioning activities; transferring a significant financial burden to the future generations. **Risk management measures** - development, approval and implementation of an appropriate investment strategy, policy for yield of funds or other financial management mechanisms to ensure the rate of return (bear an interest) covering at least the annual inflation index.
- **Risk**: Lack of public support for the implementation of projects for RAW storage or disposal. **Negative consequences**: This may result in blocked construction of DGR and problems with the transportation of SNF and RAW. **Risk management measures** - active communication with the local administrative authorities and public organisations; conduct in-depth scientific researches before proposing decisions on selecting an option; active participation in international projects; change in the legislative base to stimulate the local communities.
- **Risk:** Delay in the performance of the procedures in compliance with Chapter Six of the Environmental Protection Act (EPA) and appeal against decrees of administrative acts. **Negative consequences:** Failure to implement the Strategy objectives; delay in its approval and the resulting investment proposals; increasing the risk of criminal procedure imposed by the EC. **Risk management measures** - periodic audit of the procedures' stages in compliance with Chapter

Six of the EPA in the course of their implementation; coordination with the Ministry of Environment and Water as a competent authority.

In addition, implementing a sustainable policy of transparency and openness, keeping the public informed, creating a climate of intolerance towards failure to implement the planned activities and measures, and potential corrupt practices are of key importance. It is necessary to implement a policy considering the technical and scientific progress in the activities associated with the SNF and RAW management, and decommissioning; considering the changes in the international regulatory framework in a timely manner and their transposition into the national legislation, as well as the recommendations, lessons learned and good practices from peer reviews.

10. POLICY OF TRANSPARENCY AND OPEN DIALOGUE

The information necessary for the SNF and RAW management is made available to the workers and the general public. This obligation includes ensuring that the competent regulatory authority informs the public in the fields of its competence. Information shall be made available to the public in accordance with national legislation and international obligations, provided that this does not jeopardise other interests such as, inter alia, security, recognised in national legislation or international obligations. The public is given the necessary opportunities to participate effectively in the decision-making process regarding the SNF and RAW management in accordance with the national legislation and international obligations.

The transparency policy is based on the following main principles:

1. Openness/Transparency - contributes towards increasing the effectiveness, efficiency and sustainability of the tasks set in the Strategy approving its approach for zero tolerance to the frauds and corruption, ensures compliance with the environmental and social standards related to the funded projects and encourages the accountability and good governance;
2. Building a confidence and protection of sensitive information;
3. Willingness to listen and participate - demonstrates commitment to actively encourage the participation of the stakeholders concerned in its policies and practices. Through its commitment to open communication, it proves its willingness to listen to third parties and rely on their contribution in the course of the work to accomplish its mission.

The better communication can be achieved by clear guidance and information, providing for useful feedback, information, publicity and recommendations for the stakeholders. The incoming and outgoing information shall be correct, the latest, reliable, credible, and provided in a timely manner.

The Ministry of Energy ensures transparency and access to the information related to its activity in the field of SNF and RAW management. The Minister of Energy arranges the public hearing on the draft SNF and RAW management strategy with the participation of state and local authorities, representatives of public organizations, physical stakeholders and legal entities concerned. All the stakeholders concerned are notified by the means of the mass media or another relevant manner.

The Ministry of the environment and water ensures transparency and access to information and documentation in all the stages of the EIA and EI procedures, including through the organisation of public hearings on the EIA reports. The investment proposal is announced on the Ministry of Environment and Water website, notifying in writing the mayor of the relevant municipality, region and town hall who publishes it on the their website, if any, or on a publicly accessible place. The enacted Decision is a mandatory requirement for the approval/authorisation of the investment proposal pursuant to a special act.

The Ministry of Health, through its specialised control bodies informs the public of the measurements made and the assessments of the internal and external exposure, the assessments of the intake of radionuclides and the results from the dose rate assessment of the members of the public.

The Nuclear Regulatory Agency through its Chair pursues a policy of openness and transparency with all governmental and non-governmental organisations, media and the general public trying to expand the public involvement in the decision-making process of the safe RAW and SNF management. The NRA informs the general public on all significant issues and problems in the decision-making process important for the safe RAW and SNF management and provides for an objective information about these issues. The NRA maintains an information site and a public register of all licences and permits issued for activities related to the safe RAW and SNF management; it publishes annual reports, national reports on ratified conventions and series of other reports and information materials in the field. Press conferences and workshops related to the safety and radiation protection using nuclear power and radioactive sources and during the SNF and RAW management are held with journalists.

Kozloduy NPP EAD follows a long-standing policy of open and transparent communication and a constructive dialogue with the public. All aspects of the Company activity are made available to the public - electricity generation, safe operation, ecological role, social activities, etc.

Annually, Kozloduy NPP holds the traditional Open Doors days - an initiative that allows thousand of citizens from the country and abroad to visit the plant site and receive actual information on the operation of the nuclear facilities.

Kozloduy NPP uses also a number of recognised communication means to disseminate accurate and timely information about its activity and to promote the nuclear energy as a safe, secure and environmentally friendly source of electricity. The messages are addressed both to the general public and to individual groups - the public of the region around the nuclear power plant, representatives of non-governmental organisations and the scientific communities, professional partners, young people, etc.

There is an Information Centre at the plant that provides actual information on the plant’s operation, as well as the benefits of the nuclear energy for the economy of the country, sustainable development and the environment.

The plant official website with more than 500 000 visits each year is maintained and periodically updated with information about the electricity generated. An information about the plant safe operation, the quantities of liquid and solid RAW generated, etc. is also published.

The Parva Atomna journal is published periodically. The annual reports on the Company’s activity as well as the Company’s annual financial reports are made available to the public (both in Bulgarian and English). The House of Culture was established in centre of Kozloduy and has been functioning for more than 35 years. It provides for very good conditions for holding conferences, seminars, exhibitions, meetings with pupils, students, representatives of the public and others.

SE RAW - in order to build a public trust in the projects on the safe RAW management in Bulgaria, the SE RAW annually prepares and implements communication programmes with a schedule of the activities in compliance with the current projects of the SE RAW.

For each of its major projects, the SE RAW identifies the stakeholders in the public and implements a Plan to involve them in the discussion process of the potential negative or beneficial impacts on the environment and the social media. The SE RAW applies a working mechanism to receive complaints from the stakeholders and provides reasoned, accessible and culturally appropriate responses to their concerns.

All current practices for disclosure of information are used when working with stakeholders concerned: interaction with the mass media; preparation and dissemination of information materials; internet and new media; intra-organisational communications; holding socially significant events focusing on different target groups and with the participation of a huge number of people. Periodic meetings between the SE RAW’s management and local authorities’ representatives, and informal leaders of the public opinion are held to inform and clarify the SE RAW current projects.

APPENDICES:

Appendix 1 - A list of international treaties, regulations, directives and agreements applicable to the management of SNF and RAW;

Appendix 2 - A list of national regulations in force in the field of SNF and RAW management;

Appendix 3 - A report on the quantities of SNF;

Appendix 4 - A report and estimates of RAW - Kozloduy NPP;

Appendix 5 - Inventory and quantity of RAW - SE RAW;

Appendix 6 - Action Plan;

Appendix 7 - Plan of DGR.

Appendix 1

List of

international treaties, regulations, directives and agreements applicable to the management of SNF and RAW

- TREATY establishing the European Atomic Energy Community/EURATOM;
- Treaty on the Non-Proliferation of Nuclear Weapons;
- COMMISSION REGULATION (Euratom) No 302/2005 of 8 February 2005 on the application of Euratom safeguards - Council/Commission statement;
- Commission Implementing REGULATION (EU) No. 1113/2014 of 16 October 2014 establishing the form and technical details of the notification referred to in Articles 3 and 5 of Regulation (EU) No 256/2014 of the European Parliament and of the Council and repealing Commission Regulations (EC) No 2386/96 and (EU, Euratom) No. 833/2010 (OB L 302, 22.10.2014);
- COUNCIL REGULATION (Euratom) No. 2587/1999 of 2 December 1999 defining the investment projects to be communicated to the Commission in accordance with Article 41 of the Treaty establishing the European Atomic Energy Community (OB L 315, 09.12.1999);
- COMMISSION REGULATION (Euratom) No. 1209/2000 of 8 June 2000 determining the procedures for the examination of the communications prescribed under Article 41 of the Euratom Treaty (OB L 138, 09.06.2000);
- 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;
- COUNCIL DIRECTIVE 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom (OB L 13, 17.01.2014);
- COUNCIL DIRECTIVE 2014/87/Euratom of 8 July 2014 amending Directive 2009/71/Euratom establishing a Community framework for the nuclear safety of nuclear installations (OB L 219, 25.07.2014);
- COUNCIL DIRECTIVE 2006/117/EURATOM of 20 November 2006 on the supervision and control of shipments of radioactive waste and spent fuel;
- JOINT CONVENTION on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management;
- VIENNA CONVENTION on Civil Liability for Nuclear Damage;
- CONVENTION on the Physical Protection of Nuclear Material and its Amendment of 2005;
- CONVENTION on Early Notification of a Nuclear Accident;
- CONVENTION on Assistance in the case of a Nuclear Accident or Radiological Emergency;
- CONVENTION on Nuclear Safety;
- CONVENTION on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters;
- CONVENTION on Environmental Impact Assessment in a Transboundary Context and the Protocol on Strategic Environmental Assessment;
- AGREEMENT between the Republic of Austria, the Kingdom of Belgium, the Kingdom of Denmark, the Republic of Finland, the Federal Republic of Germany,

the Hellenic Republic, Ireland, the Italian Republic, the Grand Duchy of Luxembourg, the Kingdom of the Netherlands, the Portuguese Republic, the Kingdom of Spain, the Kingdom of Sweden, the European Atomic Energy Community(EURATOM) and the International Atomic Energy Agency (IAEA) in implementation of Article III (1) and (4) of the Treaty on the non-proliferation of nuclear weapons (78/164/Euratom, relevant to IAEA INFCIRC 193);

