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INTEGRATED REVIEW SERVICE FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT, DECOMMISSIONING AND REMEDIATION (ARTEMIS)

MISSION

TO

BULGARIA

SOFIA, BULGARIA

10 to 20 June 2018

DEPARTMENT OF NUCLEAR SAFETY AND SECURITY
DEPARTMENT OF NUCLEAR ENERGY

ARTEMIS

Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation

REPORT OF THE

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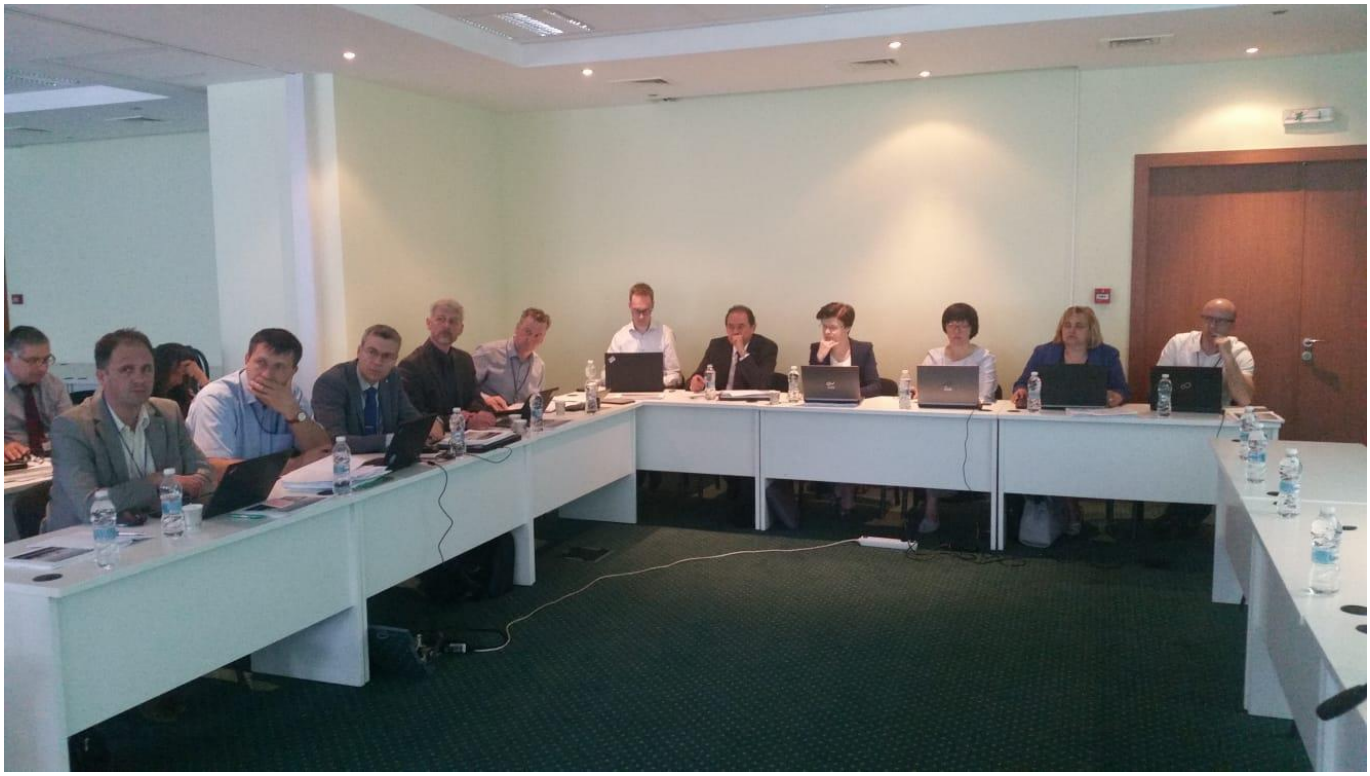

REPORT OF THE

INTEGRATED REVIEW SERVICE FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT, DECOMMISSIONING AND REMEDIATION (ARTEMIS) MISSION

TO

BULGARIA

Mission dates: *10 to 20 June 2018*
Location: *Sofia, Bulgaria*
Organized by: *IAEA*

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IAEA-2018

The number of recommendations, suggestions and good practices is in no way a measure of the status of the national infrastructure for nuclear and radiation safety. Comparisons of such numbers between ARTEMIS reports from different countries should not be attempted.

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EXECUTIVE SUMMARY

At the request of Ministry of Energy of the Republic of Bulgaria on 26 April 2017, the International Atomic Energy Agency (IAEA) organized an ARTEMIS review to fulfil Bulgaria's obligations under Article 14.3 of the 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* (*the Waste Directive*). The objective of the ARTEMIS Peer Review Service is to provide independent expert opinion and advice on radioactive waste (RAW) and spent nuclear fuel (SF) management, decommissioning and remediation, based upon the IAEA safety standards and technical guidance, as well as international good practice.

The review was performed by a team of senior international experts in the field of radioactive waste and spent fuel management, from IAEA Member States, with IAEA staff providing coordination and administrative support.

The review addressed the following topics, consistent with the elements of the *Waste Directive*:

- National policy and framework;
- National strategy;
- National inventory;
- Concepts, plans and technical solutions;
- Safety case and safety assessment of activities and facilities;
- Cost estimates and financing;
- Capacity building.

The ARTEMIS team noted the strong commitment of the Government of Bulgaria to ensure a safe implementation of the RAW and SF management aspects of the policy through the legal requirements in Act on the Safe Use of Nuclear Energy (ASUNE) and associated regulation for the safe conduct of all activities relevant for RAW and SF management, including disposal. However, the policy is presented in multiple documents at various hierarchical levels and various ministerial areas.

Therefore, the ARTEMIS team advises that:

- The Government should consider to enhance its statement of intent regarding the safety of SF and RAW management, through compilation of all elements of the policy on RAW and SF management in a single statement, to provide a position on the preferred options and endpoints as a clear basis for establishing a National Strategy for the management of SF and RAW.

The ARTEMIS team further noted, that a well-developed system of radioactive waste categorization is in use and supports waste handling and operations and further defines also the endpoints for all RAW management routes.

All collected records together cover complete national inventory of spent fuel and radioactive waste. However, there is no integrated nationwide radioactive waste inventory database maintained and managed.

Therefore, the ARTEMIS team advises that:

- To support completeness of the collected information and to ensure equal quality of collected and recorded data on radioactive waste and spent fuel inventory, the Government should consider enhancing integrating retention and use of the registers of radioactive waste and of spent fuel in one nationwide system of collection and retention of data on radioactive waste and spent fuel.

Regarding the waste management costs associated with possible future needs, the peer review team recognised the sound methodology used for estimating the long-term liabilities and also noted that the cost for geological disposal was not included in the activities covered by the RAW fund.

Therefore, the ARTEMIS team recommends, that:

- The Government should ensure that financial provisions for geological disposal are made.

The National Strategy provides a good overview of the roles and responsibilities of the organizations involved in the Bulgarian radioactive waste and spent fuel programme, as well as how and when the identified main requirements of the programme will be achieved up to 2030. An associated action plan is established for achieving the goals set in the Strategy, including success criteria for each action listed in the action plan.

Whilst the National Strategy contains all relevant elements of a strategy plan, it should also provide a coherent higher level national (top down) view that accounts for the entire lifecycle of radioactive waste management which supports ongoing site operations, SF management, decommissioning, site remediation, as well as dealing with existing legacy wastes. The Strategy should also highlight future key decision points, (e.g. when a geological disposal facility will be available and where it will be located) as well as how policy priorities and interfaces between stages of lifecycle are being implemented. In this regard, the Artemis team has provided the following advice:

- For the next update of the National Strategy the Government should provide further detail on how overarching policy objectives on safety of radioactive waste and spent fuel management and sustainable nuclear energy are supported. The strategic priorities should be outlined and the programme should address uncertainties such as the timeframe for implementing geological disposal. The Government should avoid limiting the timeframe for the National Strategy to 2030 and include long-term milestones and schedules that will consider the policy requirements, planning assumptions, strategic preferences and contingencies for the entire programme lifecycle.
- The Government should define the interim targets that support achievement of the policy end-states and goals as set out in the National Strategy
- The Government should consider making decision regarding Dry Spent Fuel Storage Facility for SF from Units 5 and 6 of the KNPP as soon as possible.

State Enterprise “Radioactive Waste” (SE RAW) is the organization designated as national operator having prime responsibility for the safe management of radioactive waste. According to its status assigned by the law, SE RAW activities include:

- radioactive waste management, including all activities related to handling, pre-treatment, treatment, conditioning, storage or disposal of radioactive waste, including the decommissioning of a radioactive waste management facility;
- construction, operation, rehabilitation and reconstruction of radioactive waste management facilities;
- transport of radioactive waste off-site;
- decommissioning of nuclear facilities of its own, being holder of rights to facility or on the basis of a contract with the owner of the facility;
- managing sources related to possibility of occurrence of an incident or accident involving them.

Developing appropriate plans and safety cases on the basis of comprehensive inventory is an essential part of these activities. Based on the cases that were presented, the ARTEMIS Team concludes that the process to perform safety demonstration of the facilities, follow in a comprehensive way the guidelines stipulated in the IAEA General Safety Requirements and Safety Standards, noting that different terminologies are used.

However, in order to efficiently carry out the tasks, SE RAW needs a clear implementation programme, adequate resources and competences including those for disposal, and dedicated R&D to support these activities as required.

In this regard, the Artemis team provided the following advice:

- The Government should consider providing the means to allow SE RAW to explore and develop needs in competence and research in response to actions foreseen in the Strategy which are not yet finally approved

Furthermore, with regard to the concepts, plans and technical solutions, the ARTEMIS team observes that:

- Licensees should consider planning the processing the spent sorbents and sludges from KNPP as soon as reasonably possible

In summary, the ARTEMIS team considers that Bulgaria has established a good basis for the safe and responsible management of radioactive waste and spent fuel, for which further improvements can be successfully implemented.

The ARTEMIS team is of the opinion that by adequately considering the outcomes of the present review Bulgaria will be in a good position to continue meeting high standards of safety for radioactive waste and spent fuel management in the country.

In this regard, the ARTEMIS team suggests that Bulgaria requests a follow-up mission as recommended in the ARTEMIS guidelines.

I. INTRODUCTION

At the request of Ministry of Energy (MoE) of the Republic of Bulgaria of 26 April 2017, the International Atomic Energy Agency (IAEA) organized an ARTEMIS review of the Bulgarian Policy on Spent Fuel and Radioactive Waste Management. The objective of the ARTEMIS Peer Review Service is to provide independent expert opinion and advice on radioactive waste and spent nuclear fuel management, decommissioning and remediation, based upon the IAEA safety standards and technical guidance, as well as international good practice. Bulgaria requested this review to fulfil its obligations under Article 14.3 of the 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* (referred after to as "*Waste Directive*").

The review was performed by a Review Team of six senior international experts in the field of decommissioning, radioactive waste management and spent fuel management, from multiple IAEA Member States, with IAEA staff providing coordination and administrative support. Subsequent to a preparatory meeting in November 2017, as well as timely receipt of Advanced Reference Material, the ARTEMIS Review Team evaluated the overall Bulgarian programme for the management of all types of radioactive waste and spent fuel, including decommissioning aspects, in course of review of received documentation and subsequent review mission, held in June 2018.

II. OBJECTIVE AND SCOPE

The ARTEMIS review provided an independent international evaluation of the overall programme for the management of all types of radioactive waste and spent fuel in Bulgaria, requested in line with the obligations of the art. 14(3) Waste Directive.

The ARTEMIS review, organized by the Department of Nuclear Safety and Security and the Department of Nuclear Energy of the IAEA, was performed against the relevant IAEA Safety Standards and proven international practice and experiences with the combined expertise of the international peer review team selected by the IAEA.

This review covered the entire national system for radioactive waste and spent fuel management, for all the recognized radioactive waste and spent nuclear fuel streams and activities, covering the following elements:

- national policy for radioactive waste and spent fuel management, with notion of legal and regulatory framework,
- national strategy for radioactive waste and spent fuel management,
- national inventory of spent fuel and radioactive waste (including legacy waste and future estimates),
- the concepts, plans and technical solutions that are intended for implementation of spent fuel and radioactive waste management facilities and activities,
- safety case and or safety assessment for management of spent fuel and radioactive waste. The topic addresses national-level aspects of safety demonstration, for which the actual safety of particular facilities and activities are not reviewed in detail,
- cost estimates for spent fuel and radioactive waste management and their financing,
- capacity building for safe and continuous spent fuel and radioactive waste management: expertise, training and skills.

The competent regulatory authority was reviewed through Integrated Regulatory Review Service (IRRS) of IAEA, most recent missions of which were hosted in 2013 and 2016 (follow-up). In this regard, outcomes of IRRS missions are considered and, as appropriate, taken into account, as part of implementation of ARTEMIS review service. Therefore, the ARTEMIS peer review has been focusing to implementation of the national programme, with notion of of legal and regulatory framework aspects in relation to its implementation.

The review is applicable to fulfil the obligations required under Article 14(3) of the EC 2011/70 EURATOM Directive establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste.

