SPENT FUEL MANAGEMENT STRATEGY DEVELOPMENT IN BELARUS

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Abstract

Strategic analysis of the principal spent nuclear fuel management approaches is reported as they are seen for Belarus. Particular features of open and closed fuel cycles are considered and compared. The deferred decision perspectives for the nuclear fuel cycle back-end are discussed. Few available and arising options for the back-end are analyzed taking into account modern trends and technology developments in Russian Federation as the principal supplier of nuclear technologies and in other countries. Some results of feasibility evaluations of long term spent nuclear fuel storage are presented. General requirements for the storage system are formulated. Problems and perspectives concerning the reprocessing of high burnup fuel are presented in the context related to Belarussian NPP. The topic of high level waste management arising after nuclear fuel reprocessing as well as the perspectives of direct spent fuel disposal in Belarus are briefly discussed. Possible intermediate level radioactive waste management strategies including its disposal are considered in some details. Available strategic approaches for the spent fuel management in Belarus are outlined and compared. Recommendations for the national strategy and the short-term national action plan are given.

1. INTRODUCTION

Spent nuclear fuel safety and security is the important part of the national security. Nationally agreed position and plans for the spent nuclear fuel management are needed for the safe and sustainable implementation of the national nuclear power program. It provides legal evidence of the country's government intent to ensure the appropriate care of managing spent nuclear fuel safely and efficiently [1]. The basic objective of the spent fuel management strategy being developed in Belarus is to protect human health and the environment from harmful effects of ionizing radiation associated with the related activities.

2. SPENT FUEL MANAGEMENT STRATEGY

There are no spent fuel inventories in Belarus at the moment. Spent fuel of the research reactor IRT-M and transportable nuclear power plant "Pamir 630D" was transferred to Russian Federation in 2010 [2]. The first nuclear power plant in Belarus (Belarusian NPP) is under construction near Ostrovets, Grodno region, now. Its first unit is planned to put in operation in the nearest future according to the plans approved. The general contractor and designer is Russian Federation based company Atomstroyexport (JSC ASE EC). Belarusian NPP is constructed according modern AES-2006 design and has two units with WWER-1200 reactors [3]. Distinguished features of nuclear fuel to be used are higher initial enrichment and burnup compared to WWER-1000 reactors, gadolinium being used as burnable absorber, extended height of the fuel pellet stack and enlarged volume for gaseous fission products preserving the external dimensions of the fuel assembly, modified materials.

The Belarusian NPP is considered as the primarily origin of the spent nuclear fuel in Belarus in the nearest future. In this respect the corresponding strategy to manage its spent fuel is required. The prime responsibility for safety legally rests on the operating organization of the Belarusian NPP. The independent regulatory body, namely, Gosatomnadzor is established by the government of the Republic of Belarus. All

activities related to the Belarusian NPP construction and its upcoming operation including spent nuclear fuel management are aimed to manage safety effectively, to demonstrate the overall benefits of the nuclear power use and to optimize the protection for the highest reasonable safety level to be achieved. Much attention is paid to protect people and environment presently and in the future against radiation risks, all practical efforts are made to prevent nuclear and radiation accidents, all necessary arrangements are implemented for emergency preparedness.

The Republic of Belarus is a state party of international treaties relevant to the spent nuclear fuel management, to mention, the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, Convention on Nuclear Safety, Convention on the Physical Protection of Nuclear Material, Treaty on the Non-Proliferation of Nuclear Weapons, Vienna Convention on Civil Liability for Nuclear Damage. The cornerstones of the existing national legal and regulatory framework are the Atomic Energy Act, laws on radiation safety, on emergency preparedness, laws on sanitary and epidemiological well-being, on environmental protection, on environmental impact assessment and strategic environmental assessment.

The Joint Institute for Power and Nuclear Research – Sosny with the involvement of TENEX as the industry integrator of the Russian back-end technologies has developed the draft Strategy for the Belarusian NPP spent nuclear fuel management reflecting the national policy in this field. Public is actively involved in decision making. The public debates were organized to provide a broader consultation on potential health, social and environmental impact associated with the proposed draft strategy implementation. Special attention has been paid to the sustainability considerations relevant in view of the long periods of time typical for the spent fuel management [4].