- ADDITIONAL PROTOCOL (1999/188 EURATOM) to the Agreement between the Republic of Austria, the Kingdom of Belgium, the Kingdom of Denmark, the Republic of Finland, the Federal Republic of Germany, the Hellenic Republic, Ireland, the Italian Republic, the Grand Duchy of Luxembourg, the Kingdom of the Netherlands, the Portuguese Republic, the Kingdom of Spain, the Kingdom of Sweden, the European Atomic Energy Community and the International Atomic Energy Agency (IAEA) in implementation of Article III(1) and (4) of the Treaty on the Non-proliferation of Nuclear weapons;
- AGREEMENT between the Government of the Republic of Bulgaria and the Government of the Russian Federation on cooperation in the field of nuclear energy;
- AGREEMENT between the Government of the Republic of Bulgaria, the Government of the Russian Federation and the Council of Ministers of Ukraine in the field of nuclear material shipment between the Russian Federation and the Republic of Bulgaria through the territory of Ukraine;
- AGREEMENT between the Government of the Republic of Bulgaria, the Government of the Republic of Moldova, the Government of the Russian Federation and the Cabinet of Ministers of Ukraine on cooperation in the field of transportation of nuclear materials between the Republic of Bulgaria and the Russian Federation through the territory of Ukraine and the territory of the Republic of Moldova;
- AGREEMENT between the Nuclear Regulatory Agency of the Republic of Bulgaria and the Federal Service for Environmental, Technological and Atomic Supervision of the Russian Federation on cooperation in the field of regulation of nuclear and radiation safety in the use of atomic energy for peaceful purposes;
- AGREEMENT between the Government of the Republic of Bulgaria and the Government of the Russian Federation on cooperation in importing spent nuclear fuel from a research reactor to the Russian Federation;
- AGREEMENT between the Government of the Republic of Bulgaria and the Government of the Russian Federation on cooperation in exporting spent nuclear fuel from a research reactor from the Republic of Bulgaria and importing to the Russian Federation.

Draft supplementary delegated act developed in accordance with Regulation (EU) 2020/852 on the establishment of a framework to facilitate sustainable investment (Taxonomy Regulation).

Appendix 2

A list of national regulations in force in the field of SNF and RAW management and decommissioning

- Safe Use of Nuclear Energy Act;
- Environmental Protection Act;
- Health Act;
- Regulation on Ensuring the Safety in Spent Fuel Management;
- Regulation on Safe Management of Radioactive Waste;
- Regulation on the procedure of Issuing Licences and Permits for the Safe Use of Nuclear Energy;
- Regulation on the procedure for assessment, collection, spending and control as well as definition of the amount of contributions to the Radioactive Waste Fund;
- Regulation on the procedure for assessment, collection, spending and control as well as definition of the amount of contributions to the Decommissioning of Nuclear Facilities Fund;
- Regulation on Ensuring the Safety of Nuclear Power Plants;
- Regulation on Radiation Protection;
- Regulation on Radiation Protection During Work Activities with Materials with Increased Concentration of Natural Radionuclides
- Regulation on the Terms and Procedure for Obtaining Vocational Qualification and on the Procedure for Issuing Licenses for Specialised Training and Individual Licenses for Work Activities involving Nuclear Power;
- Regulation for the Provision of Physical Protection of Nuclear Facilities, Nuclear Material and Radioactive Material;
- Regulation on the Conditions and Procedure for Notification of the Nuclear Regulatory Agency about Events in Nuclear Facilities and Sites with Sources of Ionising Radiation and during Transport of Radioactive Material;
- Regulation on Emergency Planning and Emergency Preparedness in Case of Nuclear and Radiological Emergencies;
- Regulation on the Conditions and Procedure for Transport of Radioactive Material and a Standard Document for Surveillance and Control of the Transport of Radioactive Waste and Spent Nuclear Fuel;
- Regulation on Safety During Decommissioning of Nuclear Facilities;
- Regulation on the Conditions and Procedure for Delivery of Radioactive Waste to the State Enterprise "Radioactive Waste:;
- Regulation on the Application of the Safeguards under the Treaty on the Non-proliferation of Nuclear weapons;
- Regulation on the terms and conditions for the conduct of environmental impact assessment;
- Regulation on the conditions and procedure for ecological assessment of plans and programmes.

Appendix 3

Report on the quantities of spent nuclear fuel

Quantities of SNF according to nomenclature and heavy metal stored at the WSFSF as at 31 December 2022

Reactor type	Fuel assembly type	Initial ^{235}U enrichment [%]	WSFSF		TOTAL	
			Number of fuel assemblies	Heavy metal mass [kg]	Number of fuel assemblies	Heavy metal mass [kg]
WWER-440	116	1.6	2	238	1268	146659
WWER-440	124	2.4	27	3152		
WWER-440	224	2.4	30	3348		
WWER-440	136	3.6	1180	136691		
WWER-440	236	3.6	29	3230		
WWER-1000	В(3000)	3.0	2	780	804	323635
WWER-1000	Г (3300)	3.3	1	417		
WWER-1000	ЕД (4230)	4.23	129	49486		
WWER-1000	Е (4400)	4.4	128	48959		
WWER-1000	N3536	3.53	121	49924		
WWER-1000	N3996	3.99	63	26028		
WWER-1000	N4306	4.30	360	148041		
TOTAL					**2072**	**470303**

Quantities of SNF according to nomenclature and heavy metal stored at the DSFSF as at 31 December 2022

Reactor type	Fuel assembly type	Initial ^{235}U enrichment [%]	DSFSF		TOTAL	
			Number of fuel assemblies	Heavy metal mass [kg]	Number of fuel assemblies	Heavy metal mass [kg]
WWER-440	116	1.6	2	236	**1596**	**184242**
WWER-440	124	2.4	31	3621		
WWER-440	224	2.4	66	7413		
WWER-440	136	3.6	1473	170279		
WWER-440	236	3.6	24	2692		

Quantities of SNF from WWER-1000 stored in the SFP of Units 5 and 6 according to nomenclature and heavy metal as at 31 December 2022

Fuel assembly type	Initial ^{235}U enrichment [%]	SFP-5		SFP-6		TOTAL	
		Number of fuel assemblies	Heavy metal weight [kg]	Number of fuel assemblies	Heavy metal weight [kg]	Number of fuel assemblies	Heavy metal weight [kg]
ЕД (4230)	4.23	2	786	4	1546	6	2332
Е (4400)	4.40	3	1150	1	382	4	1532
N 3536	3.53	1	414	2	824	3	1238
N 3996	3.99	72	29826	39	16110	111	45936
N 4306	4.30	290	119553	183	75223	473	194776
N 39712	3.97	0	0	53	24007	53	24007
N 46012	4.60	0	0	25	11301	25	11301
N 46206	4.62	0	0	48	21640	48	21640
TOTAL		**368**	**151729**	**355**	**151033**	**723**	**302726**

Total for Kozloduy NPP

Reactor type	Number of fuel assemblies	Heavy metal weight [kg]
WWER-440	2864	330901
WWER-1000	1527	626361
TOTAL	**4391**	**957271**

Radioactive waste stored in Auxiliary Building - 3 (AB-3) of Kozloduy NPP and estimates for RAW generation until the end of the operating period.

1. RAW stored as at the end of 2022

1.1. Solid RAW storage facility, AB-3

As at the end of 2022, the storage facility is filled-up at about 1.7% and stores:

- ✓ About 21 m^3 activated metals category 2a (dose rate > 10 mSv/h);
- ✓ About 14 m^3 very low level waste with dose rate < 1 μSv/h and specific activity lower than 10^4 Bq/kg, containing mainly ^{60}Co.

