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

MISSION

TO

HUNGARY

Budapest, Hungary

20-29 March 2022

DEPARTMENT OF NUCLEAR SAFETY AND SECURITY
DEPARTMENT OF NUCLEAR ENERGY

IAEA

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

ARTEMIS

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IAEA ARTEMIS

REPORT OF THE

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IAEA ARTEMIS

REPORT OF THE

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

TO

HUNGARY

Mission dates: *20-29 March 2022*
Location: *Budapest, Hungary*
Organized by: *IAEA*

ARTEMIS REVIEW TEAM	
Mr David Ulfbeck	ARTEMIS Team Leader (Denmark)
Ms Linda Kumpula	Reviewer (Finland)
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Mr Bengt Hedberg	Reviewer (Sweden)
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Ms Amparo Gonzales Espartero	IAEA Deputy Team Coordinator
Ms Irene Bollozos-Semana	IAEA Admin. Assistant

IAEA-2022

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

On 3 July 2018, the Hungarian Atomic Energy Authority (HAEA) requested the IAEA to organize and carry out the Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation (ARTEMIS) peer review mission in Hungary. On 22 March 2021, the HAEA requested the IAEA to postpone the mission to the end of the first quarter of 2022 due to the COVID-19 pandemic situation.

The objective of the ARTEMIS Peer Review Service was to provide independent expert opinion and advice on the radioactive waste and spent nuclear fuel management programme in Hungary, based on the relevant IAEA Safety Standards and proven international practice and experiences, following the guidelines of the ARTEMIS review service, requested in line with 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 review was organized by the Department of Nuclear Safety and Security and the Department of Nuclear Energy, and performed by a team of five senior international experts in the field of management of spent fuel and radioactive waste, supported by IAEA staff providing coordination and administrative assistance.

Preparatory meetings were held on 1 October 2020 and again on 15 April 2021 due to the postponement of the mission. Review of the Advanced Reference Material was carried out in the first quarter of 2022. Subsequent to this, the ARTEMIS review mission was conducted from 20 to 29 March 2022.

Hungary operates four reactors at the Paks Nuclear Power Plant, and is planning to build another two reactors at the same site. Hungary also operates two research reactors for training and research as well as isotope production and uses radioactive sources in industrial, medical and research applications.

Spent fuel from Paks NPP is stored at reactor pools and at the dry storage facility on Paks site. Two disposal facilities are in operation, Radioactive Waste Treatment and Disposal Facility (RWTDF) in Püspökszilágy for institutional waste and National Radioactive Waste Repository (NRWR) in Bátaapáti for operational waste. A disposal facility is envisaged for VLLW for the future shut down and decommissioning of the four reactors at Paks NPP. Hungary is moving ahead in the development of a deep geological disposal facility for HLW.

During the ARTEMIS mission the team held discussions with the Ministry for Innovation and Technology, the Public Limited Company for Radioactive Waste Management (PURAM), Paks NPP, and the Hungarian Atomic Energy Authority. The ARTEMIS Review Team noted that Hungary has developed and implemented a comprehensive, robust and well-functioning system for maintaining and further enhancing the safety and effectiveness of spent fuel and radioactive waste management.

However, the following recommendation aimed at enhancing the safe management of spent fuel and radioactive waste in Hungary have been made:

- The Government should provide the mechanism for when and on what basis the decision shall be made on the back-end of the nuclear fuel cycle.

In addition the ARTEMIS Review Team provided the Hungarian authorities with the following five suggestions:

- HAEA should consider completing development of safety regulations for management of very low activity level radioactive waste including disposal.
- The Government should consider approving an updated national program without undue delay taking into account the Paks II NPP project, and other relevant and technical circumstances.
- PURAM should consider demonstrating the compatibility of the KBS-3V concept to the envisaged host rock by developing a preliminary safety case early in the development of the deep geological disposal facility.
- The HAEA should consider assessing and developing its resources and competences to fulfil its responsibilities related to the safety of radioactive waste and spent fuel management, in particular with regard to the development of deep geological and very low activity level radioactive waste disposal facilities.
- PURAM should consider strengthening its management system to support its activities related to the decommissioning of Paks NPP, in particular to ensure that knowledge about the facility is collected, preserved, and available for further use.