III. BASIS FOR THE REVIEW

A) PREPARATORY WORK AND IAEA REVIEW TEAM

At the request of the Government of Bulgaria, a preparatory meeting for the ARTEMIS Review mission, was conducted from 20 to 21 November 2017. The preparatory meeting was carried out by the appointed Team Leader Mr Christophe Depaus, the IAEA Team representatives, Ms Monika Skrzeczkowska and Mr Philippe Van Marcke and the National Counterparts, Ms Katerina Kostadinova (MoE), Ms Antoaneta Zaycheva (MoE), Mr Valentin Stanchev (BNRA), Ms Yulia Dimitrova (BNRA), Mr Anton Ivanov (TSO to BNRA), Mr Georgi Razlozhki (SE RAW), Mr Ivan Petrov (SE RAW), Mr Rumen Shishkov (SE RAW), Mr Misho Monev (KNPP) and Mr Nikolay Ivanov (KNPP).

The preparatory meeting aimed at discussing:

- the Terms of Reference for the ARTEMIS review of the Bulgarian programme to fulfil obligations from article 14(3) of the Waste Directive; and
- the relevant detailed aspects for organization and conduct of the review.

IAEA staff presented the ARTEMIS principles, process and methodology. This was followed by a discussion on the work plan for the implementation of the ARTEMIS review in Bulgaria in June 2018.

Ms Katerina Kostadinova (Head of Division "Security in Nuclear Power", Ministry of Energy) and Mr Nikolay Grozev (First Secretary, Permanent Mission of the Republic of Bulgaria) were appointed as the Contat Representatives responsible for the given ARTEMIS mission and designated IAEA point of contact. In January 2018 Mr Georgi Razlozhki (Deputy Executive Director of SE RAW) replaced Ms Katerina Kostadinova.

Bulgaria provided IAEA with the Advance Reference Material (ARM) for the review as agreed during Preparatory Meeting in Sofia and within agreed timeframes and scope, consisting of:

- The Artemis self-assessment;
- Revised strategy for spent nuclear fuel and radioactive waste management up to 2030 (hereafter referred to as the "Strategy");
- the 6th Country report to the Joint Convention;
- the 5th Country report to the Joint Convention;
- National report to EC 2015;
- IRRS 2013 and follow-up 2016 review reports;
- Act on Safe Use of Nuclear Energy – ASUNE;

Other information agreed for delivery during the Preparatory Meeting, was provided within the self-assessment or by indication of where this information exists in the above official documents.

B) REFERENCES FOR THE REVIEW

The review reference was the entire Advanced Reference Material including self-assessment, as well as materials presented during the mission and associated discussions. Process-wise, the review was conducted with notion of the *Waste Directive* and accordingly to the draft guidelines for ARTEMIS review service.

The complete list of IAEA publications used as the basis for this review is provided in Appendix D.

C) CONDUCT OF THE REVIEW

The initial Review Team meeting took place on Sunday, 10 June 2018 in Sofia, directed by the ARTEMIS Team Leader Mr Christophe Depaus and the ARTEMIS Team Coordinator Ms Monika Skrzeczkowska. The Deputy Team Coordinator, Mr Philippe Van Marcke supported his respective leads.

The Contact Representative Mr Nikolay Grozev supported the initial Review Team meeting in accordance with the ARTEMIS guidelines and presented logistical arrangements planned for the mission.

The ARTEMIS mission commenced on Monday, 11 June 2018 with opening session and opening remarks made by Deputy Minister of Energy Mr. Krasimir Parvanov and Mr Christophe Depaus, ARTEMIS Team Leader, with the participation of senior management and staff of the Ministry of Energy (MoE), the Nuclear Regulatory Agency (BNRA), Ministry of Health and its National Centre of Radiobiology and Radiation Protection (NCRRP), Kozloduy Nuclear Power Plant (KNPP) and State Enterprise "Radioactive Waste" (SE RAW). Representatives of each respective organization gave introductory presentations, providing an overview of the context for radioactive waste and spent nuclear fuel management in Bulgaria.

The ARTEMIS review was conducted for all review topics within the agreed scope, with the objective of providing Bulgarian authorities with recommendations and suggestions for improvement and, where appropriate, identifying good practice.

The Review Team performed its review according to the mission programme given in Appendix B.

The ARTEMIS exit meeting was held on Wednesday, 20 June 2018, with presentation of the mission results by the ARTEMIS Team Leader Mr Christophe Depaus and closing speeches by Deputy Minister of Energy Mr. Krasimir Parvanov, and Mr Peter Johnston, Director of the Division of Radiation, Transport and Waste Safety, IAEA Department of Nuclear Safety and Security.

An IAEA press release was issued.

1. NATIONAL POLICY AND FRAMEWORK FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT

1.1. NATIONAL POLICY

Bulgaria position

According to the ARM, elements of the policy of the Republic of Bulgaria on SF and RAW management are codified in the Act on the Safe Use of Nuclear Energy (ASUNE), the Environmental Protection Act, the Health Protection Act, and pursuant regulation. Through the aforementioned acts the concepts of, *inter alia:*

- assigning responsibility for nuclear safety to the licensee
- waste minimization
- application of the graded approach
- prevention of undue burdens on future generations, and
- involvement of interested parties

are all implemented *via* the framework for RAW and SF management. National legislation and associated regulation further define the endpoints for all RAW management routes as disposal or release from regulatory control through decay storage until compliance with release criteria. Other components of policy are conveyed in the Strategy for Spent Nuclear Fuel (SF) and Radioactive Waste (RAW) Management to 2030.

During the exchange with the Bulgarian counterpart, the position of RAW and SF management as an integrated part of the Energy Strategy of the Republic of Bulgaria till 2020, was conveyed to the ARTEMIS team, providing a reference to a statement of the government's intent with respect to safe management of SF and RAW. In accordance with this Energy Strategy, a dual track approach of disposal either nationally or internationally is considered for management of High Level Radioactive Waste (HLW) and long-lived Low and Intermediate Level Waste (LILW) after processing and storage of SF. A central element in the Energy Strategy is to deliver a sustainable programme for nuclear energy, which was adopted by the Bulgarian parliament. A Governmental Program further states tasks to be carried out pursuant of the Energy Strategy from 2017 until 2021. For both the Energy Strategy and the Governmental Program, procedures for evaluating needs for amendments to legal acts as well as The Strategy for SF and RAW management until 2030 are in place.

ARTEMIS observation

The policy for safe management of SF and RAW, including the main endpoints for all RAW and SF management routes is defined at a general level as an integral part of the Energy Strategy of the Republic of Bulgaria till 2020. The safe implementation of the RAW and SF management aspects of the policy is ensured though the legal requirements in ASUNE and associated regulation for the safe conduct of all activities relevant for RAW and SF management, including disposal.

However, the long-term commitment to safety in RAW and SF management does not clearly stand out as a statement of the government's intent. The ARTEMIS team acknowledges that a well defined policy is instrumental in ensuring safety as a priority through promotion of emphasis and direction within the framework of a strategy for SF and RAW management.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *The Government's intent to ensure long term safety through setting out the preferred options for radioactive waste and spent fuel management and reflect national priorities as the basis for decisions is presented in multiple documents at various hierarchical levels and various ministerial areas.*	
(1)	**BASIS: GSR Part 1 Requirement 1 para. 2.3 states that** *"National policy and strategy for safety shall express a long term commitment to safety. The national policy shall be promulgated as a statement of the government's intent."*
(2)	**GSR Part 5 Requirement 2 states that** *"To ensure the effective management and control of radioactive waste, the government shall ensure that a national policy and a strategy for radioactive waste management are established. [...] The national policy and strategy shall form the basis for decision making with respect to the management of radioactive waste."*
(3)	**GSR Part 5 Requirement 2 para 3.5 states that** *"The national policy on radioactive waste management has to set out the preferred options for radioactive waste management. It has to reflect national priorities […]"*
S1	**Suggestion: The Government should consider to enhance its statement of intent regarding the safety of SF and RAW management, through compilation of all elements of the policy on RAW and SF management in a single statement, to provide a position on the preferred options and endpoints as a clear basis for establishing a National Strategy for the management of SF and RAW.**

1.2. LEGAL, REGULATORY AND ORGANISATIONAL FRAMEWORK

Bulgaria position

The ASUNE defines the responsibilities of the Ministry of Energy (MoE), Ministry of Environment and Water, Ministry of Health, NPP operator, State Enterprise "Radioactive Waste" (SE RAW) as well as other RAW producers in relation to management of RAW and SF. The same act provides for the establishment of an independent regulatory authority, the Bulgarian Nuclear Regulatory Agency (BNRA).

The Ministry of Energy is responsible for developing the nuclear infrastructure and also holds responsibility for implementation of the policy for RAW and SF management through establishment of a national strategy for SF and RAW management, which according to Article 74 in ASUNE is to be adopted by the Council of Ministers. The MoE further holds responsibility for periodic review and updates of the strategy, as well as monitoring of progress in the implementation of the strategy.

The MoE is also responsible for the organisation and coordination of activities in preparing proposals for constructing national facilities for storage and/or disposal of RAW, as well as monitoring construction and operation of these facilities.

The Ministry of the Environment and Waters or the director of the Regional Inspectorate for Environment and Waters is responsible for carrying out environmental impact assessments (EIA). In relation to management of RAW and SF the following types of facilities are subject to EIA:

- nuclear power plants and other nuclear reactors, including their dismantling and decommissioning;
- facilities for pre-processing SNF;
- facilities intended for processing SNF or waste with a high radioactivity level;
- facilities for permanently disposing of SNF;
- facilities dedicated solely to permanently disposing of RAW;
- facilities dedicated solely to the planned storage of SNF and RAW for more than 10 years at sites other than where they were generated.

The Ministry of Health has delegated the regulatory role for medical applications of ionizing radiation, dosimetry, working environment and assessment of exposure to the general public to Regional Inspectorates for Protection and Control of Public Health and the National Centre for Radiobiology and Radiation Protection (NCRRP). The BNRA and Ministry of Health have specific responsibilties for nuclear safety and radiation protection.

ASUNE states that bodies, which are engaged in promotion or use of nuclear energy or sources of ionising radiation, shall not exercise regulatory functions with respect to nuclear safety and radiation protection.

According to ASUNE, article 77, generators of RAW are responsible for their safe management from their generation until delivery to the SE RAW, at which point, according to the Regulation on the Terms and Conditions for Delivery of Radwaste to the SE RAW, all liabilities related to the safe management of RAW are also transferred to SE RAW. Furthermore, article 76 of ASUNE, determines that management of RAW outside the location of their origin is exclusively to be undertaken by SE RAW, which as a state owned entity operates as a commercial non-profit company focussed on the following activities:

- RAW management including the decommissioning, storage and disposal of RAW
- Construction and operation of RAW management facilities;

Financial provisions for such activities are secured through the Radioactive Waste Fund (RAW Fund) and the Nuclear Plant Decommissioning Fund (Decommissioning Fund) under the auspices of the Bulgarian Ministry of Energy (see chapter 6).

The legal framework for RAW and SF management refers to international conventions and European directives, namely:

- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management;
- Council Directive 2011/70/EURATOM establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste,

and Bulgarian national acts and regulations:

- Act on the Safe Use of Nuclear Energy (ASUNE);
- Regulation on safe management of RAW;
- Regulation for safety of spent fuel management;
- Regulation on conditions and procedure for transfer of RAW to the State Enterprise "Radioactive waste";
- Regulation for radiation protection.

The provisions in the articles of the Joint Convention are enacted in Bulgarian law through particular requirements stated in ASUNE and pursuant regulations. Bulgaria reported transposition of the requirements under Council Directive 2011/70/EURATOM, through adoption of the regulation on safe management of RAW and regulation for safety of spent fuel management issued with reference to ASUNE.

The Regulation on Safety of Radioactive Waste Management was last amended in 2013, introducing provisions regarding:

- Classification of radioactive waste relative to IAEA standard GSG-1;
- Requirements for the geological formation hosting a disposal facility for HLW to provide isolation from the biosphere for at least 100 000 years;
- Requirements for contents of plans for closure of disposal facilities;
- Procedures for assignment of responsibilities for control after closure of disposal facilities;
- Requirements to perform periodic safety review;
- Requirements for application of a graded approach.

ASUNE and associated regulation specifically defines the requirements for demonstrating safety through development of all the elements constituting a safety case and associated safety assessment for any SF and RAW management facility (see Chapter 5).

For both the Regulation on Safety of Spent Fuel Management and the Regulation on Safety of Radioactive Waste Management amendments regarding transition to an integrated management system were put in place in 2013 (see Chapter 4).

The required contents of the strategy for SF and RAW management are defined in the Regulation on safe management of RAW and Regulation for safety of spent fuel management. The Strategy for SF and RAW management until 2030 (the Strategy) was adopted by the Council of Ministers on 2 September 2015. The Strategy is updated every five years by the MoE and latest in 2015 adding analyses of SF management options. The outline of activities designed to achieve the goals of the Strategy are presented in an action plan.

ARTEMIS observation

As noted in the 2013 IRRS mission to Bulgaria, responsibilities within the national safety framework have been allocated to all governmental and regulatory organizations relevant for safety of SF and RAW management. The ARTEMIS team notes that this framework is well developed and provides a robust infrastructure for the safe management of RAW and SF, including mechanisms for development of a strategy for SF and RAW.