1.2. Liquid RAW storage facility, AB-3

As at the end of 2022, the storage facility contains:

- ✓ About 1750 m^3 liquid radioactive concentrate. The concentrate is stored in stainless steel tanks, each located in a separate reinforced concrete room in the Auxiliary Building of Units 5 and 6 (AB-3). Part of the radioactive concentrate has crystallised and 'liquid' and 'solid' phases have formed in the tanks in 1:3 ratio. Free volume in the tanks for evaporation concentrate (EC)- about 1830 m^3.
- ✓ About 120 m^3 spent sorbents (ion-exchange resin and activated charcoal with an expired life in 9:1 ratio) with a specific activity from 10^5 to 10^7 Bq/kg. The sorbents are stored in underwater tanks. Their physical and chemical characteristics are similar to those of the fresh sorbents. Free volume in the tanks for sorbents - 70 m^3.
- ✓ About 50 m^3 of sludge and sediments containing in a sedimentation tank for drainage waters. Some limited quantities of sludge and sediments are found in the Units 5 and 6 and AB-3 drainage waters sumps.

The rate of change in the status of liquid and solid RAW storage facilities in the past years is illustrated in Figures 1 and 2.

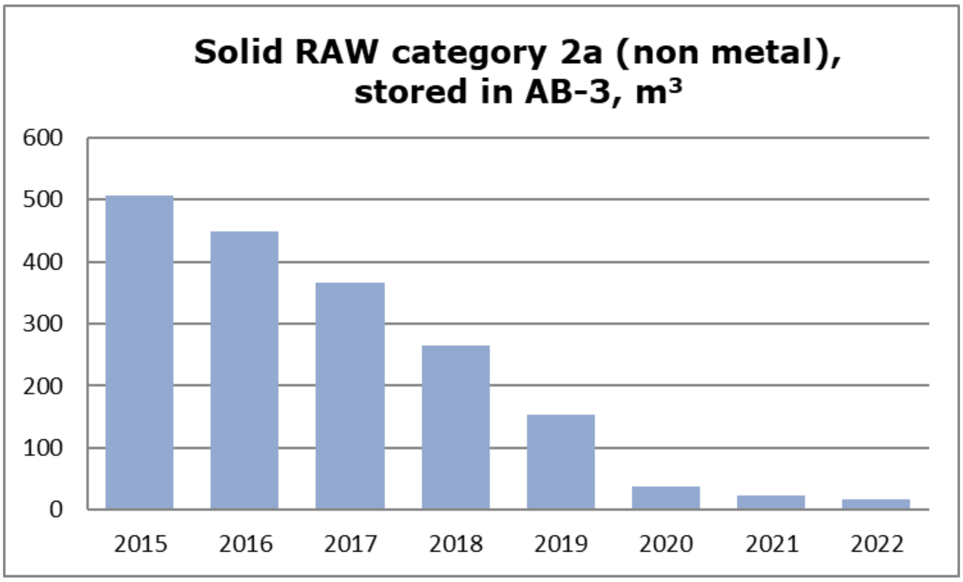


Figure 1. Solid RAW category 2a (non metal), stored in AB-3

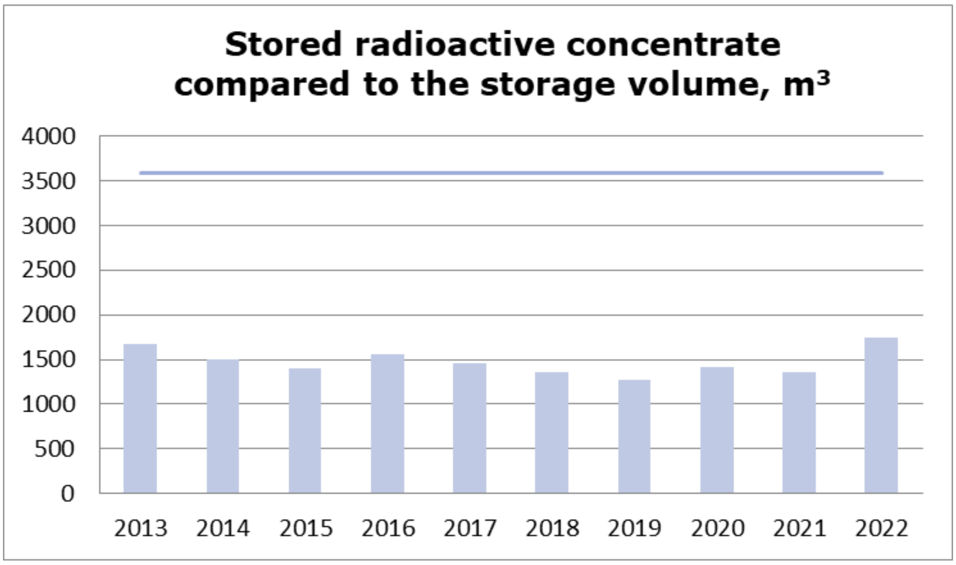


Figure 2. Radioactive concentrate stored in AB-3

2. Prognosis and estimates for expected quantities of RAW for the next 30-year period

The reconstruction and modernisation activities of Units 5 and 6 related to thermal power uprate of the reactors to 104%, as well as plant life extension carried out over the last ten years, did not cause a significant change in the generation rates of liquid and solid non-metallic (compactable and non-compactable) RAW. On this basis, it is reasonable to assume that in the next 30-year operating period of Units 5 and 6, the average generation and processing rates of solid RAW and liquid concentrate will remain the same.

2.1. Estimates for solid RAW

The quantities of solid non-metallic and metal RAW generated through the past years are presented on figures 3 and 4.

The estimated quantities of solid RAW expected to be generated over the next 30-year period of Kozloduy NPP operation are shown in Table 2.1.1. The estimates are drawn taking into account the following assumptions:

- ✓ **Non-metallic solid RAW:** In order to account for the uncertainty associated with the generation and storage of RAW from unplanned activities, the estimated quantities have been set with reference to the maximum values of non-metallic solid RAW generated in the past years. This allows to estimate that the uncertainty with respect to the average generation rate is around 30-40 %.
- ✓ **Very low level non-metallic RAW:** More accurate estimate for the quantities of very low level non-metallic RAW, which could possibly be released from regulatory control, could be made when a programme for the characterisation of solid radioactive waste from Units 5 and 6 is completed in 2026. However, the estimates completed till now show that it is reasonable to assume that the average annual generation of materials containing low level radioactive materials could a year be 400 m^3 per year.
- ✓ **Metal RAW:** Throughout the past ten years the quantity of the generated metal wastes is a relatively constant value. The average value for the past ten years plus 30% can be used in the estimates for their generation for the next 30 years. In addition to the quantities of metals that meet the acceptance criteria for processing and handing over to the Specialised Enterprise ‘RAW Kozloduy’, bulky stainless steel metal waste is also generated during modernisations and refurbishments. These wastes, on the one hand, do not meet the acceptance criteria of the Specialised Enterprise ‘RAW Kozloduy, and, on the other hand, it is not appropriate to process them as RAW as they are contaminated with radioactive substances only on the surface and could be released from regulation after decontamination. The generation of such waste is not evenly

distributed in time but for the estimate purposed it could be assumed a 50 t annual generation of RAW.

The speed of generation metal waste category 2a with dose rate above 10 mSv/h is relatively constant - maximum 1 m^3 per year (0.5 m^3 from each power unit). This means that for the next 30-year period no more than a quarter of the volume of the cells designed for their storage in the RAW storage facility will be filled (20 m^3 have been generated so far and about 30 m^3 more are expected). It is, therefore, quite possible to postpone their retrieval from the storage facility until the decommissioning of Units 5 and 6.

Table 2.1.1.

RAW type	Assessment for the average annual RAW generation	Estimate for RAW generation until 2051	Planned management activities
Solid non-metal RAW, category 2a (compactable and non-compactable)	90 t (500 m^3)	4000 t (21 000 m^3)	Transfer for processing in the SE RAW right after generation. Retrieval of all historical RAW from the storage facility.
Solid non-metal RAW, very low level waste (compactable and non-compactable)	50 t (200 m^3)	3000 t (12,000 m^3)	Temporary storage in the RAW storage facility and implementation of the clearance procedure.
Large-sized surface contaminated metal parts, category 2a	50 t	1500 t	Decontamination and implementation of the clearance procedure.
Other metal RAW, category 2a	35 t	1200 t	Transfer for processing in the SE RAW right after generation.
Volume activated metal RAW, category 2a, dose rate above 10 mSv/h	1 m^3	30 m^3	Safe storage in the RAW storage facility, AB-3.