The ARTEMIS Review Team also identified one good practice:

- Implementing an exemplary safety improvement programme of an existing disposal facility based on a comprehensive comparison of different options in terms of long term safety assessment and evaluation of radiological risks to workers and the public.

In summary, the ARTEMIS Review Team considers that the Hungarian system for management of spent fuel and radioactive waste has a well-developed infrastructure, provides robustness, effectiveness and safety now and in the future. Hungary has demonstrated the commitment and ability to enhance the safety of radioactive waste and spent fuel management. In this respect, the ARTEMIS Review Team is of the opinion that the benefits of carrying out an ARTEMIS follow-up mission could be taken into consideration as an addition to the already significant efforts being made in this area.

I. INTRODUCTION

On 3 July 2018, the Hungarian Atomic Energy Authority (HAEA) requested the IAEA to organize and carry out, in 2021, the Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation (ARTEMIS) peer review mission in Hungary, as required of all EU Member States by Article 14.3 of the European 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 (hereinafter the EU Waste Directive).

On 22 March 2021, the Hungarian Atomic Energy Authority (HAEA) requested the IAEA to postpone the mission to the end of the first quarter of 2022 due to the impact of the COVID-19 international situation.

The review was performed by a team of five senior international experts in the field of decommissioning and radioactive waste and spent fuel management, from multiple IAEA Member States, with IAEA staff providing coordination and administrative support. Subsequent to a preparatory meeting in October 2020, and the receipt and review of Advanced Reference Material in December of 2021, in March 2022 the ARTEMIS Review Team evaluated the overall Hungarian strategy for the management of all types of radioactive waste and spent fuel.

II. OBJECTIVE AND SCOPE

The ARTEMIS review provided an independent international evaluation of the Radioactive Waste and Spent Fuel Management Strategy of Hungary, 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, 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.

The ARTEMIS review assessed, as requested by the EU *Waste Directive*, the overall strategy for the management of all types of radioactive waste in Hungary.

III. BASIS FOR THE REVIEW

A) PREPARATORY WORK AND IAEA REVIEW TEAM

At the request of the Government of Hungary, an on-line preparatory meeting for the ARTEMIS Review mission, was conducted on the 1st October 2020. The preparatory meeting was carried out by the appointed Team Leader Mr David Ulfbeck, the IAEA coordinator and deputy coordinator Mr Andrey Guskov and Ms Amparo Gonzales Espartero, and the team of National Counterparts led by Mr István Lázár from the Hungarian Atomic Energy Authority (HAEA), with participation of representatives of the Public Limited Company for Radioactive Waste Management (PURAM).

The ARTEMIS mission preparatory team had discussions regarding:

- the Terms of Reference for the ARTEMIS review of the Hungarian strategy to fulfil obligations from article 14(3) of the EU 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 Hungary in March 2022.

Mr István Lázár was appointed as the National Counterpart for the ARTEMIS mission and designated IAEA point of contact.

Hungary provided IAEA with the Advance Reference Material (ARM) for the review at the end of December 2021.

B) REFERENCES FOR THE REVIEW

The articles of the EU *Waste Directive*, the draft guidelines for the ARTEMIS review service and the responses to the self-assessment questionnaire were used as the basis for the review together with the ARM and materials presented during the mission and associated discussions. The complete list of IAEA publications used as the basis for this review is provided in Appendix E.

C) CONDUCT OF THE REVIEW

The initial Review Team meeting took place on Sunday, 20 March 2022 in Budapest, directed by the ARTEMIS Team Leader Mr David Ulfbeck, the ARTEMIS Team Coordinator Mr Andrey Guskov and the Deputy Team Coordinator, Ms Amparo Gonzales Espartero.

The National Counterpart Mr István Lázár was present at the initial Review Team meeting, in accordance with the ARTEMIS guidelines, and presented logistical arrangements planned for the mission.