2. NATIONAL STRATEGY FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT

Bulgaria position

In 2015 the Council of Ministers adopted the latest National Strategy for RAW and SF management until 2030 (the Strategy). The Strategy is outlined in the "Revised Strategy for Spent Nuclear Fuel and Radioactive Waste Management up to 2030". The Strategy is updated every five years by the Ministry of Energy and establishes a framework designed to ensure the safe management of SF and all RAW categories.

The Strategy presents information on the overall policy goals and principles, objectives and management options as well as practices for SF and RAW, waste categorisation and overview of present and projected inventories, human resource development, economy and finance and milestones and performance indicators.

The specific steps in SF and RAW management, as well as the relations between the main responsible entities, are set in regulations issued under ASUNE, most notably: the Regulation on the safe management of RAW, the Regulation on the safe management of SNF and the Regulation on conditions and procedure for the delivery of radioactive waste to the SE RAW.

The Strategy designates SF as a potential resource, which is to be reprocessed in an economical and environmentally responsible manner. SF for which reprocessing is not an economically viable solution may be declared as a RAW and stored until a final management decision is made. Interim storage of such SF declared as waste is to take place using dry casks. A deep geological disposal solution is envisaged for disposal of HLW or SF declared as waste, as well as other long-lived LILW. A dual track approach may be followed seeking international solutions for the disposal of HLW and long-lived LILW. Until a disposal solution is available, a long-term storage solution for HLW and long-lived LILW is planned. An important component of the Strategy is to send SF (50 tHM *per* year) for reprocessing abroad which may take between 10 to 25 years, while pursuing projects enabling storage and disposal upon return of the HLW from reprocessing by 2030.

Other LILW from decommissioning of nuclear facilities, as well as from other waste generators in Bulgaria, is to undergo waste minimization, processing and conditioning with the aim of disposal in a single national near-surface repository that is currently in the first stages of construction with an expected completion date of 2021. Disused sealed radioactive sources (DSRS) as well as orphan sources are to be disposed of in the national near-surface repository or undergo long-term storage together with other HLW and long-lived LILW. Ongoing decommissioning of units 1 to 4 of KNPP will continue until reaching a "brown field"-state by 2030. The outline of activities designed to achieve the goals regarding RAW, SF and decommissioning key to the Strategy are presented in an action plan. Research and development is also included in the action plan, and is focused on options for HLW disposal, management of SF as an energy resource and options for transmutation of HLW.

According to the ARM, responsibility for implementation of each action in the action plan rests with the relevant competent authority or licensee, while the MoE holds overall responsibility for monitoring of progress in conduct of the action plan. The provided "Status of the implementation of the action plan in accordance with the Strategy for SF and RAW management to 2030" gives the status and success criteria for each action listed in the action plan.

The Strategy foresees management of all types of RAW and of the SF, and a final point of management is identified for each stream of RAW, as shown by the following table:

Waste stream or spent fuel	Long-term management	Existing and planned storage and disposal facilities
spent nuclear fuel	reprocessing abroad or management as HLW	Long term storage facilities pending future decisions on disposal and / or reuse
Radioactive waste from the nuclear fuel cycle	disposal	Conditional or free release National Disposal Facility for short-lived LILW (in construction) Interim long-term storage facility for HLW and long-lived LILW. Geological disposal facility
Radioactive waste from nuclear applications	disposal	Conditional or free release National Disposal Facility for short-lived LILW (in construction) Interim long-term storage facility for HLW and long-lived LILW. Geological disposal facility
Decommissioning waste	strategy for continuous decommissioning	Conditional or free release National Disposal Facility for short-lived LILW (in construction) Interim long-term storage facility for HLW and long-lived LILW. Geological disposal facility

Waste stream or spent fuel	Long-term management	Existing and planned storage and disposal facilities
Disused sealed sources, orphan sources	Return to the manufacturer; disposal	Conditional or free release National Disposal Facility for short-lived LILW (in construction) Interim long-term storage facility for HLW and long-lived LILW. Geological disposal facility or deep borehole

As for continuous improvement and updating of the strategy, the RAW management system at the KNPP, as an example, is controlled through the Comprehensive Programme for Management of Radioactive Waste (CP). The objective of the CP is to continuously improve safety during operation and long-term storage of RAW by applying adequate engineering and organisational measures at all stages of the process.

A progress review of the implementation of the CP is conducted each year and appropriate activities and resources are planned for the coming five years. The implementation of the CP is monitored by the KNPP management via: a) periodical implementation reports, and b) reporting of self-assessment indicators selected from within the activities in the CP.

ARTEMIS observation

The ARTEMIS review team acknowledges that the Strategy provides a good overview of the following:

- the roles and responsibilities of the organizations involved in the Bulgarian radioactive waste and spent fuel programme;
- how and when the identified main requirements of the programme will be achieved up to 2030;
- an action plan for achieving the goals set in the Strategy, including success criteria for each action listed in the action plan;
- the waste classification system used and the associated disposal route.

Whilst the National Strategy contains all relevant elements of a strategy plan, it should also provide a coherent higher level national view (top down) that accounts for the entire lifecycle of radioactive waste management which supports ongoing site operations, SF management, decommissioning, site remediation, as well as dealing with existing legacy wastes. The National Strategy should provide a simple overview of how the principles for RAW and SF will be put into effect over the entire lifecycle, clearly highlighting future key decision points, e.g. when a geological disposal facility will be available and where it will be located. The National Strategy would benefit from a clearer description of how policy priorities are being implemented (see chapter 1), the interfaces between stages of the lifecycle and management expectations including consideration of intergenerational responsibilities such as long term

safe storage, the relationship between sustainable nuclear energy and RAW & SF management and also the mechanism for declaring materials as radioactive waste, such as SF, NORM and materials generated by extractive industries.

Three areas in particular where discussed in detail where the policy drivers could help to clarify the strategic priorities at a national level with the following observations:

- Continued spent fuel reprocessing is preferred at this stage in the programme with two alternative options proposed: direct disposal of SF and reuse. Given the importance of this strategic choice for the overall programme, the review team suggest to further develop these points in the strategy by clearly articulating the spent fuel management programme and dependencies such as reprocessing and proposed lifetime extensions of KNPP units 5 & 6.
- The strategy does not describe how predisposal activities such as waste packaging and storage cope with the uncertainty regarding the timescales for implementing geological disposal. The review team was informed that the high-level waste storage facility is being designed for an expected lifetime of 100 years, although this design intent is not documented in the strategy.
- The strategy on NORM waste was presented to the ARTEMIS team during the mission. This information is however not incorporated in the Strategy. The review team proposes to document the provisions for management of NORM in the Strategy and to highlight the conditions when the NORM will be treated as radioactive waste and state the responsible organisation.

Following the above observations, the review team recommends that the next update of the strategy should provide a coherent higher level national view (top down) that accounts for the lifecycle of the RAW and SF management programme.

Another example concerns the uncertainty about the radioactive waste inventory, as this inventory is only an estimate and will be subject to change as decommissioning and remediation progresses. The inventory will also depend on the final decision on how much SF is reprocessed. Furthermore, many elements of the RAW and SF programme must continue many decades beyond 2030, where it is understood units 5 and 6 of the KNPP are aiming to operate up to 2047 and 2051 respectively, and a government decision on the location of geological disposal facility will not be made until 2030. The review team therefore recommends the strategy should consider the entire programme lifecycle for both RAW and SF management with timescales extending well beyond 2030.

The review team appreciates the information provided on monitoring of progress in implementing the Strategy. The review team is of the opinion that the plan should be further enhanced by monitoring significant activities that directly support policies on sustainable nuclear energy and sustainable radioactive waste management including developing suitable metrics for achievement of interim targets and end states that would measure programme trend and overall progress against overarching policy objectives and strategy priorities.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *Whilst the National Strategy contains all relevant elements of a strategy plan, it does not provide a coherent higher level national view (top down) that accounts for the entire programme in terms of lifecycle radioactive waste management activities that support ongoing site operations, SF management, decommissioning, site remediation, as well as dealing with existing legacy wastes.*	
(1)	**BASIS: GSR Part 1 Requirement 1, para. 2.3 states that** *"National policy and strategy for safety shall express a long term commitment to safety. The national policy shall be promulgated as a statement of the government's intent. The strategy shall set out the mechanisms for implementing the national policy."*
(2)	**BASIS: GSR Part 5 Requirement 2 para. 3.6 states that** *"The national strategy for radioactive waste management has to outline arrangements for ensuring the implementation of the national policy. It has to provide for the coordination of responsibilities. It has to be compatible with other related strategies such as strategies for nuclear safety and for radiation protection."*
R1	**Recommendation: For the next update of the National Strategy the Government should provide further detail on how overarching policy objectives on safety of radioactive waste and spent fuel management and sustainable nuclear energy are supported. The strategic priorities should be outlined and the programme should address uncertainties such as the timeframe for implementing geological disposal.**

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *The National Strategy does not provide clear guidelines on the management of the radioactive waste and spent fuel after 2030 and does not consider all key initiatives, interim targets and end states implementing the essential elements of Government Policy.*	
(1)	**BASIS: SF-1 Principle 7, para 3.29 states that** *"Radioactive waste must be managed in such a way as to avoid imposing an undue burden on future generations; that is, the generations that produce the waste have to seek and apply safe, practicable and environmentally acceptable solutions for its long term management. The generation of radioactive waste must be kept to the minimum practicable level by means of appropriate design measures and procedures, such as the recycling and reuse of material*."
(2)	**GSR Part 5 Requirement 2 para. 3.6 states that** *"The national strategy for radioactive waste management has to outline arrangements for ensuring the implementation of the national policy. It has to provide for the coordination of responsibilities. It has to be compatible with other related strategies such as strategies for nuclear safety and for radiation protection."*
(3)	**GSR Part 1 Requirement 1, para. 2.3 states that** *"National policy and strategy for safety shall express a long term commitment to safety. The national policy shall be promulgated as a statement of the government's intent. The strategy shall set out the mechanisms for implementing the national policy."*
(4)	**GSR Part 1 Requirement 10, para. 2.28 states that "***Decommissioning of facilities and the safe management and disposal of radioactive waste shall constitute essential elements of the governmental policy and the corresponding strategy over the lifetime of facilities and the duration of activities [3, 7]. The strategy shall include appropriate interim targets and end states. Radioactive waste generated in facilities and activities necessitates special consideration because of the various organizations concerned and the long timescales that may be involved. The government shall enforce continuity of responsibility between successive authorized parties."*
R2	**Recommendation: The Government should avoid limiting the timeframe for the National Strategy to 2030 and should include long-term milestones and schedules that will consider the policy requirements, planning assumptions, strategic preferences and contingencies for the entire programme lifecycle.**
R3	**Recommendation: The Government should define the interim targets that support achievement of the policy end-states and goals as set out in the National Strategy.**

3. INVENTORY OF SPENT FUEL AND RADIOACTIVE WASTE

Bulgaria position

According to the ARM, the national scheme for the classification of radioactive waste in Bulgaria is adopted with the Regulation for safe management of RAW (last changed in 2013). It defines the categories and subcategories of the solid RAW in accordance with the IAEA Safety Guide GSG-1 (Classification of Radioactive Waste).

1. Category 1 - waste containing radionuclides with low activity, which do not require the implementation of measures for radiation protection or do not need a high level of isolation and containment; RAW from this category is further sub-divided into:

- category 1a - waste that meets the levels for release from regulatory control under the ASUNE;
- category 1b - very short-lived waste containing mainly radionuclides with short half-life (not more than 100 days), whose activity decreases below the levels for release from regulatory control as a result of appropriate storage on the site for a limited period of time (usually not more than several years);
- category 1c - very low-level waste with levels of specific activity exceeding by a minimal value the levels for release from regulatory control under the ASUNE and with a very low content of long-lived radionuclides, which represent a limited radiological risk; for this category of waste, the application of specific measures for radiation protection or for isolation and containment is not required;

2. Category 2 – low and intermediate level waste: RAW containing radionuclides in concentrations that require measures for reliable isolation and retention, but do not require special measures for heat removal during storage and disposal; RAW from this category is further divided into:

- category 2a – low and intermediate level waste containing mainly short-lived radionuclides (with a half-life not longer than that of cesium-137) as well as long-lived radionuclides at significantly lower levels of activity, limited for the long-lived alpha- emitters under 4.10^6 Bq/kg for each individual package and a maximum average value for all packages in the respective facility of 4.10^5 Bq/kg; for such RAW reliable isolation and containment is required for up to several hundred years;
- category 2b – low and intermediate level waste containing long-lived radionuclides at activity levels of long-lived alpha emitters, exceeding the limits of category 2a;

3. Category 3 - high-level waste: RAW with such a concentration of radionuclides in which heat removal must be taken into account during storage and disposal.

For Category 3 (HLW) and Category 2b (Long Lived LILW) regulation determines disposal in deep, stable geological formations as the end point.