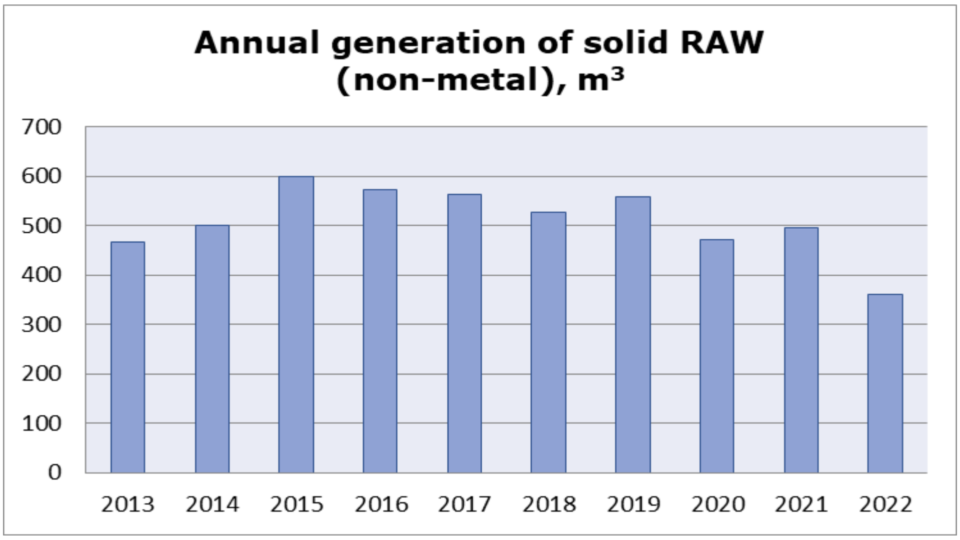


Figure 3. Annual generation of solid RAW (non-metal)

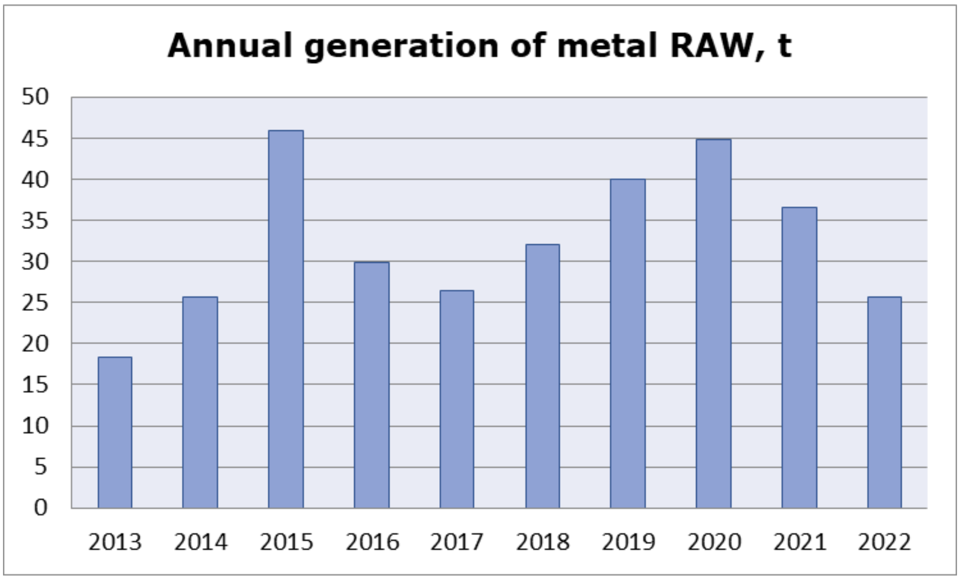


Figure 4. Annual generation of metal RAW.

2.2. Liquid RAW

The estimated quantities liquid RAW expected to be generated during the next 30-year period of the Kozloduy NPP operation are given in Table 2.2.1. The estimates are drawn taking into account the following assumptions:

The annual generation of radioactive concentrate generated following wastewater treatment varies between 150 and 250 m^3. The generation rate of the evaporation concentrate and the further hand-over for processing to SE RAW-Kozloduy are relatively constant and it can be assumed that they will remain the same in future. The balance between the generated concentrate and the concentrate handed-over for processing during the past eight years is given in Figure.5.

However, the quantity of processed liquid waste and the waste generated after conditioning depends mainly on the content of salts into the concentrate. Figure 6 presents the quantities of evaporation concentrate generated for the past eight years compared to the quantities of evaporation concentrate normalised to content of salts into the concentrate of 200 g/l. The Figure shows that the real generation of evaporation concentrate for the past years has reduced.

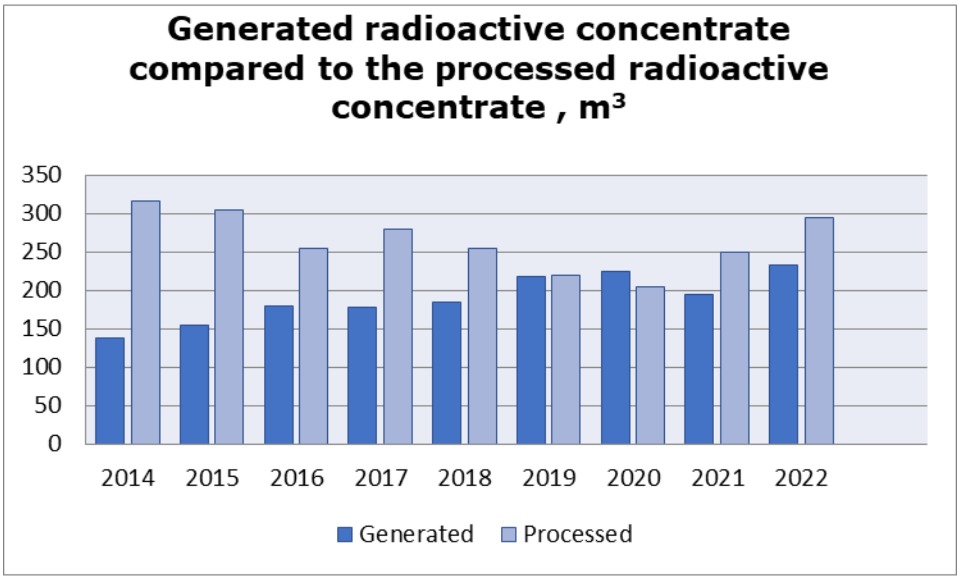


Figure 5. Generated to processed radioactive concentrate.

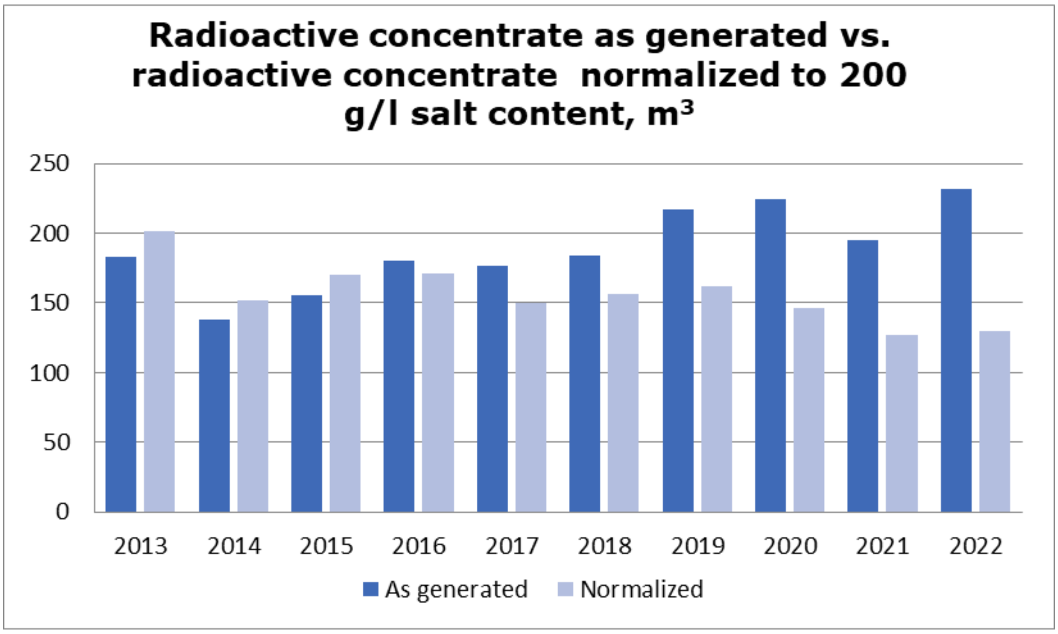


Figure 6. Comparison of the as generated concentrate amount to the normalized amount

Regarding the quantity of sludges accumulated in the process systems, it is expected to have it increased between 1.5 and 2 times during the next years of plant operation. Therefore, it is necessary to implement a technology for sludge retrieval and processing within the next 10 years.

Currently, the free volume of the spent sorbents tanks is only about 70 m^3. This means that having this speed of generation of spent sorbents and about 3-4 m^3 annually, this volume will be filled- up for the next 12 to 15 years. Therefore, it is necessary to implement a technology for spent sorbents retrieval and processing within the next 4 years.

Table 2.2.1.