The ARTEMIS entrance meeting was held on Monday, 21 March 2022, with the participation of the the Hungarian Atomic Energy Authority (HAEA), the Public Limited Company for Radioactive Waste Management (PURAM) senior management and staff. Opening remarks were made by Ms Andrea Beatrix Kádár President, HAEA and Mr David Ulfbeck, ARTEMIS Team Leader. Mr Mark Alföldy Boruss deputy state secretary for energy policy gave an overview of the Hungarian context.

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

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

The ARTEMIS Exit Meeting was held on Tuesday, 29 March 2022. Opening remarks were made by Ms Andrea Beatrix Kádár President, HAEA. A presentation of the results of the Review Mission was given by the ARTEMIS Team Leader Mr David Ulfbeck. Closing remarks were made on behalf of the IAEA by Ms Anna Clark, Section Head, Waste and Environmental Safety Section, Division of Radiation, Transport and Waste Safety, 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

Hungarian position

The Hungarian national policy on the management of spent fuel and radioactive waste (national policy) is presented as one document in Annex 1 to Parliament Resolution 21/2015. (V. 4.) OGY. The national policy was adopted for the first time by the Hungarian Parliament in 2015 and is according to the provisions in Act CXVI of 1996 on Atomic Energy (Atomic Act) revised every 5 years. The current version has been in effect since December 2020. Development and revision of the national policy is the task of the minister responsible for energy policy (ITM).

The policy refers to the fundamental principles of justification, of not imposing undue burdens on future generations and of waste minimization. It takes into account the interdependencies between all stages of radioactive waste and spent fuel management. It also specifies that safety in the long-term shall rely on passive features. According to the policy, the state carries the ultimate responsibility for spent fuel and radioactive waste management. Further references are made to maintaining adequate safety requirements (legal provisions), undertaking research and development and to maintaining and developing competences.

Provisions for assigning responsibilities for regulatory oversight, and for ensuring that radioactive waste and spent fuel is safely managed, also in the long term, are provided through the Atomic Act and associated decrees and regulations. The Atomic Act thus codifies fundamental principles and forms the foundations of the national policy.

Costs associated with execution of the national policy (and associated strategy) are financed through a national Central Nuclear Financial Fund (CNFF), established in accordance with the Atomic Act. Payments by licensees and the state of Hungary are to cover costs for radioactive waste and spent fuel management including storage and disposal of radioactive waste, storage of spent fuel, the back end of the nuclear fuel cycle and decommissioning of nuclear facilities. The Fund covers activities determined in the Atomic Act and is managed by the Department for Energy Management, Atomic Energy and Mining in the Ministry for Innovation and Technology.

Central elements in the national policy relate to the management of spent fuel (the back end of the fuel cycle), decommissioning of nuclear facilities and management and disposal of radioactive waste.

In Hungary spent fuel is generated from the Paks NPP, the Budapest Research Reactor and the Training Reactor at the Budapest University of Technology and Economics. Plans for new units at Paks site will lead to further generation of spent fuel.

The national policy outlines a “do and see” approach to the management of spent fuel in the back end of the fuel cycle. The open fuel cycle is the reference scenario of the back-end, but options for re-processing of spent fuel can also be considered, taking into account research and development as well as opportunities potentially becoming available through the introduction of new reactor technologies. As outlined in the strategy (national program), the “do and see” approach provides for decisions regarding spent fuel management to be made in several stages and at several points in time, in each case enabling a final decision on the back end of the fuel cycle to be made later. The Public Limited Company for Radioactive Waste Management

(PURAM) plans its activities in accordance with reference scenarios compatible with the "do and see" approach. The reference scenario for the back end of the fuel cycle is direct disposal in a deep geological disposal facility. The reference scenario is compatible with the fact that in all relevant scenarios, a deep geological disposal facility is needed. The ARTEMIS team was informed that no further systematic analysis of alternative reference scenarios was carried out as a basis for selecting direct disposal of spent fuel as the reference scenario.

Spent fuel from the Research Reactor of the Energy Research Centre (Budapest Research Reactor) and Training Reactor of the Institute of Nuclear Technology of the Budapest University of Technology and Economics (Training Reactor) may be returned to the Russian Federation within the framework of a bilateral agreement. In this case neither uranium nor plutonium or any product from processing would be returned to Hungary. Should the option not be exploited, as the bilateral agreement has expired and not yet renewed, the policy states that management and disposal of spent fuel from the Budapest research reactor and Training Reactor will take place in Hungary.