One of the principal governmental obligations stated in the strategy is the establishment and improvement of an effective legal and management framework for the safety and security of the spent fuel management, including the support of the independent regulatory body.

The main principles underling the strategy are based on the IAEA Safety Fundamentals and include management of safety, justification of facilities and activities, optimization of protection, limitation of risks to individuals, protection of present and future generations, prevention of accidents, emergency preparedness and response, protective actions to reduce existing or unregulated radiation risks as defined and recommended in [1].

Stated strategic goals are achieved through practical implementation of the following tasks. Expansion of the national regulatory framework is required, especially through the development of the national technical standards in the field of the peaceful nuclear power use, under the organizational, financial, scientific and technical circumstances actual for Belarus and approved strategic directions of the national policy in the field of SNF management. Initiated legislative consolidation of the duties of all participants in the process of SNF management to be deepened and further concretized. Started processes of establishing the mechanisms for providing material and human resources and funds for the safe long term management of SNF continue. This includes the further infrastructure development required for the safe and effective SNF and arising radioactive waste handling. Distinguished part of the strategy is devoted to long term R&D activities in disciplines related to safe, environmentally acceptable, economically efficient and technically achievable spent fuel, high and medium level radioactive waste management.

Sufficient attention in the strategy is paid to security and physical protection issues as well as to the further development of the existing accounting and control system of nuclear material, radiation sources and waste both at the national and facility levels. Emergency preparedness must be ensured at all stages of spent nuclear fuel and associated radioactive waste management. Nuclear liability and insurance topics, corresponding legislation are addressed in the strategy draft. Tasks are set for the further involvement of the public and other interested parties in the process of making and revising key strategic decisions in the future when implementing strategic directions for SNF radioactive waste management. The strategic importance of international cooperation enhancement when dealing with all the issues mentioned is recognized.

Two principal distinct nuclear fuel cycle back-end strategies are generally employed in IAEA Member States. Namely, open fuel cycle, when SNF is considered to be a high level waste, and closed fuel cycle, when SNF is intended to be reprocessed to recover and recycle unused uranium and generated plutonium. It is recognized that some Member States have postponed the decision and adopted “wait and see” approach. The last option does not solve the problem of the fuel cycle back-end, but simplifies the decision making process and

allows to optimize it in accordance with the changing country specific socio-political and economic factors, expected advances in science and technology development.

The design fuel cycle strategy of the Belarusian NPP with two WWER-1200 reactors assumes four-year fuel cycle with one reloading per year. The average design burnup of unloaded fuel assemblies in the stationary mode is 55.6 MW d / kg U. The number of spent fuel assemblies (SFA) unloaded during 60 years of operation of two power units of the Belarusian NPP and the mass of the heavy metal (HM) contained is estimated according to the design as follows: having a burnup of up to 50 MW d / kg U is 1076 SFA (506 t HM), burnup from 50 to 55 MW d / kg U - 148 SFA (70 t HM), over 55 MW d / kg U - 4070 SFA (1916 t HM), thus totaling 5294 SFA with a total weight of 2492 t HM. In the future the 18 month fuel cycle is not excluded.

The Agreement between the Government of the Republic of Belarus and the Government of the Russian Federation on cooperation in the construction of a nuclear power plant on the territory of the Republic of Belarus of March 16, 2011 stipulates that nuclear fuel spent in the reactors of the Belarusian NPP units will be returned to Russian Federation for reprocessing under conditions determined by the separate Intergovernmental Agreement.

The currently preferred option for the Belarusian NPP SNF management is reprocessing in the Russian Federation with return to the Republic of Belarus of radioactive waste included in the glass-like matrix containing radionuclides of the cesium-strontium fraction, excluding long-lived radioisotopes [5].

Based on the impact assessment of the available options for the Belarusian NPP SNF management estimated within the framework of a strategic environmental assessment procedure of the possible fuel management strategies on the components of the environment, it is found preferable to reprocess the SNF from the Belarusian NPP in the Russian Federation. The option without reprocessing of the Belarusian NPP SNF has a more significant impact on the environmental components as compared with the option of SNF reprocessing [4].