RAW type	Assessment for the average annual generation	Estimate for RAW generation until 2051	Planned management activities
Radioactive concentrate (after evaporation)	200 m^3	6600 m^3	Safe storage in AB-3 and periodical retrieval for processing in the SE RAW-Kozloduy
Spent sorbents	3-4 m^3	150 m^3 (in case of unplanned download of the sorbents)	Safe storage in AB-3 and implementation of a technology for their retrieval and processing.
Sludge	1-3 m^3	80 m^3	Safe storage and implementation of a technology for periodic retrieval and processing.

Appendix 5

Inventory and quantity of RAW managed by the State Enterprise Radioactive Wastes as at 31 December 2022

1. SD RAW-Kozloduy

Composition of packaged RAW, %

Facility		Total	SFCRAW				Site 2		
Package type				Reinforced	Reinforced	Reinforced		Reinforced	Reinforced
Drums with solid RAW, %	Textiles	4.3	1.43	17.32	15.5	0.52	13.99	12.7	16.02
	Metal	3.28	0.83	10.45	10.19	0.28	11.53	15.08	5.92
	Shavings	0.15	0.01	0.2	0	0	0.61	0.53	0.75
	Wood	0.42	0.16	2.37	1.67	0.04	1.3	1.03	1.72
	Construction waste	2.16	0.67	4.49	7.14	0.43	7.2	6.99	7.53
	Polymers	0.33	0.13	1.18	0.75	0.07	0.99	0.78	1.31
	Wool	1.76	0.54	4.69	2.64	0.32	5.87	5.02	7.22
	Rubber	0.03	0	0	0	0	0.11	0.06	0.17
	Paper	0.01	0	0	0	0	0.02	0.02	0.02
	Mixed	12.35	5.29	46.31	54.13	2.87	36.15	30.89	44.43
	Secondary	0.65	0.82	0.1	2.05	0.84	0.07	0.03	0.14
	Cables	0.06	0	0	0	0	0.24	0.38	0.02
Solid non-compactible RAW, %		1.55	0	0	0	0	6.8	11.11	0
Bulk RAW, %		5.31	2.4	12.88	5.93	1.85	15.13	15.38	14.74
Cemented liquid RAW, %		67.65	87.71	0	0	92.77	0	0	0

Radionuclide composition of RAW in the facilities of SD RAW-Kozloduy

Radionuclide composition	Activity, Bq		
	SFCRAW	Site 2	Trench type storage
^{54}Mn	5.41E+08	4.08E+08	5.14E+06
^{59}Fe	2.54E+07	2.46E+07	4.11E-07
^{57}Co	3.39E+08	0.00E+00	0.00E+00
^{58}Co	3.41E+07	1.01E+08	1.20E-01
^{60}Co	3.68E+11	6.91E+10	3.74E+10
^{110m}Ag	5.51E+08	4.26E+08	4.31E+05
^{134}Cs	1.67E+11	9.37E+08	9.14E+07
^{137}Cs	4.46E+13	1.30E+11	8.05E+10
^{95}Nb	3.78E+05	5.23E+07	3.18E-11
^{129}I	1.57E+08	3.09E+08	3.02E+08
^{14}C	9.48E+10	7.47E+10	8.81E+10

^{90}Sr	6.88E+10	4.15E+10	3.45E+10
^{63}Ni	3.22E+12	3.79E+11	2.22E+11
^{55}Fe	3.55E+10	3.73E+10	1.40E+10
^{99}Tc	2.62E+09	1.11E+09	1.04E+09
^{94}Nb	2.10E+09	1.21E+09	7.22E+08
^{233}U	2.29E+08	5.79E+08	4.20E+08
^{234}U	3.42E+08	7.79E+08	6.14E+08
^{235}U	3.18E+08	7.78E+08	6.14E+08
^{238}U	3.49E+08	8.10E+08	6.55E+08
^{238}Pu	2.41E+09	2.02E+09	1.87E+09
$^{239/240}Pu$	5.99E+09	5.06E+09	4.42E+09
^{242}Pu	2.04E+08	1.29E+08	1.04E+08
^{242}Cm	2.83E+07	1.20E+08	1.22E+06
^{244}Cm	5.86E+08	1.44E+09	1.24E+09
^{241}Am	1.11E+10	8.88E+09	7.90E+09

Quantities of RAW stored in the facilities of SD RAW-Kozloduy

Facility	Quantity	Comment
1. Storage facility for conditioned RAW, pcs		Category 2a
Reinforced concrete container-1	165	
Reinforced concrete container-2	21	
Reinforced concrete container-3	1367	
2. Trench type storage, m^3		Solid RAW, Category 2a. Textiles (28%), metal (7%), shavings (0.2%), wood (2.5%), construction waste (7%), polymers (2%), wadding (5%), rubber (0.2%), paper (0.1%), mixed waste (48%).
Packed in 210 litre drums	4.20	
Compacted with a force of 910 t	2040	
3. Storage area for interim storage of processed solid RAW, m^3		mixed waste (96.3%), sludges (3.7%)
Compacted with a force of 910 t	86.4	
Sludges in 210 litre drums	3.36	
4. Site No.2 for interim storage of solid RAW, pcs		Category 2a
Reinforced concrete container-1	529	
Reinforced concrete container-2	423	
5. Site for interim storage of solid RAW in ISO casks, m^3		Category 2a; construction waste (51.7%), mixed waste (9.8%), metal

		(0.9%), filters (37.2%), wood (0.4%)
Unprocessed	70.06	
Packed in 210 litre drums	26.67	
6. Contaminated soil storage, m^3	255.9	
7. Process waste landfill (BB-1), m^3		Unprocessed construction and other bulk waste category 1a
Bulk soil, [t]	250.311	
Bulk p. Waste, [t]	193.058	
Sludge from BB1 etc., [m3]	223	
Big Beg - sludge from BB2, [pcs.]	51	
210l drums, [m3]	96.39	

2. SD PRRAW - Novi Han - inventory as at 31.12.2022

2.1. Solid RAW storage facility, Volume of stored RAW, m^3: 58.60

Radionuclide composition of RAW in a solid RAW storage facility

Radionuclide composition	Activity, Bq
^{3}H	6.22E+11
^{14}C	3.98E+11
^{60}Co	6.49E+10
^{90}Sr	4.9E+11
^{137}Cs	2.04E+12
Total activity	**3.61E+12**

2.2. Biological RAW storage facility, Volume of stored RAW, m^3: 64

Radionuclide composition of RAW in the biological RAW storage facility

Radionuclide composition	Activity, Bq
^{3}H	3.11E+09
^{14}C	9.98E+09
^{60}Co	1.17E+09
^{90}Sr	9.07E+09
^{137}Cs	7.29E+10
Total activity	**9.63E+10**

2.3. Storage facility for spent sources, Volume of stored RAW, m^3: 0.65

Radionuclide composition of RAW in the storage facility for spent sources

Radionuclide composition	Activity, Bq
^{60}Co	5.91E+11
^{90}Sr	4.54E+10
^{137}Cs	3.65E+13
^{226}Ra	5.61E+11
^{239}Pu	1.98E+11
Total activity	**3.79E+13**

2.4. **Engineering trench for solid RAW**, Volume of stored RAW, m^3: 160

Radionuclide composition of RAW in an engineering trench

Radionuclide composition	Activity, Bq
^{60}Co	2.37E+10
^{90}Sr	9.07E+10
^{137}Cs	4.57E+11
^{239}Pu	6.87E+05
Total activity	**5.71E+11**

2.5. **Liquid RAW storage facility**, Volume of stored RAW, m^3: 1.0 m^3

Radionuclide composition of RAW in the liquid RAW storage facility

Radionuclide composition	Activity, Bq
^{60}Co	6.22E+02
^{137}Cs	8.84E+05
^{90}Sr	3.68E+05
^{3}H	2.68E+05
Alpha emitters	6.00E+02
Total activity	**1.52E+06**

2.6. Site No.1 and 1A for storage of solid RAW.

Storage units type: ЖПК, СтБКУБн

Radionuclide composition of RAW at Sites No.1 and 1A

Radionuclide composition	Activity, Bq
^{241}Am	1.762E+12
Am-Be	1.4748E+12
^{85}Kr	1.71E+11
Pu (mixture of isotopes of Pu)	2.9816E+12
Pu-Be	6.8808E+12
^{226}Ra-Be	2.1691E+08
^{238}U	3.16E+08
^{232}Th	2.32E+08
Pu-Be	6.8808E+12
Total activity	**1.33E+13**
U D, kg	**13766**

2.7. Site No.2 for storage of solid RAW

Storage units type: СтБКУБ, СтБК, СтБКГОУ

Radionuclide composition of RAW at Site No.2

Radionuclides	Activity, Bq
^{241}Am	1.37E+12
^{14}C	1.65E+10
^{60}Co	2.39E+14
^{137}Cs	2.19E+15
^{3}H	2.99E+13
^{226}Ra	5.63E+10
^{90}Sr	1.93E+10
^{85}Kr	9.87E+10
Pu (mixture of isotopes of Pu)	1.29E+10
Total activity	**2.46E+15**
U D, kg	**3500**