For decommissioning, the policy states that decommissioning plans shall elaborate the scheduling of decommissioning, the periods of safe enclosure, and the end state of decommissioning, taking into account the provisions of the national programme and the planned long term use of the site. The national policy on decommissioning defines no generally preferred option for decommissioning (immediate or deferred dismantling), nor a desired end state. This also applies to the Budapest Research Reactor and the Training Reactor, as well other institutional facilities.

The bulk of radioactive waste generated in Hungary is envisaged to result from operation of nuclear power plants as well as other nuclear facilities and their subsequent decommissioning. In addition, radioactive waste will be generated from institutional use.

The policy states that radioactive waste not suited for disposal in near surface landfill type facilities, shall be disposed in Hungary in surface or subsurface facilities designed to receive them. This part of the policy is already implemented through operation of the Radioactive Waste Treatment and Disposal Facility (RWTDF) in Püspökszilág and the National Radioactive Waste Repository (NRWR) at Bátaapáti. Radioactive waste generating heat in excess of 2 kW/m^3 as well as radioactive waste containing long-lived radionuclides in amounts not enabling disposal at the Püspökszilág and Bátaapáti sites is to be disposed of in a deep geological disposal facility. Similarly spent fuel declared as waste shall be disposed in a deep geological disposal facility. The national policy holds provisions for classification of radioactive waste and disposal thereof. The national policy outlines the system for classification of radioactive waste, which is further specified in Annex 12 of the Govt. decree 487/2015. Korm. (The Radiation Protection Decree).

The national policy sets the framework for defining and implementing the actions to be carried out as part of the national strategy, in which also the interdependences among all steps in the predisposal management of radioactive waste, as well as the impact of the anticipated disposal option must be taken into account. The "do and see" principle determines that PURAM, and any other organisation operating in the framework of the program, operates in accordance with a staged decision-making process. According to the "do and see" principle, implementation of the activities related to the elements of the national program is to be managed with the aim of ensuring flexibility for the longest possible time.

ARTEMIS observation

The national policy rests upon the fundamental principles for safety on the management of spent fuel and radioactive waste, and these principles are embedded in the underlying legal framework. The Hungarian policy thus provides a robust framework for ensuring responsible and safe management of spent fuel and radioactive waste. The policy is subject to regular review and update.

For heat generating and long-lived radioactive waste and spent fuel declared as radioactive waste, the policy defines disposal in a deep geological disposal facility as the ultimate end point. The approach defines a reference scenario (direct disposal of spent fuel), but provides no specific timeline for adopting a decision regarding the actual end point for management of spent fuel in Hungary. As such the national policy sets out a sequence of decisions regarding management of spent fuel but it does not specify when or how the decisions will be made.

The "do and see" approach impacts on the development of a deep geological disposal facility and in turn, on plans for management of heat generating as well as long-lived radioactive waste within the framework of the national strategy.

The approach may also affect costing and the ability to assure adequate financing in relation to siting, construction and operation of a deep geological disposal facility.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *The national policy specifies endpoints for managing all classes of radioactive waste. Pathways for managing spent fuel have been identified and decisions will be made taking into account future research and developments as well as opportunities potentially becoming available through the introduction of new technologies. As such the national policy sets out a sequence of decisions regarding management of spent fuel but it does not specify when or how the decisions will be made*	
(1)	**BASIS: GSR Part 5 Requirement 2 states that** *"[…] The national policy and strategy shall form the basis for decision making with respect to the management of radioactive waste."*
(2)	**BASIS: 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 and available resources and has to be based on knowledge of the waste to be managed (e.g. knowledge of the inventory and of waste streams) now and in the future. […]"*
R1	**Recommendation: The Government should provide the mechanism for when and on what basis the decision shall be made on the back-end of the nuclear fuel cycle.**

1.2. LEGAL, REGULATORY AND ORGANISATIONAL FRAMEWORK (PARTLY REFFERING TO IRRS)

Hungarian position

The Parliament decides about the national policy for the management of spent fuel and radioactive waste in a normative parliament resolution based on proposals made by the minister responsible for energy policy. The implementation of the provisions of the parliamentary resolutions are in part ensured through legal acts, partly through the general obligations for Hungarian state entities to comply with such normative decisions.