Nowadays SNF storage is the dominating feature of the nuclear fuel cycle back-end. It is integral part intrinsic to both open and closed fuel cycle routes. Existing proven technologies for long term SNF and high level radioactive waste storage provide economically efficient storage of the necessary capacity [6]. Optimization of fuel transport and handling operations associated with the preparation and subsequent shipment of SNF from the Belarusian NPP for reprocessing requires a cumulative storage site with a capacity of 8 to 16 dual-purpose (transportation and storage) containers that are technologically compatible with the Belarusian NPP nuclear fuel handling system. The strategy prescribes to envisage the opportunity of expanding the cumulative storage site for the construction of an intermediate storage facility for SNF. The total number of unloaded SFA during the 60 years of Belarusian NPP operation will be about 5,300 SFA. Thus the option of long-term intermediate storage of all SNF requires the storage capacity sufficient for that amount of SFA. The storage facility based on dry container technologies is suitable both for SNF and high level waste from reprocessing long-term storage. The construction of the facility for the long-term storage of SNF and high level reprocessing waste based on container solutions will make it possible to form cost-effectively transport batches for subsequent SNF shipment to the Russian Federation. It provides logistic benefits when export SNF and import regenerated nuclear materials and the vitrified high level waste. The capacity of the intermediate storage should be chosen optimal to ensure the flexibility of the SNF, regenerated material and wastes handling. Intermediate storage sitting procedures must be accomplished during the pre-design phase.

Management of the SNF and products of its reprocessing (regenerated nuclear materials and waste) is based on the radiation equivalence principle. The amounts of the SNF imported into the Russian Federation for reprocessing and the amounts of the products and wastes returned to the Republic of Belarus must be recognized as equivalent. The methodology of determining the specific radiation equivalence criteria should be developed and approved in the framework of the negotiation process between the authorized organizations of the Republic of Belarus and the Russian Federation.

The SNF reprocessing must be started after the Russian partners confirm the technical readiness of the relevant industrial facilities and the Belarussian side makes all the necessary arrangements to take and handle arising wastes and under the conditions agreed by authorized organizations of the Republic of Belarus and the Russian Federation, including agreements on the use of the target reprocessing products. The reprocessing of SNF from the Belarusian NPP is expedient from a technical, environmental and economic point of view after resolving all the issues ensuring the long term storage of the reprocessing wastes containing the cesium-strontium fraction and its disposal in the buried subsurface structures when meeting the requirements for the

"delayed disposal" option. As an alternative strategic option for the Belarusian NPP SNF management at the present stage the long-term intermediate storage of SNF is considered with subsequent disposal in a deep geological formation.

The implementation of the governmental policy and strategy in the field of SNF management is carried out through the interaction of the dedicated state regulatory bodies on safety and nuclear power use, scientific organizations and other interested parties with clear delineation of their authorities and responsibilities.

3. CONCLUSIONS

The strategy implementation allows developing the basic elements, the organizational and legal mechanisms of the national SNF and arising wastes management system. It ensures the effective protection of the public and environment from all possible hazards caused by ionizing radiation, prevention and mitigation of the consequences of accidents at any stage of the handling of SNF and associated wastes. The consistent strategy implementation provides the fulfillment of the basic safety principles within the framework of the international obligations of the Republic of Belarus, determines mechanisms to provide human resources and financial support for the safe management of SNF of the Belarusian NPP and the arising radioactive wastes, physical protection and security of nuclear materials and the maintenance of the non-proliferation regime.

REFERENCES

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

[2] The Sixth National Report of the Republic of Belarus for the Joint Convention on the safety of spent fuel management and on the safety of radioactive waste management. - Minsk, 2017.

[3] The Seventh National Report of the Republic of Belarus under Convention on Nuclear Safety. – Minsk, 2016.

[4] ENVIRONMENTAL REPORT on the strategic environmental assessment of the draft Strategy for the management of spent nuclear fuel of the Belarusian nuclear power plant. – Minsk, 2018 (in Russian).

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Spent Fuel Reprocessing Options, IAEA-TECDOC-1587, IAEA, Vienna (2008).

[6] Storage of Spent Fuel from Power Reactors 2003 (Proc. Int. Conf. CSP-20 2003), Vienna (2003).