2.8. Site No.4* for storage of historical RAW

RAW, conditioned in CB 210 l

Radionuclide composition	Activity [Bq]
^{60}Co	6.00E+07
^{137}Cs	1.34E+09
^{14}C	4.06E+09
Total activity	**2.21E+11**

** Site 4 was reconstructed in 2020. It is used for interim storage of historical RAW from Storage Facility for Solid RAW.*

3. SD Decommissioning Unit 1-4 – RAW quantities as at 31.12.2022

Facility	Quantity	Comment
1. Storage facilities for solid RAW, AB-1, m^3		Used capacity 10.5 % Metal (22 %), wood (2 %), polymers (20%), mixed (56 %).
Unprocessed solid RAW	102	Category 2a
2. Storage facilities for solid RAW, AB-2, m^3		Used capacity 22 % Textile (4%), metal (1%), shavings (1%), wood (4 %), polymers (42 %), wool (1 %), mixed (47 %).
2.1. Unprocessed solid RAW	100	Category 2a
2.2. Compacted with a force of 910 t	120	Category 2a
3.By-the-reactor storage facility (“Landfill”) for RAW from Units 1 and 2, m^3	46	Used capacity 56 % Category 2a

4. 3.By-the-reactor storage facility ("Landfill") for RAW from Units 3 and 4, m^3	28	Used capacity 34 % Category 2a
5. Storage facilities for liquid RAW, AB-1, m^3		
5.1. Evaporator concentrate	2170	Used capacity 87 % Category 2a Predominantly deposited solid phase, mainly sodium borates
5.2. Spent sorbents, m^3	209	Ion exchange resins, activated carbon. Category 2a
5.3. Process systems, m^3	474	Sludge and sediments
6. Storage facilities for liquid RAW, AB-2, m^3		
6.1. Evaporator concentrate	1950	Used capacity 80 % Category 2a Predominantly deposited solid phase, mainly sodium borates
6.2. Spent sorbents, m^3	266	Ion exchange resins, activated carbon Category 2a
6.3. Process systems, m^3	498	Sludge and sediments

Appendix 6

Action Plan according to the Strategy

Strategic objectives	Tasks and measures for each objective	Specific operations under the tasks	Responsible organisation /institution	Deadline	Resources (financial, human, etc.)	Key Performance Indicators/KPIs
I. Safe management of spent nuclear fuel						
Responsible and safe management of SNF at Kozloduy NPP site	Maintaining the SFSF in a safe condition. Renewal of the SFSF licence for SNF storage after 2024 (for a new 10-year period).	Implementation of a Programme for the implementation of measures to improve the safety of the SFSF. Preparation of licensing documents.	Kozloduy NPP	2023	Kozloduy NPP funds	Minimum frequency of safety related operational events. Overall implementation of the Programme by 2023/ % (number) of programme measures completed on schedule; Observing the schedule for the preparation of documentation for the next licensing period.
		Renewal of the operating licence for the SFSF for up to 10 years.	Kozloduy NPP	2024	Kozloduy NPP funds	Renewed operating licence on time until June 2024.
	Maintaining the SFSF in a safe condition. Periodic renewal of the operating licence of the SFSF after 2034.	Implementation of a Programme for the implementation of measures to improve the safety of the SFSF. Programme for periodic safety review of the SFSF and preparation of documentation for the next licensing period.	Kozloduy NPP	2033 2043 and 2053	Kozloduy NPP funds	Minimum frequency of safety related operational events. Overall implementation of the Programme on time. % (number) of programme measures completed on schedule. Observing the schedule for the preparation of documentation for the next licensing period. % (number) of licence conditions fulfilled.

		Periodic licence renewal.	Kozloduy NPP	2034 2044 and 2054	Kozloduy NPP funds	Renewed license.
Safe management of SNF at the site of Kozloduy NPP *The projected tasks, measures and actions are for the implementation of the realistic scenario.*	Transportation of WWER-440 SNF from the SFSF and DSFSF for long-term storage and processing according to current practices and existing contracts.	Conclusion of an Annex to an existing contract for the transport and processing of 1268 SNF assemblies stored at the SFSF, and 1596 SNF assemblies stored at the DSFSF.	Kozloduy NPP	2023 2025 for SNF at the DSFSF	Kozloduy NPP funds	Concluded agreement.
		Testing the transport scheme.	Kozloduy NPP	2023	Kozloduy NPP funds	All potential issues successfully resolved. The transport scheme is implemented.
		Returning one cask from the DSFSF to the SFSF, testing its opening technology and checking the condition of the stored assemblies.	Kozloduy NPP	2025	Kozloduy NPP funds	Operations successfully completed and report on results compiled
		Shipment and processing of SNF from WWER-440 reactors in the period 2024-2029 (two/three shipments per year).	Kozloduy NPP	2029	Kozloduy NPP funds	Total number of transported SNF casks compared to the planned ones.
	Maintaining preparedness for shipment of SNF from WWER-440 reactors for long-term storage and processing using transport scheme via third countries.	Regular communication with third countries to maintain preparedness to use a transport scheme via third countries.	Kozloduy NPP	permanent	Kozloduy NPP funds	Successful use of a transport scheme via third countries (if necessary).
	Investigating the possibilities for the	Political consultations between Bulgaria and France,	CM ME	2023		Intergovernmental agreement signed.

	shipment and processing of SNF from WWER-1000 reactors to EU countries with technological capabilities (France).	conclusion of an intergovernmental agreement for all activities related to the processing of SNF from Kozloduy NPP in France.				
		Conducting bilateral technical consultations on the technological options for processing of WWER-1000 fuel in France and reaching an agreement on the timing and financial terms related to the re-design and retrofitting of existing process lines.	ME BEH Kozloduy NPP	2025	BEH Kozloduy NPP	Signed agreement.
		Developing a transport scheme for the transport of SNF from Kozloduy NPP to the processing plant, and a return scheme for the vitrified high level RAW and other RAW resulting from processing, including the resulting fissile materials, including transport casks; SNF transport vehicles; lifting equipment used in the handling operations; safety justification and certification of casks and vehicles; licensing of relevant infrastructure and lifting equipment off-site Kozloduy NPP.	Ministry of Transport Kozloduy NPP	2028	Kozloduy NPP	Transport scheme adopted.
		Study of the licensing and customs regime for the transport to and import into France of SNF in accordance with the chosen transport scheme.	NRA Kozloduy NPP	2028	Kozloduy NPP	Report approved by the Minister of Energy.

		Conclusion of a contract for processing of SNF and subsequent testing of the transport scheme.	Kozloduy NPP	2028	Kozloduy NPP	Contract signed.
		Start of shipment of SNF for processing in France.	Kozloduy NPP	2030	Kozloduy NPP	Shipment completed. Confirmed safety of the transport scheme.
		Regular shipment of SNF until 2060 for processing in France.	Kozloduy NPP	after 2030	Kozloduy NPP	Implementation of one to three SNF shipments depending on the specific conditions.
	Transportation of SNF from WWER-1000 reactors for long-term storage and processing according to the current practice.	Transportation of the remaining 118 of the contracted 414 WWER-1000 spent fuel assemblies according to the current contracts.	Kozloduy NPP	2023	Kozloduy NPP funds	Total number of SNF assemblies transported. % (number) of spent fuel assemblies transported per year compared to the planned 118 assemblies.
Safe management of SNF at Kozloduy NPP site *The projected tasks, measures and actions are for the implementation of an optimistic scenario.*	Transportation of SNF from WWER-1000 reactors for long-term storage and processing according to the current practice.	Coordination with the Supply Agency and obtaining approval from the EC (according to Art. 62. 1 (c) of the Euratom Treaty) for the conclusion of an Annex to the Contract with FSUE "PO MAYAK" for the transport of 379 spent fuel assemblies delivered before 01.01.2007 and finally removed from the WWER-1000 reactor cores after 01.01.2007.	Kozloduy NPP	Under favourable geopolitical conditions	Kozloduy NPP funds	Concluded Annex to the contract for transport of 379 spent fuel assemblies delivered before 01.01.2007.
		Transport of 379 WWER-1000 spent fuel assemblies delivered before 01.01.2007 under the Annex to the Contract with FSUE "PO MAYAK".	Kozloduy NPP	Under favourable geopolitical conditions	Kozloduy NPP funds	Total number of SNF assemblies transported. % (number) of spent fuel assemblies transported compared to the planned 379 assemblies.
	Transportation of **WWER-1000 SNF**	Conclusion of an agreement for the transport of WWER-1000	Kozloduy NPP	Under favourable	Kozloduy NPP funds	Concluded agreement.