The responsibility for oversight of the safe use of atomic energy in Hungary is delegated to the atomic energy oversight organisation (HAEA) according to Act 114 of 2021, from 1 January 2022. The HAEA is supervised by the Parliament. Furthermore, the Act 114 of 2021 determines that the HAEA is subordinate only to the law and performs its tasks independently from other organizations. The HAEA is headed by a president and two vice-presidents. The president of the HAEA is appointed by the Prime Minister.

HAEA's responsibilities encompass all regulatory aspects related to safety of nuclear facilities and radioactive waste disposal and storage facilities. These responsibilities include licensing, inspection, review and assessment and enforcement related to all stages in the lifetime of a facility: siting, construction, commissioning, operation, modification, maintenance and termination of activities. In addition, the HAEA is responsible for regulatory tasks related to transport of radioactive and nuclear materials, safeguards, security and clearance.

General requirements for licensees subject to the Atomic Act include assuming responsibility for nuclear safety of the nuclear facility or radioactive waste disposal or storage facility in question. The licensee is also responsible for site characterization and evaluation of suitability, construction, extension, commissioning, operation, operation beyond design service life, modification, final shutdown and decommissioning of the nuclear facility and the closure of radioactive waste disposal facility.

In the Atomic Act, PURAM is designated as the organization performing tasks related to the disposal of radioactive wastes, storage of spent fuel, the back-end of the nuclear fuel cycle and decommissioning of the nuclear facilities. In these areas, PURAM tasks include:

Planning

- Proposing contents of the national policy and associated strategy (program), including conducting review every 5 years.
- Preparing medium- to long term plans for activities to be financed by the CNFF, including cost estimates and proposals for annual payments from the CNFF.

Construction

- Planning and construction of disposal and storage facility for low and intermediate activity level radioactive waste (NRWR and RWTDF)
- Construction and extension of the spent fuel interim storage facility
- Preparation of the deep geological disposal facility,
- Construction of an underground research laboratory for site selection purposes

Disposal of radioactive waste and spent fuel

- Operation and closure of the NRWR at Bataapati
- Operation and closure of the RWTDF at Püspökszilágy

- Operation of the interim storage facility for spent fuel
- Operation and closure of the deep geological disposal facility
- Transportation of radioactive waste to storage and disposal facilities

Decommissioning of nuclear facilities:

- Review of the preliminary decommissioning plans, preparation of final decommissioning plans
- Safe enclosure of nuclear facility from final shutdown until decommissioning,
- Demolition and remediation of the site of the nuclear facility

The proposals prepared by PURAM includes detailed safety, technical logistical, and economic analyses, that are presented to the Expert Committee of the CNFF, which includes representatives from relevant ministries, the HAEA, PURAM and Paks NPP as well as Paks II NPP, as the main current and future generators of spent fuel and radioactive waste in Hungary.

The Expert Committee of the CNFF is tasked to evaluate and develop a preliminary standpoint in support of decisions regarding cost estimates, payments to the CNFF, medium and long-term plans under the strategy as well as national policy and strategy. Once passed by the expert committee of the CNFF and approved by the minister, a proposal e.g., of the national policy, may be presented to the government and the parliament for approval.

ARTEMIS observation

The legal, regulatory and organizational framework in Hungary for management of radioactive waste and spent fuel is comprehensive and appropriately provides for assignment of responsibilities to licensees and assures the formal as well as effective independence of the regulatory authority, HAEA.

The framework also designates a single national entity, PURAM as responsible for all essential tasks related to storage of spent fuel, the back-end of the nuclear fuel cycle, decommissioning of nuclear facilities and radioactive waste management and disposal, within the framework of the national strategy. The ARTEMIS Review Team notes that no tasks for the back-end of the nuclear fuel cycle have been detailed for alternative scenarios.