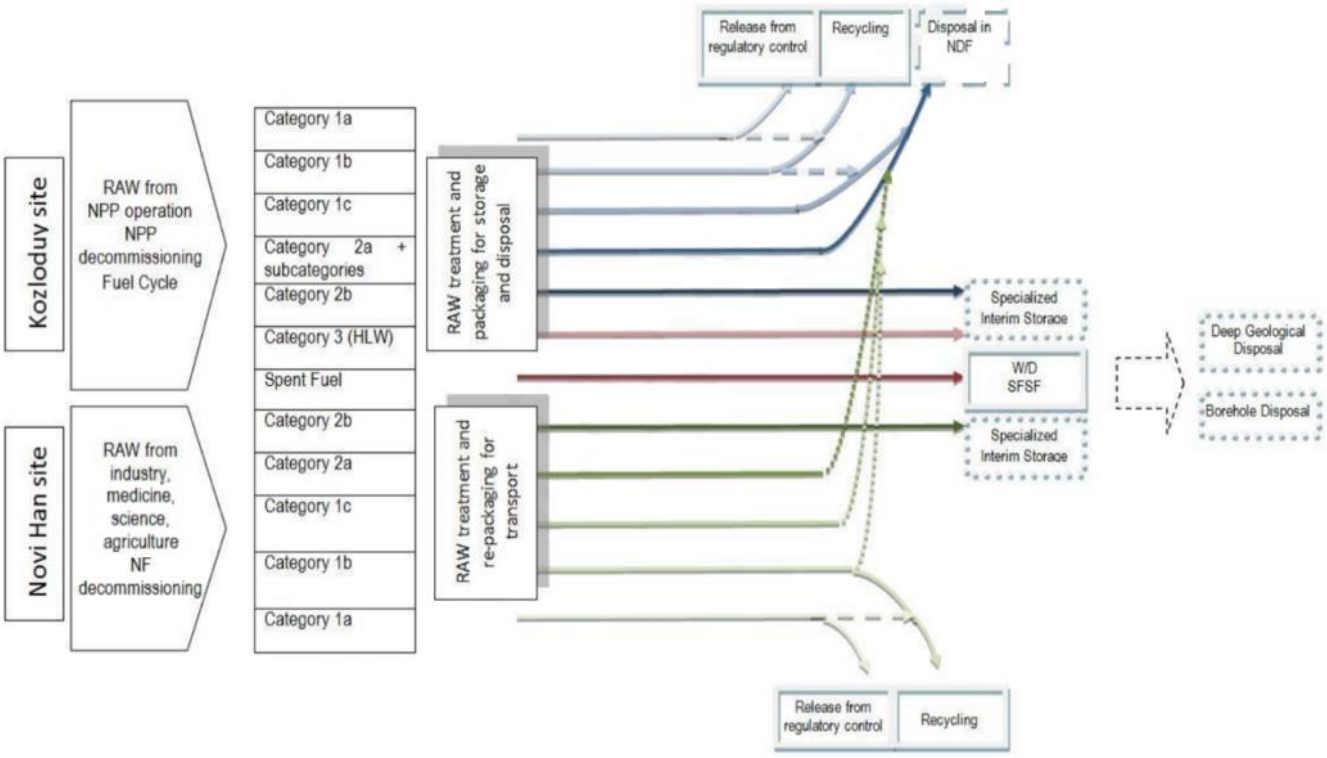

Figure #1: High level representation of RAW classification system with management and disposal routes indicated

For handling and processing purposes additional classification schemes for category 2 solid RAW and for category 2 liquid RAW are applied by the nuclear operators KNPP and SE RAW. This operational classification is based on the dose rate and is oriented toward the operational radiation protection. This operational classification is integrated into the higher level classification scheme.

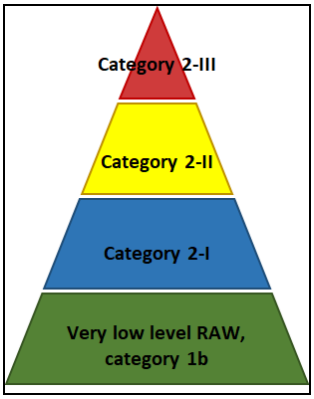

Figure #2: Operational classification for management and handling of solid RAW

For solid RAW:

- Category 2-I – gamma dose rate of 1μSv/h to 0.3 mSv/h at a distance of 0.1 m from the surface;
- Category 2-II – gamma dose rate of 0.3 mSv/h to 10 mSv/h at a distance of 0.1 m from the surface;
- Category 2-III – gamma dose rate of more than 10 Sv/h at a distance of 0.1 m from the surface;

For liquid RAW:

- Category 2-L – specific beta activity up to $3{,}7.10^5$ Bq/l
- Category 2-M – specific beta activity of $3{,}7.10^5$ Bq/l to $7{,}2.10^7$ Bq/l
- Category 2-H – specific beta activity of over $7{,}2.10^7$ Bq/l.

The operators (SE RAW and KNPP) are responsible for collecting data and maintaining the inventory of nuclear material and RAW. The operators of nuclear facilities maintain the traceability of all the SF and RAW streams according to their integral management systems. The operators have to report their individual inventories to BNRA in three-monthly reports and yearly reports. The national inventory is updated during the preparation of the National Reports to the Joint Convention (every 3 years) and during the review and update of the Strategy (at least every 5 years). The Joint Conventions reports are made publicly available and contain the actual and full information about the inventory.

Waste owners have to prepare inventory records in a prescribed format before transfer of the waste to SE RAW. The information collected includes physical composition, activity and isotopic concentration, type of materials, surface dose rate, unique identification, date of transfer, transport details including name of receiving information. Some information about the non-radiological content of the waste package is also collected. During treatment, a number of waste consignments may be repackaged as a single package and a new data record is completed after waste has been treated and repackaged but the original identification numbers are retained on new records, in order to guarantee traceability.

The characterization of solid and liquid RAW covers the specification of all parameters that are important for the subsequent processing of waste and their safe storage. This includes, for example, the following for liquid RAW: the content of salt, pH, the content of boric acid, the content of surfactants and radionuclide contents. Solid RAW is divided into compactable, non-compactable and metals.

The anticipated future inventory of spent fuel assemblies (SFA) is based on projected operation of KNPP units 5 and 6 according to the national strategy. The forecast for expected SFA and RAW from possible new NPP project in Bulgaria is also provided as a forecasted inventory in the strategy.

Import of RAW from other countries is prohibited by the ASUNE, except in cases of return of spent sources produced in Bulgaria and HLW from reprocessed SF. Details on waste format of future HLW inventories to be returned to Bulgaria after SF reprocessing are also uncertain, as the waste format will be determined later (according to the contract with the supplier of the reprocessing service). HLW from WWER-440 SFA will be returned ten years after determining the waste format. The return format for HLW from WWER-1000 SFA will be determined in contract with the supplier of reprocessing (potential date of contract with reprocessing supplier is envisaged around 2026).

Planned future inventories of RAW till 2030 arising from decommissioning are provided and are based on the approved decommissioning plan of KNPP units 1 to 4. Decommissioning plans and future inventories of RAW from decommissioning for KNPP units 5 and 6 are provided in the Safety Analysis Report (SAR) of each respective KNPP unit. Future inventories of RAW from decommissioning of KNPP wet and dry spent fuel facilities are provided in its respective SARs.

ARTEMIS observation

The ARTEMIS team recognized that a well-developed system of radioactive waste categorization is in use which is defined by the national Legislation and associated Regulations. This categorization system supports waste handling and operations and further defines also the endpoints for all RAW management routes as disposal or release from regulatory control through decay storage until compliance with release

criteria.

The ARTEMIS team acknowledges that a well defined clearance procedure exist. Clearance levels are stipulated in regulations for radiation protection. Before clearance the operator (KNPP or SE RAW) has to confirm the activity levels according to the procedure prescribed by BNRA. The operator documents the clearance process and performs measurement. A certified laboratory, independent from the operator, performs specific activity measurements, and confirms compliance with the clearance levels.

The inventory compilation process described and in use in Republic of Bulgaria is implemented by license owners. Inventory compilation is performed according to the established national waste classification system. Inventory data are recorded using either paper or electronic carriers. ARTEMIS team has been informed that there is no single nationwide inventory database in place, however specific waste registers are in place that cover complete national inventory of spent fuel and radioactive waste. Waste registers managed separately are:

- waste and spent fuel inventory of KNPP;
- waste registers of SE RAW SD RAW – Kozloduy;
- waste registers of SE RAW SD PSFRAW - Novi han;
- separate Disused Sealed Radioactive Sources (DSRS) register.

All separate waste registers together cover the entire national inventory of radioactive waste and spent fuel and are presented in the National Strategy. Therefore, these registers represent a sound basis for the national-level policy and strategy development and planning.

To support completeness of the collected information and to ensure equal quality of collected and recorded data on the radioactive waste and spent fuel inventory, the review team proposes the use of an integrated electronic data processing system as future development option.

ARTEMIS team understood that SE RAW's and KNPP's approach on verification and uncertainty management of the inventory differs from other facilities. Uncertainties management and verification procedures are in place for almost all separate inventories. Within Novi han facility SE RAW manages uncertainties for waste accepted after 2006 with physical checks and acceptance controls. However, for waste accepted before 2006 and stored in underground RADON facilities no uncertainty management is in place.

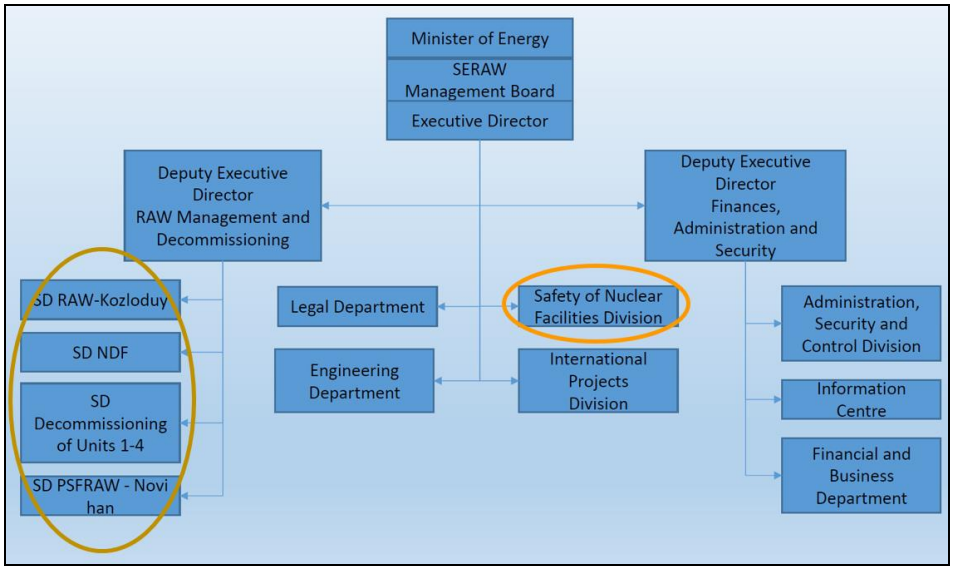

Figure #3: Schematic representation of organization of SE RAW ensuring organizational separation needed for independent verification of waste management processes

Through the discussions SE RAW explained their integrated approach to independently verify the waste packages. The verification is performed by personnel other than those who process the waste. The waste is processed by personnel under Deputy Executive Director RAW Management and Decommissioning while the waste packages are verified by personnel in the Safety of Nuclear Facilities Division reporting directly to Executive Director of SE RAW (see figure 3). This approach is in line with proposed IAEA safety guide on waste package verification, which states that "*The conformance of waste packages […] should be independently verified by personnel other than those who prepared the waste packages*." (Article 6.7. of GS-G-3.3 "The Management System for the Processing, Handling and Storage of Radioactive Waste"). In addition, BNRA is performing administrative as well technical verifications of the waste management process during inspections.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *The radioactive waste and spent fuel inventory records collection and management process in Republic of Bulgaria is implemented by individual license owners. All collected records together cover complete national inventory of spent fuel and radioactive waste and are presented in the National Strategy. However, there is no integrated nationwide radioactive waste inventory database maintained and managed.*	
(1)	**BASIS: GSR Part 1 Requirement 35, para.4.63 states that** *"The regulatory body shall make provision for establishing and maintaining the* following main registers and inventories: *[...] inventories of radioactive waste and of spent fuel."*
(2)	**GSR Part 1 Requirement 35, para. 4.64 states that** *"The regulatory body may or may not be the sole entity responsible for the maintenance of these registers and inventories, but it shall be involved in their proper retention and use. [...] The requirement for the regulatory body to maintain records cannot diminish the responsibility of authorized parties to keep their own records."*
(3)	**GSR Part 1 Requirement 7 states that** *"[...] the government shall make provision for the effective coordination of their regulatory functions, to avoid any omissions or undue duplication and to avoid conflicting requirements being placed on authorized parties".*
S2	**Suggestion: To support completeness of the collected information and to ensure equal quality of collected and recorded data on radioactive waste and spent fuel inventory, the Government should consider enhancing integrating retention and use of the registers of radioactive waste and of spent fuel in one nationwide system of collection and retention of data on radioactive waste and spent fuel.**

4. CONCEPTS, PLANS AND TECHNICAL SOLUTIONS FOR SPENT FUEL AND RADIOACTIVE WASTE MANAGEMENT

Bulgaria position

The main source and background for the review team to review of the Bulgarian solutions (operational or planned) on management of spent fuel and radioactive waste was presented in the ARM.