	for long-term storage and processing.	SNF delivered after 01.01.2007 following EC approval.		geopolitical conditions		
		Regular shipment of SNF until 2060 depending on geopolitical conditions.	Kozloduy NPP	Under favourable geopolitical conditions	Kozloduy NPP funds	Total number of transported SNF casks compared to the planned ones.
Safe management of SNF at Kozloduy NPP site	Licensing of the DSFSF extension for storage of WWER-1000 SNF, selection of dry storage casks.	Preparation of the necessary documentation for the selection of WWER-1000 SNF dry storage casks.	Kozloduy NPP	2025	Kozloduy NPP funds	Decision made on the selection of WWER-1000 SNF dry storage casks.
		Preparation of justification documentation for the licensing of the DSFSF extension for storage of WWER-1000 SNF.	Kozloduy NPP	2029	Kozloduy NPP funds	Completion of justification documentation for licensing of the DSFSF extension for storage of WWER-1000 SNF.
		Amendment of the DSFSF licence for storage of WWER-1000 SNF in the extension.	Kozloduy NPP	2030	Kozloduy NPP funds	DSFSF licence amended.
		Readiness for delivery of WWER-1000 SNF casks.	Kozloduy NPP	2035	Kozloduy NPP funds	Entire documentation developed.
	Amendment of the SFSF license.	Preparation of justification documentation for the handling in the SFSF of WWER-1000 SNF dry storage casks.	Kozloduy NPP	2030	Kozloduy NPP funds	SFSF licence amended.
		Reaching operational readiness for loading and transportation of WWER-1000 SNF dry storage casks to the DSFSF.	Kozloduy NPP	2035	Kozloduy NPP funds	Entire documentation developed.
Safe management of SNF at Kozloduy NPP site.	Updated assessment of the WWER-1000 SNF dry storage facility capacity.	Determining the number of casks and the required storage volume in the DSFSF depending on the degree of implementation of the SNF	Kozloduy NPP	2028	Kozloduy NPP funds	Approval of the evaluations prepared.

		management options as at 2028.				
II. Responsible and safe management of RAW						
Responsible and safe interim storage of high level RAW at Kozloduy NPP site.	Agreement on the methodology for the determination of the quantity and characteristics of RAW from the processing of WWER-440 SNF and WWER-1000 SNF.	Agreement between Kozloduy NPP and FSUE PO MAYAK. Agreement between Kozloduy NPP and the processing operator in France.	ME Kozloduy NPP SE RAW	10 years prior to the first shipment of HRAW 2028	Kozloduy NPP funds	Agreed methodology within 10 years prior to the first shipment of HRAW. Signed agreement.
	Agreement on a methodology for determination of the quantity and characteristics of RAW from processing of WWER-1000 SNF.	Agreement between Kozloduy NPP and FSUE "GHC" .	ME Kozloduy NPP SE RAW	2030	Kozloduy NPP funds	Agreed methodology.
	Preparation of a long-term plan for the construction of a interim storage facility for vitrified high level RAW and other RAW from SNF processing.	Analysing the possibility of using the DSFSF for interim storage of vitrified high level RAW resulting from the processing of SNF after their return to Bulgaria. Developing a baseline design of a storage facility using the DSFSF and/or an entirely new design to accommodate high level RAW and other RAW from SNF processing from both Bulgaria and France.	ME Kozloduy NPP SE RAW	2030	Kozloduy NPP funds RAW Fund	Analysis approved. Established baseline design for the storage facility.
Safe management of low and medium level radioactive waste from Kozloduy NPP Units 5 and 6.	Improving the efficiency of RAW separation according to its radiological, physical and chemical	Developing and implementing a programme for the management, reporting and control of all types of RAW generated, stored, exempted from regulation, or transferred	SE RAW Kozloduy NPP	2026	Kozloduy NPP funds RAW Fund	Programme developed and implemented. Database established to report quantities of generated RAW and track their subsequent management.

	characteristics and achieving compliance with RAW acceptance criteria.	for processing.				
	Minimising the RAW generation.	Completing the Characterisation Programme for Solid RAW from Units 5 and 6, which are candidates for regulatory exemption.	Kozloduy NPP	2024	Kozloduy NPP funds	Scaling factors and a nuclide vector developed and a methodology for their application and maintenance developed.
		Developing and implementing a Waste Management and Radiation Control Programme for wastes that are candidates for regulatory exemption.	Kozloduy NPP SE RAW	2028	Kozloduy NPP funds	Equipment and methods for sorting and control of RAW put in place in order to exempt from regulation. Exempting from regulation between 30 and 40% of the total amount of solid RAW generated annually in the controlled area.
	Enhancing safety in the storage and management of liquid and solid historical RAW.	Retrieval and conditioning of sludge and spent sorbents	Kozloduy NPP and SE RAW	Until end of lifetime	Kozloduy NPP funds and RAW Fund resources	100% retrieval and processing of historical sludge and sorbent quantities.
		For the period of the modernisation of the RAWTF and their subsequent retrieval after the completion of the modernisation, setting up an accountability, traceability system for the safe transfer of all currently generated solid RAW to the RAW storage facility.	Kozloduy NPP and SE RAW	2030	Kozloduy NPP funds	All RAW received at the RAW storage facility during the modernisation period, shall be retrieved and transferred for processing within five years of its completion.

Achieving and maintaining sustainability in the management of RAW.	Ensuring safe and efficient storage of RAW in the interim storage facilities of SE RAW and their subsequent transportation, conditioning and disposal.	Establishing a programme for the modernisation of the RAWTF.	SE RAW	2024	KIDSF RAW Fund NFD Fund	Implementation of the modernisation programme of the RAWTF.
		Retrieval and conditioning of the solid phase from the liquid concentrate of RAW currently stored in the AB-1 and AB-2 tanks - evaporate concentrate (liquid and solid phase, spent resins, sludge and sediments).	SE RAW	2030	KIDSF RAW Fund NFD Fund	Developing and implementing an effective technology.
	Building a National Disposal Facility for low- and medium-level RAW.	Completing the construction of Stage 1.	SE RAW	2024	KIDSF and RAW Fund	Availability of relevant administrative acts.
		Commissioning and licensing of Stage 1.	SE RAW	2025	KIDSF and RAW Fund	Stage 1 commissioning permission and operating licence obtained.
		Construction of Stage 2.	SE RAW	2045	RAW Fund	Availability of relevant administrative acts.
		Construction of Stage 3.	SE RAW	2065	RAW Fund	Availability of relevant administrative acts.

		Operation of NDF.	SE RAW	2025-2085	RAW Fund	Operating license. Total number of disposed casks compared to planned ones. Minimum practicable frequency of operational safety related events.
		Closure of NDF.	SE RAW	2085-2100	RAW Fund	Availability of relevant administrative acts. Closure of facility.
		Institutional control	SE RAW	2100-2400	RAW and DNF funds	Absence of radiological events. Availability of relevant administrative acts.
		Post-institutional control period - remediation and site clearance.	SE RAW	after 2400	DNF Fund	Availability of relevant administrative acts.
Decommissioning of the Specialised Division Permanent Repository for Radioactive Waste – Novi Han, by combining deferred dismantling and the possibility for personnel access to the facility.	Preparation of documents for the issuance of a decommissioning license. Safe and efficient decommissioning.	**Stage 1:** Preparatory activities for decommissioning as per the operating license.	SE RAW	till 2025	RAW fund NDF fund	Obtaining a decommissioning license. Partial clearance of RAW on the territory of the SD PRRAW - Novi Han. Prevention of radiation incidents.

		Stage 2: Waste retrieval, RAW retrieval and subsequent dismantling of underground RADON-type facilities.	SE RAW	2025-2030	RAW fund NDF fund	Prevention of radiation incidents. All RAW is packaged and located for interim storage.
		Stage 3: Remediation of cleared land.	SE RAW	2040	NFD Fund	Implementing a radiation monitoring programme.
	Safe management of RAW from past activities.	Implementing a special programme of the SE RAW in accordance with Article 10 of the Regulation on Safe Management of Radioactive Waste. Obtaining the necessary permits. Preparing plans and projects for the RAW management. Implementation of the projects.	Owner/ Licence holder	2030	Owner/ Licence holder SE RAW	Project implementation rate, % Final result - RAW clearance from site and remediation
III. Disposal of HRAW, IRAW and SSRS Cat. 26 and 3						
Construction of a DGR.	Activities under Appendix 6	Implementation of planned activities under Appendix 6	SE RAW	2050	new national fund	Ratio of actual activities to planned activities (%).
Deep borehole disposal of spent sealed radioactive sources (SSRS).	Planning and implementation of a deep borehole disposal concept.	Inventory, characterisation of sources; Development of preliminary concept for disposal and safety analyses.	SE RAW	2023	RAW Fund	Concept developed, proposals for sites potentially suitable for the construction of a deep borehole repository.
	Packaging	Packaging of sealed spent radioactive sources in metal capsules/casks. Deep borehole disposal of spent source packages.	SE RAW	2030	RAW Fund	Developing and implementing a deep borehole disposal programme.
IV. Decommissioning of the BAS research reactor IRT-2000						
Decommissioning	Preparatory activities	Preparation of a draft Decision	INRNE-BAS	2023	INNE-BAS	Adoption of a decision of the