The plans and technical solutions for spent fuel and radioactive waste management at the sites of the main operators are outlined in the National Strategy. The National Strategy sets out the options until 2030 for radioactive waste management by reflecting the Bulgarian priorities and available resources and is based on knowledge of the waste to be managed now and in the future (as in table in chapter 2). The concepts, plans and technical solutions for processing of radioactive waste are based on the characteristics of the waste and of the demands imposed by the different steps in its lifecycle (pre-treatment, treatment, conditioning, transport, storage and disposal).

The management of radioactive waste is carried out by SERAW and KNPP manages its spent fuel and the operational waste until it is transferred to SERAW.

Uranium mining in Bulgaria ended in 1992 and the remediation of those closed uranium mining and processing sites has started. This task has been delegated to Ecoengineering-RM EOOD. The scope of work includes remediation activities, as well as monitoring. Three tailings ponds – Buchovo-1, Buchovo-2 and Eleshnitsa – are partially re-cultivated. Purification of uranium contaminated ore waters is carried out on the "Chora", "Byalata voda" and "Iskra".

4.1. SE RAW

SE RAW's waste management activities are structured into four specialised divisions that are set up at the following nuclear installations:

- Radioactive Waste-Kozloduy;
- Decommissioning of Units 1-4;
- Storage Facility-Novi Han;
- National Disposal Facility of Radioactive Waste (under construction).

In addition to those facilities, SERAW plans a geological disposal facility for high level, long-lived RAW and SF declared as a waste (radioactive waste classification 2b and 3).

4.1.1. Radioactive Waste-Kozloduy

RAW from the KNPP is being stored on site. It is treated and processed by State Enterprise-Radioactive Waste (SERAW) at the plant. In 2005 at the KNPP site was constructed SP RAO-Kozloduy facility for the management of RAW from the KNPP (current generation and 'historically' accumulated in storage facilities), and also from the decommissioning of Units 1-4. This facility consists of several facilities:

- Solid and liquid RAW processing facility;
- Warehouse for storing conditioned RAW packed in ferro-concrete containers;
- Varovo Stopanstvo site – with storage units for the temporary storage of pre-treated and untreated RAW;
- Extraction Base for the production of ferro-concrete containers.

Compactable solid RAW are compacted with the volume reduction ratio of seven. Solid uncompactable waste is collected in 200-litre drums without further processing. In some cases metallic RAW is treated and released from regulatory control for recycling or reuse.

Liquid RAW volume is reduced by evaporation. For the conditioning of solid and liquid RAW a cement encapsulation process is used.

RAW conditioned for disposal is stored in ferro-concrete containers. Conditioned RAW from the KNPP is transferred to a temporary storage facility.

4.1.2. Decommissioning of Units 1-4

Waste from the decommissioning of Units 1-4 of the KNPP is stored in two RAW storage facilities, two landfill areas and in liquid RAW storage facilities. For the conditioning of solid RAW – from the decommissioning activities, but also for historical waste – a plasma incineration installation (PII) is constructed and designed to process all combustible waste with a high volume reduction factor. It is planned that the PII will be put into operation in 2018. The rest of the solid RAW, for which the treatment in PII is not viable, is planned to be processed using available alternative technologies.

A large part of the metallic radioactive materials, from the decommissioning activities, can be decontaminated. A Reduction and Decontamination Workshop (RDW) was built for the decontamination of metallic RAW (metals) to release levels. The available technologies for decontamination of RDW are as follows: mechanical - with metallic dropping, water blasting cabin and cable peeling machine, and chemical - electro-chemical and ultrasonic.

Wet solid RAW include: the solidified phase of the liquid waste in the spent fuel pools (SFP), the spent ion exchange resins and sludges and sediments. Method of treatment for these wet solid RAW has yet to be implemented.

4.1.3. Storage Facility-Novi Han

The Novi Han storage facility accepts RAW from nuclear applications, including disused sealed radioactive sources (DSRS). The types of waste to be managed cover a wide range of physical, chemical and radioactive characteristics.

SE RAW - Novi Han operates facilities for receiving and storing low and intermediate-level RAW from nuclear applications, as well as transfer of this waste to the site of the facility.

At the site of Novi Han, the radioactive waste treatment and conditioning activities, as well as their preparation for storage, are carried out in "Acceptance-preparatory and Laboratory Complex" (APLC) and "Hot Cell" (HC). APLC includes a physical and radiochemical laboratory. There are specialized workplaces in APLC equipped with radiochemical chambers for treatment of low-level RAW and fire detectors. Liquid radioactive waste treatment system is also located in the APLC. Purification of liquid radioactive waste is achieved by prefiltration, ultrafiltration, zeolite sorption, ion exchange treatment and/or vacuum evaporation. There is also an abrasive decontamination system, a compression system, a solid and liquid RAW cementing system. A hot chamber is designed for inbound control, treatment and characterization of DSRS. Temporary storage is made on 4 sites in 14 standard ISO casks and reinforced concrete casks. Site No. 2 was built for temporary storage of low and intermediate solid RAW 2a and 2b categories in concrete casks (7 receptacles) and reinforced concrete containers for gamma emitters (18 receptacles), reinforced concrete cubes (171 receptacles), and reinforced concrete containers (60 receptacles).

According to the Action plan of the Strategy the decommissioning of Novi Han storage facility commences in 2025.

4.1.4. National Disposal Facility of Radioactive Waste (under construction)

The construction of a National Disposal Facility for Low and Intermediate Radioactive Waste (NDF) (classification 2a) is on-going. The site selection process for the NDF was completed in 2012 and in 2017 the NRA issued the permit for constructing the first stage of the facility. It is planned that the construction of this first stage will be completed by 2021.

The multi-barrier engineering facility is of a modular type, which will allow for a staged construction of individual elements and a gradual increase in capacity. NDF will take RAW from the operation and decommissioning of KNPP, RAW from possible new nuclear unit and RAW from nuclear applications that meet the NDF waste acceptance criteria.

The construction of the second stage will be carried out in parallel with the operation of the first stage. The operation of the NDF should continue for 60 years. The period of institutional control will run for 300 years, after which the site will be released.

4.1.5. Geological disposal facility (planned)

A geological disposal facility is accepted as the most appropriate long-term management solution for Bulgaria's high level, long-lived RAW and SF declared as a waste (radioactive waste classification 2b and 3). A programme for research of the possibilities for construction of deep geological disposal facility for disposal of HLW and long lived LILW, category 2b was therefore set up. The programme envisages the approval of a methodology for determining the amount and quantity of the products (the inventory) from SF processing subject to return into the country. At this initial stage of the programme a preliminary screening assessment of the territory of Bulgaria has been conducted. A general map has been prepared, indicating five potential areas whose characteristics best meet the preferred natural conditions and requirements. Six potential geological blocks have been localised, which can be examined in further detail.

In parallel, SERAW participates in projects that are investigating possible joint international solutions for the disposal of these types of waste as part of a dual track approach.

Anticipating the forthcoming decommissioning of Novi Han facility, Bulgaria considers DSRS borehole disposal as an option for the disposal of those DSRS that cannot be disposed of in the NDF. Another disposal route for DSRS is co-disposal in the geological disposal facility for SF and HLW.

4.2. Kozloduy Nuclear Power Plant (KNPP)

RAW and SF management activities undertaken by KNPP concern the operational waste and spent fuel until they are transferred to SERAW. RAW management activities by the KNPP include the collection, sorting, pre-treatment and temporary storage of primary solid and liquid RAW. These activities are carried out at the power plant site.

4.2.1. KNPP operational waste

KNPP's operational waste consists of:

- Radioactive concentrate (liquid waste): The radioactive concentrate obtained after evaporation is stored in tanks located in KNPP. Since 2005, the concentrate is periodically pumped from the tanks and piped through a pipeline to the SE RAW for treatment and conditioning. Prior to transferring the concentrate to the SE RAW its compliance with the acceptance criteria for treatment is checked;
- Spent sorbents: no method for their treatment and conditioning has yet been implemented;
- Sludges: a method for their extraction, treatment and conditioning is under development;

- Solid RAW: This is mainly waste of low and medium activity (2a category). Depending on the subsequent treatment methods, the solid RAW at the point of generation is divided into: compressible, non-metallic non-compressible and metallic.

Solid RAW generated from the operation of Units 5 and 6 of the KNPP and SFP is handed over directly for processing to the SE RAW.

The RAW storage facilities at the nuclear power plant by design are two types:

- bunker storage facilities for solid waste and
- corrosion-resistant steel tanks each located in a separate ferro-concrete installation.

4.2.2. Spent fuel

The SNF generated from the operation of the KNPP is managed solely by the plant. Spent fuel is stored at the KNPP for at least three years in the reactor SFPs. An independent 'wet' Repository for Spent Nuclear Fuel has been constructed and is operating at the KNPP site. The Dry Spent Fuel Storage Facility for spent nuclear fuel from WWER-440 has been in operation since 2012. Repository for dry storage allows SF to be stored for a 50-year period.

Bulgaria transports the SF abroad for storage and processing. The HLW returned from the processing of SF will be in a form suitable for long-term storage and final disposal. The returned HLW containers will be stored in interim long-term storage facility for HLW and long lived LILW containers on KNPP site which is to be commissioned by 2025. This facility will also be used for the storage of high-activity DSRS.

ARTEMIS observation

The Review Team observed that SE RAW activities are related to collecting, handling, pre-treatment and treatment, conditioning, storage and disposal of RAW, including decommissioning of radioactive waste management facilities. An integrated management system is being applied effectively for the wastes that are currently managed.

In the near future SE RAW will decommission historical RAW storage facilities at Novi Han. Currently, there are uncertainties related to waste characterization stored within these facilities (see chapter 3). The integrated management system will therefore need to cope with this uncertainty when developing the safety case(s) for the next stages of RAW management including treatment and disposal.

The Strategy considers the management of NORM at closed uranium mining and processing sites as an existing exposure situation. Therefore, no specific technical concepts and plans for management of NORM at closed uranium mining and processing sites as waste were presented to the review team.

The Review Team observed that no plans for the processing (treatment and conditioning) of spent sorbents and sludges from KNPP have been developed.

The Review Team observed that an important milestone in the management of the SF from the Units 5 and 6 of the KNPP is the decision on the construction of new Dry Spent Fuel Storage Facility for WWER-1000 fuel. The transfer of WWER-440 fuel into existing dry storage, will free up long term storage capacity for spent WWER-1000 fuel from KNPP units 5 and 6 before shipment for reprocessing abroad. Without reprocessing abroad, the wet spent fuel storage facility will be filled up before 2030. During discussions with the Counterparts, it was apparent, that the minimum required time for establishing the new dry storage facility is estimated to be in the order of 8-10 years from project initiation to start of operations.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *The Strategy does not state a treatment and conditioning method for spent sorbents and sludges from KNPP.*	
(1)	**BASIS: GSR Part 5 Requirement 10, para. 4.13 states that** *"The main purpose of processing radioactive waste is to enhance safety by producing a waste form, packaged or unpackaged, that fulfils the acceptance criteria for safe processing, transport, storage and disposal of the waste. Waste has to be rendered into a safe and passive form for storage or disposal as soon as possible. The processing of radioactive waste can yield effluent that is suitable for authorized discharge or material that is suitable for authorized use or clearance from regulatory control."*
(2)	**SF-1 Principle 7, para. 3.29 states that** *"Radioactive waste must be managed in such a way as to avoid imposing an undue burden on future generations; that is, the generations that produce the waste have to seek and apply safe, practicable and environmentally acceptable solutions for its long term management. The generation of radioactive waste must be kept to the minimum practicable level by means of appropriate design measures and procedures, such as the recycling and reuse of material."*
(3)	**GSR Part 1 Requirement 2, para. 2.30 states that** *"Radioactive waste generated in facilities and activities shall be managed in an integrated, systematic manner up to its disposal. The interdependencies of the steps in the entire management process for radioactive waste, and likewise for spent fuel, shall be recognized."*
S3	**Suggestion: Licensees should consider planning the processing the spent sorbents and sludges from KNPP as soon as reasonably possible.**

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *According to the Strategy, a dry Spent Fuel Storage Facility is needed by 2030 to ensure sufficient storage space for SF. Given the long time period for licensing such a facility, the implementation of this facility needs to start by 2022.*	
(1)	**BASIS: GSR Part 1 Requirement 2, para. 2.30 states that** *"Radioactive waste generated in facilities and activities shall be managed in an integrated, systematic manner up to its disposal. The interdependencies of the steps in the entire management process for radioactive waste, and likewise for spent fuel, shall be recognized."*
S4	**Suggestion: The Government should consider making decision regarding Dry Spent Fuel Storage Facility for SF from Units 5 and 6 of the KNPP as soon as possible.**

5. SAFETY CASE AND SAFETY ASSESSMENT OF RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT ACTIVITIES AND FACILITIES

Bulgaria position

The demonstration of safety is an essential part of the licensing process for each step of the lifecycle of facilities and activities related to SF and RAW in Bulgaria.

The process for the demonstration of safety is established in the Bulgarian legislation. According to the existing regulation, a Safety Analysis Report (SAR) shall be developed together with the facility or activity and it becomes the basis for the decisions related to the issuance of licences for the different stages in the development process of such facilities or activities. Also, according to the regulation, a Safety Assessment (equivalent to Safety Case in Bulgarian legislation) is an essential part of the SAR. The safety assessment shall include, without being limited to, a systematic analysis of all radiation hazards in order to prove the capability of the facility to ensure safety in normal operation of the facility as well as in the case of anticipated operational occurrences and design basis accidents.