of the BAS research reactor IRT-2000	for decommissioning	of the Council of Ministers repealing previous Decisions of the Council of Ministers (332/1988 and 552/2001) concerning the designation of a nuclear installation within the meaning of the Vienna Convention and concerning the conversion and partial decommissioning				Council of Ministers
		Developing a decommissioning plan for the site, including an estimate of the costs required.	INRNE-BAS	2025	INNE-BAS	Approved decommissioning plan.
		Activities related to the RAW management during decommissioning to be carried out by SE RAW.	INRNE-BAS SE RAW	2030	SE RAW	Activities implemented according to the decommissioning plan.
	Decommissioning activities	Site remediation.	INRNE-BAS	2032	INNE-BAS SE RAW	Final radiological survey report submitted to the NRA.
V. Decommissioning of Units 1-4 of Kozloduy NPP						
Decommissioning of the units by continuous dismantling.	Ensuring safe and efficient decommissioning. Interim storage of the resulting RAW and its subsequent transport, conditioning and disposal.	Dismantling of SSCs in the units and management of the resulting waste. In accordance with the schedules of the decommissioning plan (2022-2030)	SE RAW	2030	KIDSF RAW fund NDF fund	Reaching the final state of "brown field". Meeting the deadline.
		Implementing a technology for retrieval and processing of evaporate concentrate, spent sorbents and sludge.	SE RAW	2023	KIDSF NFD Fund	Successful results of the implemented technology. Reduced volume of RAW for disposal.
		Completing a project to dismantle equipment from the CA.	SE RAW	2024	KIDSF NFD Fund	Approved technical designs and SAR for dismantling in the controlled area.
		Design and implementation of the Reactor department reconstruction and supply of	SE RAW	2028	KIDSF NFD Fund	Preparedness to store activated equipment in the CA.

		casks for interim storage of activated materials.				
		Construction of a facility for the production of Reinforced concrete container (RCC) type packagings.	SE RAW	2025	KIDSF NFD Fund	Commissioning of the facility.
		Modernisation of site infrastructure.	SE RAW	2026	KIDSF	Infrastructure separation. Emergency power supply. Storage sites.
		Decontamination of premises and buildings of Units 1-4	SE RAW	2030	KIDSF NFD Fund	Exemption from regulatory control of premises and buildings remaining outside the controlled area after the end of the IE. Reaching permissible radiation parameters in the controlled area of Unit 3-4.
		Survey and reclamation of soils around Units 1-4	SE RAW	2032	NDF fund RAW fund	Completed investigation and remediation of soils around Units 1-4 and achieved criteria for sites outside regulatory control.
VI. Decommissioning of Units 5 and 6 of Kozloduy NPP and SFSF						
Decommissioning of Kozloduy NPP Units 5 and 6.	Developing a preliminary decommissioning concept for Kozloduy NPP Units 5 and 6.	Study of best practices of other countries and experience from the decommissioning of Units 1-4. Developing a preliminary concept.	Kozloduy NPP SE RAW	2025	Kozloduy NPP funds	Developed decommissioning concept.
	Developing a decommissioning plan for Kozloduy NPP Units 5 and 6.	Defining specific milestones, deadlines and targets.	Kozloduy NPP SE RAW	2027	Kozloduy NPP funds	Adopted decommissioning plan.
SFSF decommissioning.	Developing a preliminary decommissioning concept and decommissioning plan.	Study of best practices of other countries and experience from the decommissioning of Units 1-4. Developing a preliminary concept.	Kozloduy NPP SE RAW	2052	Kozloduy NPP funds	Preliminary concept and plan adopted.

	Implementing decommissioning activities	Activities according to adopted decommissioning plan.	SE RAW	2056-2080	NFD Fund	Completed activities. Reaching the final state of "brown field".
VII. Adequate financial and human resources						
Ensuring adequate financial resources to implement the high level RAW management and decommissioning programmes.	Ensuring a long-term mechanism for accumulating funds.	Setting up of a fund for the construction of a DGR.	ME, MF, Kozloduy NPP EAD	2024	% of electricity revenues	Adopted regulation on the procedure for the establishment, collection, disbursement and control of funds and the amount of the contributions due to the fund for the construction of the DGR.
	Methodology for determining the costs of financing of Kozloduy NPP Units 5 and 6 decommissioning.	Developing a methodology.	Kozloduy NPP ME	2028	Kozloduy NPP funds	Methodology adopted by the Board of the NFD fund.
		Re-estimation of the total costs for Units 5 and 6 decommissioning based on the adopted Decommissioning Plan and Costing Methodology.	Kozloduy NPP	2028	Kozloduy NPP funds	Consistency of the determined annual contributions with the total decommissioning costs.
	Investment strategy for the financial assets of the NFD fund, RAW fund and earmarked fund for the construction of a DGR.	Developing a strategy	ME, MF, Kozloduy NPP	2023		Investment strategy for the funds resources, adopted by the Board of the funds and approved by the Council of Ministers

	Sufficient resources accumulated in the funds.	Assessment of the funds adequacy.	ME, MF, Kozloduy NPP	Periodically, every 5 years until 2051.	In accordance with an approved investment strategy for determining the return on the financial assets of the funds	% of accumulated resources in the fund to their amount planned in the decommissioning plan; Achieved % return of the fund against the planned return
Ensuring and maintaining sufficient human resources by the licence holder to fulfil its safety obligations in the management of SNF and RAW, and decommissioning.	Ensuring sufficient and qualified personnel to carry out the SNF and RAW management activities.	Analysis of the staffing needs for the SNF and RAW management.	Kozloduy NPP, SE RAW	Annually	Kozloduy NPP funds, RAW Fund	Maintaining a 5-year and 10-year plans for staffing needs. % occupied positions related to the implementation of SNF and RAW activities.
	Ensuring sufficient and qualified personnel for the implementation of decommissioning activities.	Analysis of staffing needs for decommissioning activities.	SE RAW	Annually	KIDSF funds NFD Fund	% occupied positions related to the implementation of decommissioning activities.

Appendix 7

Indicative plan and timetable for the activities for the DGR.

	Year	Schedule of DGR by activity and facility life cycle stage
	2023-2024	Decision of the Council of Ministers on the construction of the DGR. Preparation and adoption of a proposal to amend the Safe Use of Nuclear Energy Act. Developing a Regulation on the procedure for the establishment, collection, disbursement and control of funds and the amount of contributions due to the fund for the construction of the DGR.
	ongoing	Informing the public.
Preliminary analyses and activities		
	2022-2025	Summarising all previous activities and analysis of the results thereof. Review and analysis of the world experience in the field; highlighting the best practices applicable to the Bulgarian conditions - political, technical, geological, economic, legislative, regulatory, and social aspects. Studying foreign experience on the financing of DGR and long-term storage facilities for high level RAW.
Licensing process for the selection of a DGR site in accordance with Article 25 of the Regulation on Safe Management of Radioactive Waste		
	2025-2028	Implementation of Stage 1 "Developing a disposal concept and planning of site selection activities".
	2025-2028	Implementation of Stage 2 "Data Collection and analysis of areas in the country"; exclusion of areas with unfavourable conditions; identification of areas for analysis that have favourable geological-tectonic, geomorphological (topographic), hydrogeological, engineering-geological, hydrological, climatic and other characteristics; selection of prospective sites that meet the criteria for siting a disposal facility; identification of prospective sites for in-depth study.
	2028-2030	Implementation of Stage 3 "Site characterization through in-depth studies and surveys; selection of one site".
	2030-2035	Implementation of Stage 4 "Site approval".
	2036-2040	**Informing the public and local authorities, preparing an investment proposal and performing an EIA for the DGR.**
Licensing process for the design of the DGR		
	2036-2037	Submission of an application for design permit. Issuance of a design permit.
	2036-2039	DGR Design. Submission of a request for the issuance of an order approving the technical design.
	2039-2040	Issuance of an order approving the technical design.

Appendix 7

Licensing process for the construction of the DGR		
	2040-2041	Submission of the application for the construction permit. Issuance of a construction permit.
	2041-2046	Construction.
Commissioning		
	2046-2047	Submission of an application for a commissioning permit Issuance of a commissioning permit.
	2047-2050	Commissioning.
Operation		
	2051	Issuance of an operating licence.
	2051-2111	Operation. Parallel development of a shut down plan, taking into account the technical design (including modifications) and the SAR
	2111	Activities on facility shut down. Site remediation. Development and start of implementation of a post-operational monitoring programme.
Shut down		
	2111-2161	Post-operational active site monitoring.
	2161-2461	Post-operational passive monitoring.