The Act on the Safe Use of Nuclear Energy (ASUNE) stipulates the stages that require authorisation in the lifetime of a nuclear facility. Also, according to the ASUNE, any SF and RAW management facility in Bulgaria is considered a nuclear facility. The authorisation stages and the method for authorisation are:

- A permit is required to begin the site selection process. Afterwards, an order for the approval of the selected site is granted;
- A permit is also required for the design phase. And afterwards the design is authorised by way of an order for the approval of the technical design of the facility;
- A construction permit is required to begin construction;
- A commissioning permit is required for commissioning of the facility;
- To start operations, an operation licence is required that has a validity period of 10 years, and
- A licence is also required for the decommissioning phase, or closure in the case of a disposal facility.

Safety Analysis Reports, which contain Safety Assessments, are required in three of these authorisation stages:

- A Preliminary SAR (PSAR) for the approval of the selected site;
- An Intermediate SAR (ISAR) for the approval of the design of the nuclear facility, and
- A Final SAR for issuance of an operating licence.

Authorisations can only be granted by the Bulgarian Nuclear Regulatory Agency (BNRA).

Regarding the periodicity of the elaboration or updating of the safety assessment, the ASUNE requires that a Periodic Safety Review (PSR) be performed at least every 10 years during the operation or decommissioning of the nuclear facilities, and that the results of the PSR shall be reflected in the updated version of the SAR for the facility. Also, the licencee is obliged to update the respective safety assessment in case of significant modifications related to safety of the facility or to its operating procedures, and also to reflect the information on operational experience, or to include information about accidents.

The SAR (Intermediate SAR, specifically) should also be updated according to the results obtained during the commissioning stage of the facility to produce the Final SAR which shall be submitted for the application of the operating licence.

Additionally, updates of the SAR for the facilities are carried out annually by the KNPP and by the State Enterprise "Radioactive Waste" (SE RAW).

Other concepts and requirements of safety assessments considered under the Bulgarian regulation are the following. The concept of defence in-depth is taken into consideration in the safety of SF and RAW management facilities where it is to be implemented in the design, commissioning, operation and decommissioning stages. Deterministic and probabilistic assessments, where appropriate, are to be applied in the development of the safety analyses.

In the particular case of the NDF for LILW, the safety analysis was developed by using ISAM methodology and based on the completed assessments of the normal system evolution scenarios as well as the probable alternative evolution scenarios

Waste acceptance criteria shall be provided by the licencee as part of the safety demonstration. In the case of disposal facilities, it is required to include in the SAR a plan for the closure and post-closure monitoring and safety assessments of the facility both for operation and after closure periods. All models, computer codes, and input data for the performance of the safety analysis shall be verified, validated and also evaluated to confirm their applicability to the cases analysed.

As well, independent reviews have to be organised by the licencee in the SAR development process for verification purposes. In the case of the NDF, two reviews were conducted: one by a consultant contracted by SE RAW and another by a consultant working for the BNRA.

Also of note is that the Bulgarian regulation considers the application of a graded approach scheme to the development of safety assessments, in which the requirements and the extent of the regulatory control applied are commensurate to the radiation risk associated with the facility or activity.

Process of safety demonstration (based on the NDF facility on Radiana site) – key reported example

During the site selection process, the demonstration is reported in the PSAR and consists of a number of documents that include:

- the development of the disposal concept and the activities performed for the site selection (criteria). At this stage, preliminary waste acceptance criteria are also developed, the radionuclides inventory is defined and forecasts for the required financial resources are established. A check of the compliance with the national and international legal requirements/standards is performed. The prospective sites have to meet general requirements regarding favourable geological structure contributing to the isolation and the confinement properties, including low water flow and with low tectonic and seismic activity. Processes occurring at the surface of the facility (e.g.; erosion) should not affect the ability of the disposal system to perform its main safety functions. The urban infrastructure (roads) in the vicinity of the facility is also taken into account. The site selected should be amenable to a simple and reliable mathematical modelling.
- the characterisation of the preferred sites. This characterisation relies on seismic analysis, geodetic measurements, geotectonic and geomorphological observations, experimental-methodological research in order to demonstrate the acceptability of sites for construction of the NDF, the conductions of engineering geological hydrogeological and geophysical explorations, etc.

- the confirmation of the site which is based on a comparison of the proposed sites from nuclear safety and radiation protection point of view, on-site monitoring programs of the environment and the decision on the EIA conducted under the Environmental Protection Act.

The approval of the site by the BNRA chairman is based on the outcomes of the PSAR and the Environmental Protection Act Report. Therefore, non-radiological and radiological aspects are taken into account.

During the design and the construction process, the safety demonstration is done through a Technical Specification and Design Basis Report setting the frame for the required design of the facility and then, the ISAR. In the particular case of the NDF, six different layouts were first sketched out and after a detailed evaluation, two of them were retained for further assessment based on multi-attribute analysis. This analysis takes into account the safety and security; the structural integrity and stability; the environmental impact; the system robustness; the simplicity of deployment and the cost and implementation time.

During the construction phase, special attention is given to the compliance of the construction works with the quality levels requirements of the SSCs. Should any deviation from the approved design occur, the change can be only admitted if there is no negative impact.

During operation, the safety demonstration is done in the frame of FSAR and renewed every 10 years. A complete safety assessment taking into account the operational history has to be done and updated. The facility has still to be responsive to the safety objectives and requirements.

ARTEMIS observation

Based on the ARM information that described the supporting legal framework for safety demonstration and the detailed process as applied to the safety analysis for the NDF, the ARTEMIS Review Team evaluated the way in which safety demonstration of facilities and activities related to SF management and RAW management are performed in Bulgaria.

Additional information was later provided by BNRA that included more detail of the legal and regulatory framework in this area and by the KNPP that offered information on the update of the Safety Analysis Report (SAR) of the KNPP to implement the changes introduced by the Plant Life Extension project and on the structure of the SARs developed for the Spent Fuel Storage Facility and for the Dry Spent Fuel Storage Facility.

Therefore the ARTEMIS Review Team could assess the following:

- The term Safety Case is not directly used in Bulgarian nuclear legislation. However, the legal framework is based on the concept of safety case development. In the Bulgarian legal framework the essential part of the authorisation process is the Safety Demonstration, which involves the safety assessment and a collection of technical, administrative and managerial arguments to support the safety of a facility or activity in order to demonstrate its compliance with legal and regulatory requirements. The Safety Assessment, as the main part of the safety demonstration, determines the potential radiological impact of the facility or activity on human health and the environment in order to ensure the Regulatory Authority that all safety requirements are met.
- To support the application for authorisation of a given facility, several safety analysis reports containing the safety assessments are required along the process, from the site selection stage until the operational stage, and those benefit from independent verification.

- The process of safety demonstration follows a graded approach, includes the application of several methodologies in order to identify and address the uncertainties, derive scenarios, perform qualification, verification and validation of computer models by using tools such as FEP (Features-Events-Processes) lists, fault tree analyses, deterministic and probabilistic assessments, and sensitivity analyses. The design of the facility is also developed and optimised with respect to the defence-in-depth principle.

The ARTEMIS Team concludes that the process to perform safety demonstration of the facilities, in the cases that were presented, follow in a comprehensive way the guidelines stipulated in the IAEA General Safety Requirements and Safety Standards.

6. COST ESTIMATES AND FINANCING OF RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT

Bulgaria position

The costs for managing the RAW and SF from the KNPP are paid directly from the company's budget. This includes costs for storing, transporting and reprocessing spent fuel and collecting, sorting, processing, storing and transporting the radioactive waste, until it is transferred to SERAW. These costs are included in the electricity price.

Long-term liabilities related to the decommissioning of the nuclear power plants and the management of the radioactive waste by SERAW are covered by 2 funds:

- the Decommissioning Fund (DF)
- the Radioactive Waste Fund (RAW fund)

The DF covers the costs for decommissioning the KNPP: Units 1 – 4, which are already shut down and being decommissioned and the future decommissioning of Units 5 and 6 who are still in operation. The financing of the decommissioning of Units 1 – 4 is supported by the "Kozloduy International Decommissioning Support Fund (KIDSF)", a fund established to manage aid released by the European Commission.

The RAW fund covers the costs of radioactive waste management activities carried out be SERAW. This concerns the management of waste from the KNPP and waste from nuclear applications, including disused sealed radioactive sources and legacy waste.

The funds are accumulated in separate accounts in the National Bank of Bulgaria. Their financial management and control are exercised by the MoE, according to the provisions in ASUNE (Chapter 3 regarding the "Nuclear facilities Decommissioning Fund" and Chapter 4 regarding "Radioactive Waste Management Financing").

The cost estimate of the decommissioning of Units 1 – 4 is based on the International Structure for Decommissioning Costing (ISDC) of Nuclear Installations[1]. The evaluation of the future decommissioning costs for Units 5 and 6 is based on the comparative analyses of IAEA[2] and the OECD[3], and the existing international practices in this field.

Assessments for the decommissioning costs and the long-term liabilities for managing the RAW are developed by KNPP and SERAW respectively. The assessments are approved by the MoE. The cost estimates contain contingencies based on a risk assessment for each cost item. Sensitivity analyses have been performed to evaluate the impact of changes to parameters such as the inflation rate, rate of financial return on the assets, period for instalment collection, etc.

ARTEMIS observation

The ARTEMIS team acknowledges that the mechanisms to fund the decommissioning and radioactive waste management liabilities are in place in Bulgaria. The methods to estimate the decommissioning and radioactive waste management costs appear to be well developed following internationally applied

[1] OECD/NEA. International Structure for Decommissioning Costing (ISDC) of Nuclear Installations, NEA No. 7088.(2012).
[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Financial aspects of Decommissioning. IAEA-TECDOC-1476. (2005).
[3] OECD/NEA. Decommissioning Funding: Ethics, Implementation, Uncertainties. NEA No. 5996. (2006).

methods, such as the ISDC that follow good international practice (OECD). The estimates are subjected to the verification and approval of the MoE.

The review team commends the method followed to take account of cost uncertainties and risks. Those are incorporated in the estimated cost by applying contingencies for each aspect of the work breakdown structure. Such contingency management applies to different cost elements and sensitivity analyses are conducted to evaluate the impact of parameters such as material costs, labour costs, the inflation rate and the financial return on the funds. In addition, the review team was informed that a risk management methodology is in place.

Whilst the peer review team recognised the sound methodology used for estimating the long-term liabilities, the peer review team was informed that the cost for geological disposal was not included in the activities covered by the RAW fund. The peer review team recommended including geological disposal in the activities covered by the RAW fund.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *The RAW fund covering the waste management activities by SE RAW does not cover the cost for a geological disposal facility.*	
(1)	**BASIS: GSR Part 1 Requirement 10, para. 2.33 states that** *"Appropriate financial provision shall be made for:* *(b) Management of radioactive waste, including its storage and disposal"*
R4	**Recommendation: The Government should ensure that financial provisions for geological disposal are made.**

7. CAPACITY BUILDING FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT – EXPERTISE, TRAINING AND SKILLS

Bulgaria position

The system for preparing and qualifying staff in nuclear energy in Bulgaria follows a multi-level approach including secondary vocational education, higher education as well as initial and specialized training for specific jobs.

- The secondary vocational education for Nuclear Energy is provided either by Marie Sklodowska Curie Secondary school in Belene or the Igor Kurchatov Secondary school in Kozloduy. These schools form a good basis for continuing higher studies in nuclear energy but also allow students to work directly as operating staff in nuclear sector. Additional initiatives were undertaken regarding in particular, the RAW management at Igor Kurchatov school in Kozloduy.
- The higher education allowing to obtain undergraduate (professional bachelor and bachelor) and master's programme in nuclear power engineering energy and nuclear power technology is provided by Sofia Technical University and Sofia University St. Kliment Ohridski. The Technical University also delivers the scientific degree of "doctor" (PhD) in the field of nuclear power engineering and train the students with an emphasis on nuclear reactor operations whereas the St. Kliment Ohridski University offers training in management of nuclear fuel cycle and nuclear physics for various scientific and medical fields.
- The initial and specialized training for specific jobs/roles consists of delivering certificates to work in NPPs and positions which include ensuring or controlling nuclear safety and radiation protection at nuclear facilities. The training and qualification system is maintained in compliance with national and international standards/practices in the field. In particular, RAW and SNF management is carried out after obtaining a licence/permit in compliance with the requirements under the ASUNE. For instance, KNPP has its own 'Personnel and Education Training centre' which is an independent structural unit of KNPP and which holds a licence for specialized education. The positions related to the control of nuclear safety and radiological protection have also to fulfil requirements laid down by the "*Regulation on the conditions and procedures for the acquisition of personal qualification and on the procedures for the issuance of licences for specialised training and certificates of legal capacity for the use of nuclear energy*". These requirements include the level of education and professional experience to undertake the relevant duties, the functions related to the safe operation of the nuclear facilities that the person holding the position must perform, the minimum of knowledge in nuclear energy use, nuclear safety and radiological protection required by the function as well as the practical skills to carry out the activity.

According to ASUNE, each license holder or a holder of radioactive material (including waste) has to ensure that arrangements for the selection, education and training of its staff are adequate. Moreover, this trained staff has to be available also in the long term. Only the organizations holding a license for specialised training can deliver specialised initial and continuing training for staff engaged at nuclear facilities. In the particular case of personnel performing activities related to the control of nuclear safety or radiation protection, an individual employment license has to be issued by the NRA chairman.

In order to ensure that staff are qualified and competent, a recruitment system is applied and requires health check and work permit to work in an ionising radiation environment; psychophysiological assessment to establish the suitability of the personnel (according to a guidance of the Ministry of Health) and a professional selection to guarantee the appropriate level of education and the work experience. The

jobs description are prepared in accordance with the aforementioned regulation for acquiring professional qualification.

Except for the licenses issued by the NRA Chairman, examinations (initial, periodic or extraordinary) for staff are organised at departmental examination boards formed by areas and which lay down in internal documents, the criteria for determining the several groups of exams. The initial and some continuing trainings are conducted off-the job whereas others are conducted on-the job.

A system of curricula is developed for each job planned on the basis of training and qualification programs/sessions/requests. This system serves as a basis for individual programme for each person belonging to one of the personnel groups according to the occupied position or performed function: A and B for nuclear safety and radiation protection, C for operation and maintenance of equipment in a nuclear facility. Curricula for supporting specialized training are compiled each previous year and takes into account the results of the annual analysis of the operational experience, the changes in regulatory requirements, the changes in the nuclear facility, the feedback from deviations, incidents or accidents, the level of preparedness for emergency response/plan and the requirements related to the implementation of the state regulation under ASUNE.

In the particular case of SE RAW, the training of the personnel is carried out on the basis of research and analysis of the training needs of the staff, in compliance with the normative documents applicable to SE RAW (including the aforementioned ASUNE and Regulation for acquiring professional qualification).

Regarding the research, one direction followed is the development of procedures for characterising and sorting of the waste to take into account a.o. the interdependence between the different stages of RAW generation and management. Besides, there is a plan to expand SE RAW with a laboratory to experiment the storage of high level and medium level waste (category 2b) with the scientific support of the Bulgarian Academy of Sciences. Finally, research is also performed via international projects like Western European Nuclear Regulators Association (WENRA), European Repository Development Organisation (ERDO) and the European Decommissioning Assistance Programme (NDAP) as well as the Kozloduy International Decommissioning Support Fund (KIDSF).

The system for training and qualification of the personnel of SE RAW aims at ensuring efficient and safe management of RAW, starts from the conclusion of the employment contract and continues until the end of the career. The system consists of internal, external and mixed elements regarding their belonging to SE RAW. The internal elements carry out the functions and tasks related to the organization itself, the external elements are specialized educational institutions and training organizations holding accreditation whereas mixed elements perform knowledge verification which include, specialized state bodies like the Qualification Examination Commissions (QEC) and the Departmental Examination Committees (DEC). The QEC delivers capacity for people who carry out activities related to nuclear safety and radiation protection, on basis of which the NRA Chairman may issue a certificate of competence whereas the DEC delivers attestations for other officials, through exams.

Various types (initial, supporting, extraordinary, on the job, etc.) and forms (theoretical, practical, briefings, etc.) of training are organised together with a verification system of knowledge and skills. The verification takes place after each stage of the training and at the end, at individual stage, periodically after the expiry of certain period and on an extraordinary basis when changes in the legal framework, the organization and/or the technology of the work occur.

The overall objective of these systems is to maintain sufficient, competent and motivated staff for RAW and SNF management. The Business Plan takes into account the number of employees to be dismissed, recruited, retired and who left for other reasons, via average calculations based on data of the previous years.

As a state owned enterprise, SE RAW are underlain general budgetary restrictions, limiting the scope of long term HR management strategies to activities that are clearly defined, for instance through the action plan associated with the National Strategy.

In the particular case of NRA, maintaining sufficient human and financial resources to fulfil its responsibilities completely is a basic principle of the ASUNE. 90% of the employees have a higher education degree (Master or PhD) and 69% are civil servants. As such, the general training of the NRA employees in the form of courses and seminars is provided by the Institute for Public Administration and European Integration. A good communication with European institutions is a matter of concern and therefore, foreign languages are part of the training.

The education and training system of the staff is a part of the IMS and establishes a systematic approach to train, retrain, maintain (continuing education) and transfer the knowledge and skills. The knowledge comprises "hard" and soft skills. The first ones are twofold: legal and regulatory framework on one side and technical on the other side. Regarding the soft skills, a regulatory attitude as well as individual and collective efficiency are developed.

The Internal Examination Board confers, after exam, the full inspector's rights and obligations.

The training and education of the staff is entrusted to a dedicated unit which is also in charge of controlling the discharge of the licensees' training and qualification obligations.

The NRA makes use of the training opportunities provided by the IAEA and the Russian Joint Institute for Nuclear Research in Dubna. For some specific areas of competences of the regulatory control and in addition to its own human resources, NRA relies on external expertise coming from countries with similar facilities (e.g. IRSN for disposal facilities).

National Centre of Radiobiology and Radiation Protection (NCRRP) is the scientific organisation, based at the Medical University, which conducts research in the field of radiation protection including radiobiology, medical radiological physics, etc. allowing the development of post-graduate education for medical and non-medical specialists. NCRRP got a license for specialized education from BNRA, encompassing initial and continuous training. As a research entity, NCRRP is involved in international (e.g. IAEA) and European projects.

The number of persons qualifying through this system was reported to be decreasing resulting in a downward trend in the number of qualified applicants for specialized positions advertized in the RAW and SF insfrastructure.

For some multidisciplanry projects (e.g. NDF), external consultance is used in support the staff in place.

ARTEMIS observation

Based on the ARM and complementary information provided in the course of the mission, the Artemis Review Team observes that at a formal level, there is a comprehensive education system starting from secondary vocational education for Nuclear Energy up to the highest level at university. At present, the demand for qualified staff is met. The training policy in the several entities (BNRA, SE RAW, KNPP, NCRRP) involved in nuclear energy and RAW and SNF management as well as system of continuous training and its associated qualifications including the management of knowledge is consistently implemented. However, the Review Team observes the limitations for some institutions and in particular SE RAW, to act proactively in order to map out and develop the necessary human resources required to undertake the tasks up to 2030 and beyond as described in the National Strategy (e.g. geological disposal).

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *While the regulatory and operational infrastructure for capacity building is well developed and comprehensive in Bulgaria, the regulation on budgetary constraints for SE RAW does not allow for identification and accommodation of human resource requirements in response to actions foreseen in the Strategy as long as these actions are not finally approved.*	
(1)	**BASIS: SF-1 para 3.7. states that** *"Since radioactive waste management can span many human generations, consideration must be given to the fulfilment of the licensee's (and regulator's) responsibilities in relation to present and likely future operations. Provision must also be made for the continuity of responsibilities and the fulfilment of funding requirements in the long term".*
(2)	**GSR Part 1 Requirement 11 states that** *"The government shall make provision for building and maintaining the competence of all parties having responsibilities in relation to the safety of facilities and activities.* **para. 2.35 states that:** *The building of competence shall be required for all parties with responsibilities for the safety of facilities and activities, including authorized parties, the regulatory body and organizations providing services or expert advice on matters relating to safety. Competence shall be built, in the context of the regulatory framework for safety, by such means as:* *− Technical training;* *− Learning through academic institutions and other learning centres;* *− Research and development work.*
S5	**Suggestion: The Government should consider providing the means to allow SE RAW to explore and develop needs in competence and research regarding those actions foreseen in the Strategy which are not yet finally approved.**

APPENDIX A: TERMS OF REFERENCE

ARTEMIS Review of the Bulgarian programme for management of Spent Fuel and Radioactive Waste

Terms of Reference

1. Introduction

On 26th April 2017, Mr Latchesar Kostov, Chairman of Nuclear Regulatory Agency requested the International Atomic Energy Agency (IAEA) to organize and carry out in second quarter of 2018, an ARTEMIS Review in the framework of the obligations under Article 14.3 of the 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 (the EU Waste Directive).

2. Objective

The ARTEMIS review will provide an independent international evaluation of the Radioactive Waste and Spent Fuel Management Programme of Bulgaria, requested in line with the obligations of the EU Waste Directive.

The ARTEMIS review, organized by the Department of Nuclear Safety and Security and the Department of Nuclear Energy of the IAEA, will be performed against the relevant IAEA Safety Standards and proven international practice and experiences with the combined expertise of the international peer review team selected by the IAEA.

According to preliminary discussions, the national counterpart responsible of Bulgaria for the organization of the review mission is Ministry of Energy of the Republic of Bulgaria.

3. Scope

The ARTEMIS review will assess, as requested by the EU Waste Directive, the overall programme for the management of all types of radioactive waste and spent fuel in Bulgaria.

4. Basis for the review

As indicated earlier the ARTEMIS review will be carried out, following the draft guidelines of the ARTEMIS review service, against the relevant IAEA safety standards and proven international practice and experience.

5. Reference material

The basis for the review will encompass all documentation submitted by the national counterpart according to the draft guidelines for the ARTEMIS review service and the responses to the self-assessment questionnaire.

All documents for the purpose of the ARTEMIS review will have to be submitted in English.

6. Modus operandi

The working language of the mission will be English.

- Guidelines for ARTEMIS review service: available to Bulgaria as of May 2017
- Self-assessment: available to Bulgaria as of May 2017
- Preparatory Meeting: 20th to 21st November 2017, Sofia (2 days)
- Reception of English documents for the purpose of the review: at the latest 2 months before mission (including self-assessment responses)
- Peer review mission: 10th to 20th June 2018 (11 days)
    - Sunday: arrival of experts and their meeting
    - Monday to Friday: interviews/exchange/discussion with Counterpart(s) on the basis of preliminary analysis and drafting of recommendations and suggestions
    - Saturday-Sunday: drafting of the report (Review Team)
    - Monday: Delivery of draft report/recommendations – fact checking by Counterpart(s) and discussions
    - Tuesday: discussions – finalization of draft report
    - Wednesday: report delivery – closure
    - The National Counterpart is the Ministry of Energy of Republic of Bulgaria with contact representatives:
        - Ms. Katerina Kostadinova, Head of Division "Security in Nuclear Power", Ministry of Energy
        - Mr. Nikolay Grozev, First Secretary, Permanent Mission of the Republic of Bulgaria

7. International peer review team

The IAEA will convene a team of international experts to perform the ARTEMIS review according to the agreed Terms of Reference. The team will comprise 6 (six) qualified and recognized international experts from regulatory bodies and technical support organizations, operating and waste management organizations with experience in the safe management of radioactive waste and spent fuel and 3 IAEA staff (2 professionals and 1 administrative) from the Department of Nuclear Safety and Security, as well as the Department of Nuclear Energy, to coordinate the mission. The peer review team will be led by a Team Leader assisted by a Deputy Team Leader from the international expert team as defined in the ARTEMIS draft guidelines. The IAEA will formally inform Bulgaria regarding the composition of the proposed review team prior to conducting the mission.

The review mission may include presence of observers, upon the approval of the counterpart.

8. Reporting

The findings of the Artemis review will be documented in a final report that will contain the proceeding, the recommendations and suggestions. The report will reflect the collective views of the team members and not necessarily those of their respective organization or Member State or the IAEA.

The ARTEMIS Review Report will be delivered to the national counterpart.

9. Funding of the peer review

The peer review activities will be funded by Bulgaria. The costs for the services will be limited to the travel costs and per diem of the peer review team (external experts and IAEA staff) and external expert fees in line with IAEA Financial Regulations and Rules.

By agreeing to the Terms of Reference it is understood that Bulgaria accepts to cover the full cost of the mission, currently estimated at Euro XXX (hereinafter referred to as “the voluntary contribution”) based on the scope of the mission. Bulgaria is aware that the currently estimated cost of the mission includes 7% programme support costs.

APPENDIX B: MISSION PROGRAMME

AGENDA - ARTEMIS MISSION TO BULGARIA
10th to 20th June 2018, Sofia

Sunday, 10th June 2018; ***Hotel Vega Sofia, Dimitrov Boulevard 75***		
17:00	Team meeting *[Hotel Vega Sofia, suite]*	*Artemis Team*

Monday, 11th June 2018, ***State Enterprise "Radioactive Waste", Dimitrov Boulevard 52A (1st floor)***		
9:00 – 10:30	Opening session	
09:00 – 10:30	Opening	*Deputy Minister of Energy Mr Krasimir Parvanov*
	Introduction of ARTEMIS Team and National Counterparts	*All*
	Objectives and process of the ARTEMIS mission	*Artemis Team Leader / IAEA*
	General introductory presentation on RAW&SFM in Bulgaria	Presentations by: Ms Marina Kadreva (Chief expert, Security of power Supply and Crisis Management Directorate, MoE) Ms Yuliya Dimitriva (Executive Secretary, BNRA) Mr Orlin Stoyanov (Deputy Director General, RC of NCRRP) Ms Katerina Kostadinova (Chief Expert Radiation protection, KNPP) Mr Georgi Razlozhki (Deputy Director, SE RAW)
10:30 – 18:00	**Session 1.** National Policy & Framework & **Session 2.** National Strategy	
10:30 – 11:15	Presentation on National Policy & Framework	Presentation by: Ms Marina Kadreva (Chief expert, Security of power Supply and Crisis Management Directorate, MoE)

11:15 – 12:00	Presentation on National Strategy	Presentations by: Ms Atoaneta Zaycheva (Expert, Security of power Supply and Crisis Management Directorate, MoE) Mr Ivan Petrov (Chief Technology Officer at NDF)
13:00 – 14:00	***LUNCH BREAK***	
14:00 – 18:00	Session discussions	*Review Team & Counterparts*
From 18:30	*Team meeting [Hotel Vega Sofia, hall Triaditsa]*	*Artemis Team*

Tuesday, 12th June 2018, ***State Enterprise "Radioactive Waste", Dimitrov Boulevard 52A (1st floor)***		
9:00 – 13:00	**Session 2.** National Strategy (or both sessions ctd.)	
09:00 – 13:00	Session discussions – ctd.	*Review Team & Counterparts*
13:00 – 14:00	***LUNCH BREAK***	
14:00 – 18:00	**Session 3.** Inventory	
14:00 – 14:45	Presentation on Inventory by National Counterparts	Presentations by: Ms Valentina Stancheva (KNPP) Mr Nikolay Ivanov (KNPP) Ms Maya Pavlova (SE RAW) Ms Evgeniya Hristova and Mr Plamen Bekyarov (SE RAW) Clarifications on the NORM by: Mr Nikolay Todorov (Head of division "Radiation protection of SIR"; BNRA) Mr Misho Monev (Head of Nuclear Safety Department, KNPP)
14:45 – 18:00	Session discussions	*Review Team & Counterparts*
From 18:30	*Team meeting [Hotel Vega Sofia, hall Triaditsa]*	*Artemis Team*

Wednesday, 13th June 2018, ***State Enterprise "Radioactive Waste", Dimitrov Boulevard 52A (1st floor)***		
9:00 – 13:00	**Session 4.** Concepts, plans and technical solutions	
09:00 – 09:45	Presentation on Concepts, plans and technical solutions	*Presentations by:* Mr Nikolay Ivanov (KNPP) Mr Georgi Razlozhki (Deputy Director, SE RAW) Mr Rumen Shishkov (SE RAW) Mr Avgustin Naydenov and Mr Nikolay Nikolaev (SE RAW)
09:45 – 13:00	Session discussions	*Review Team & Counterparts*
13:00 – 14:00	***LUNCH BREAK***	
14:00 – 18:00	**Session 5.** Safety case and safety assessment	
14:00 – 14:45	Presentation on Safety case and safety assessment	*Presentations by:* Ms Pepa Stoyanova-Todorova (State Inspector, BNRA) Mr Svetoslav Naydenov, Head of group"license documentation" (KNPP) Mr Ivan Petrov (Chief Technology Officer at NDF)
14:45 – 18:00	Session discussions	*Review Team & Counterparts*
From 18:30	*Team meeting [Hotel Vega Sofia, hall Triaditsa]*	*Artemis Team*

Thursday, 14th June 2018, ***State Enterprise "Radioactive Waste", Dimitrov Boulevard 52A (1st floor)***		
9:00 – 13:00	**Session 6.** Cost estimates and financing	
09:00 – 09:45	Presentation on Cost estimates and financing	*Presentations by:* Ms Margarita Korkinova (Deputy Executive Director of Finance, Administration and Security, SE RAW) and Ms Galya Simeonova, Head of International Projects Division, SE RAW) Ms Siyka Penkova (Head of Financial Resources Division, KNPP)
09:45 – 13:00	Session discussions	*Review Team & Counterparts*
13:00 – 14:00	***LUNCH BREAK***	
14:00 – 18:00	**Session 7.** Capacity building	
14:00 – 14:45	Presentation on Capacity building	*Presentations by:* Mr Lubomir Pironkov (Head of "Staff and Training-Training Center", KNPP) Ms Maya Ignatova (Head of HR Section) and Ms Zhulieta Tosheva (Head of HR Section, SE RAW) Ms Galina Makedonska (Deputy Director of NCRRP) and Ms Kremena Ivanova (Head of radiation Expertise and Radon Monitoring Laboratory, Ministry of Health)
14:45 – 18:00	Session discussions	*Review Team & Counterparts*
18:15 – 19:30	*Team meeting [Hotel Vega Sofia, hall Triaditsa]*	*Artemis Team*

Friday, 15th June 2018		
09:30 – 13:00	Team meeting *[Hotel Vega Sofia]*	*Artemis Team*
14:00 – 18:00	Presentation & Discussion on Recommendations, Suggestions and Good Practices ***[SE RAW]***	*All participants*
From 18:30	*Team meeting [Hotel Vega Sofia, suite]*	*Artemis Team*

Saturday & Sunday, 16th – 17th June 2018, ***Hotel Vega Sofia, Dimitrov Boulevard 75, hall Triaditsa***		
Saturday	Drafting report	*Artemis Team*
Sunday	Drafting report & submission to National Counterparts for Fact Checking	*Artemis Team*

Monday, 18th June 2018, ***State Enterprise "Radioactive Waste", Dimitrov Boulevard 52A (1st floor)***		
09:00 – 14:00	Fact-checking of draft report by National Counterparts	*National Counterparts*
14:00 – 18:00	Discussion on the draft report	*All participants*
From 18:30	*Team meeting [Hotel Vega Sofia, hall Triaditsa]*	*Artemis Team*

Tuesday, 19th June 2018, ***Hotel Vega Sofia, Dimitrov Boulevard 75, hall Triaditsa***		
09:00 – 13:00	Team meeting – finalizing draft report	*Artemis Team*
13:00 – 14:00	***LUNCH BREAK***	
From 14:00	Team meeting – ctd.	*Artemis Team*

Wednesday, 20th June 2018, ***State Enterprise "Radioactive Waste", Dimitrov Boulevard 52A (1st floor)***		
Closure meeting		
09:00 – 12:00	Presentation of ARTEMIS Outcomes	*Artemis Team Leader*
	Closing remarks on behalf of National Counterparts	*Deputy Minister of Energy Mr Krasimir Parvanov*
	Closing remarks on behalf of IAEA	*Mr Peter Johnston, Director of Radiation, Transport and Waste Safety Division (IAEA)*

APPENDIX C: RECOMMENDATIONS AND SUGGESTIONS

Area		R:Recommendations S: Suggestions G: Good Practices	Recommendations, Suggestions or Good Practices
1.	**NATIONAL POLICY AND FRAMEWORK FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT**	S1	The Government should consider to enhance its statement of intent regarding the safety of SF and RAW management, through compilation of all elements of the policy on RAW and SF management in a single statement, to provide a position on the preferred options and endpoints as a clear basis for establishing a National Strategy for the management of SF and RAW.
2.	**NATIONAL STRATEGY FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT**	R1	For the next update of the National Strategy the Government should provide further detail on how overarching policy objectives on safety of radioactive waste and spent fuel management and sustainable nuclear energy are supported. The strategic priorities should be outlined and the programme should address uncertainties such as the timeframe for implementing geological disposal.
		R2	The Government should avoid limiting the timeframe for the National Strategy to 2030 and should include long-term milestones and schedules that will consider the policy requirements, planning assumptions, strategic preferences and contingencies for the entire programme lifecycle.
		R3	The Government should define the interim targets that support achievement of the policy end-states and goals as set out in the National Strategy.
3.	**INVENTORY OF SPENT FUEL AND RADIOACTIVE WASTE**	S2	To support completeness of the collected information and to ensure equal quality of collected and recorded data on radioactive waste and spent fuel inventory, the Government should consider enhancing

Area		R:Recommendations S: Suggestions G: Good Practices	Recommendations, Suggestions or Good Practices
			integrating retention and use of the registers of radioactive waste and of spent fuel in one nationwide system of collection and retention of data on radioactive waste and spent fuel.
4.	**CONCEPTS, PLANS AND TECHNICAL SOLUTIONS FOR SPENT FUEL AND RADIOACTIVE WASTE MANAGEMENT**	S3	Licensees should consider planning the processing the spent sorbents and sludges from KNPP as soon as reasonably possible.
		S4	The Government should consider making decision regarding Dry Spent Fuel Storage Facility for SNF from Units 5 and 6 of the KNPP as soon as possible.
6.	**COST ESTIMATES AND FINANCING OF RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT**	R4	The Government should ensure that financial provisions for geological disposal are made.
7.	**CAPACITY BUILDING FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT – EXPERTISE, TRAINING AND SKILLS**	S5	The Government should consider providing the means to allow SE RAW to explore and develop needs in competence and research regarding those actions foreseen in the Strategy which are not yet finally approved.

APPENDIX D: LIST OF ACRONYMS USED IN THE TEXT

ASUNE - Act on the Safe Use of Nuclear Energy

ARM – Advanced Reference Material

BNRA – Bulgarian Nuclear Regulatory Agency

CP – Comprehensive Programme for Management of Radioactive Waste

DF – Nuclear Plant Decommissioning Fund / Decommissioning Fund

DSRS – Disused Sealed Radioactive Sources

EIA – Environmental Impact Assessment

ERDO – European Repository Development Organisation

FSAR – Final Safety Analysis Report

HLW – High Level Radioactive Waste

IAEA – International Atomic Energy Agency

ISAR – Intermediate Safety Analysis Report

ISDC – International Structure for Decommissioning Costing

KIDSF – Kozloduy International Decommissioning Support Fund

KNPP – Kozloduy Nuclear Power Plant

LILW – Low and Intermediate Level Waste

MoE – Ministry of Energy

NCRRP - National Centre of Radiobiology and Radiation Protection

NDF – National Disposal Facility for LILW

NPP – Nuclear Power Plant

OECD – Organisation for Economic Co-operation and Development

PSAR – Preliminary Safety Analysis Report

RAW – Radioactive Waste

RAW Fund – Radioactive Waste Fund

RDW – Reduction and Decontamination Workshop

RM EOOD – EcoEngineering – RM, Ltd

SAR – Safety Analysis Report

SD D 1-4 Unit – Specialized Department Decommissioning 1-4 Unit of Kozloduy NPP

SD – Kozloduy – Specialized Division RAW - Kozloduy

SD PSF – Novi Han - Specialized Division Permanent Storage Facility - Novi Han

SE RAW – State Enterprise “Radioactive Waste”

SF– Spent Fuel

SFA – Spent Fuel Assemblies

SFP – Spent Fuel Pool

WENRA – Western European Nuclear Regulators Association

WWER – Water Cooled Water Moderated Energy Reactor

APPENDIX E: IAEA REFERENCE MATERIAL USED FOR THE REVIEW

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Fundamental Safety Principles, Safety Fundamentals No. SF-1, Vienna (2006).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Governmental, Legal and Regulatory Framework for Safety, General Safety Requirements No. GSR Part 1 (Rev. 1), Vienna (2016).

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Leadership and Management for Safety, General Safety Requirements No. GSR Part 2, IAEA, Vienna (2016).

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, IAEA Safety Standards Series No. GSR Part 3, IAEA, Vienna (2014).

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Assessment for Facilities and Activities, IAEA Safety Standards Series No. GSR Part 4, IAEA, Vienna (2009).

[6] INTERNATIONAL ATOMIC ENERGY AGENCY, Predisposal Management of Radioactive Waste, IAEA Safety Standards Series No. GSR Part 5, IAEA, Vienna (2009).

[7] INTERNATIONAL ATOMIC ENERGY AGENCY, Decommissioning of Facilities, IAEA Safety Standards Series No. GSR Part 6, IAEA, Vienna (2014).

[8] INTERNATIONAL ATOMIC ENERGY AGENCY, Decommissioning of Facilities, IAEA Safety Standards Series No. GSR Part 6, IAEA, Vienna (2014).

[9] INTERNATIONAL ATOMIC ENERGY AGENCY, Disposal of Radioactive Waste, IAEA Safety Standards Series No. SSR 5, IAEA, Vienna (2011).

[10] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety of Nuclear Fuel Cycle Facilities, IAEA Safety Standards Series No. NS-R-5 Rev. 1, IAEA, Vienna (2014).

[11] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Energy Basic Principles, Nuclear Energy Series, NE-BP, Vienna (2008).

[12] INTERNATIONAL ATOMIC ENERGY AGENCY, Radioactive Waste Management and Decommissioning Objectives, Nuclear Energy Series, NW-O, Vienna (2011).

[13] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Fuel Cycle Objectives, Nuclear Energy Series, NF-O, Vienna (2013).

[14] INTERNATIONAL ATOMIC ENERGY AGENCY, Policies and Strategies for Radioactive Waste Management, IAEA Nuclear Energy Series No. NW-G-1.1, IAEA, Vienna (2009).

[15] INTERNATIONAL ATOMIC ENERGY AGENCY, Policies and Strategies for the Decommissioning of Nuclear and Radiological Facilities, IAEA Nuclear Energy Series No. NW-G-2.1, IAEA, Vienna (2012).

[16] INTERNATIONAL ATOMIC ENERGY AGENCY, Policy and Strategies for Environmental Remediation, IAEA Nuclear Energy Series No. NW-G-3.1, IAEA, Vienna (2015).

[17] INTERNATIONAL ATOMIC ENERGY AGENCY, Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, IAEA International Law Series No. 1, IAEA, Vienna (2006).

[18] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Glossary – Terminology used in Nuclear Safety and Radiological Protection, IAEA, Vienna (2007).

[19] Official Journal of the European Union No. L 199/48 from 2nd Aug 2011, 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, Brussels (2011).