Through participation in the Expert Committee of the CNFF, relevant ministries, authorities and licensees are involved in defining the national policy and strategy as well as decisions regarding their implementation. The ARTEMIS Review Team notes that the task and mandate of the Expert Committee of the CNFF provides for a comprehensive inclusion of the positions of ministries, authorities and licensees in the decision process regarding the national policy and strategy, and even regarding specific aspect of implementing the strategy.

The Hungarian classification system refers to activity concentration criteria compatible with operational management systems rather than long term safety. This can be correlated to the classification schemes presented in IAEA Safety Standard Series No. GSG-1 Classification of Radioactive waste. Recently a classification for radioactive waste suited for disposal in near surface landfill type facilities was introduced as part of the policy, and this subclass was later introduced in the Radiation Protection Decree. The relevant legal provisions for management and disposal for such waste have been under development since 2018.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *The Government introduced the subclass of very low activity level radioactive waste in the requirements for classification in the Radiation Protection Decree. Safety regulations for management of very low activity level waste including disposal are under development.*	
(1)	**BASIS: GSR Part 5, Requirement 3, para 3.7 states that**: *"[…] The regulatory body has to establish regulatory requirements specific to the predisposal management of radioactive waste, on the basis of national policy and legislation and with due regard to the objectives and principles set out in Section 2.*"
(2)	**BASIS: SSR-5, Requirement 2, para 3.8 states that**: "*[…] The regulatory body has to develop regulatory requirements specific to each type of disposal facility for radioactive waste, including each type that is envisaged, on the basis of national policy […]*"
S1	**Suggestion: HAEA should consider completing development of safety regulations for management of very low activity level radioactive waste including disposal.**

2. NATIONAL STRATEGY FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT

2.1 SCOPE

Hungarian position

The National Program (2016 version) describes the Hungarian national strategy for radioactive waste and spent fuel management up to around 2080. The primary goal of the program is the implementation of national principles and aims established by the national policy taking into account the current and foreseen inventory. The program presents plans and technical solutions for the management of spent fuel and radioactive waste, and details the framework for financing, as well as R&D activities related to the implementation of activities.

The National Program covers the management of all radioactive waste and spent fuel generated on the territory of Hungary, from generation to disposal including decommissioning as well as closure of facilities. The national program defines scenarios which includes alternative service lifetimes for nuclear facilities. Scenarios are selected conservatively to take into account the longest envisaged service lifetimes.

Radioactive waste and spent fuel is generated, treated, stored, disposed or planned to be disposed in several facilities in Hungary (see Figure 1):

- Paks NPP contains four operating units (Paks 1-4). The last unit will operate until 2037.
- Spent Fuel Interim Storage Facility (SFISF) operates for Paks units 1-4 at least until 2070s, and will continously be expanded to meet demands.
- The Budapest Research Reactor will operate at least until 2023.
- The Training Reactor will operate at least until 2027.
- Disposal of low and intermediate activity level radioactive waste from the Paks NPP will take place at Bátaapáti until 2080.
- Institutional radioactive waste is generated in hospitals, laboratories and industrial enterprises. Also radioactive waste from the Budapest Research Reactor and the Training Reactor are managed as institutional waste. The processing, storage and disposal of institutional radioactive waste will take place at Püspökszilágy until 2067.
- Research activities for the siting of a deep geological disposal facility hosted in the Boda Claystone Formation in the southwest Mecsek Hills are ongoing. According to the plans, the construction of the deep geological disposal facility can start in 2055 after several decades of site investigation. The commissioning of the facility is expected to take place around 2064. The disposal facility is foreseen to operate until early 2080s.
- A near surface landfill type disposal facility is in a preliminary conceptual planning phase and a geoinformatics screening of the potentially suitable sites has been started. According to plans, the facility could start its operation in 2030s.

The Paks II NPP Project for two new units (Paks 5-6) is in a construction licensing phase. The construction licence application has been submitted by Paks II Ltd. and is currently under evaluation. According to the plans, the units are expected to enter commercial service in 2030. The generated spent fuel and radioactive waste is to be integrated in the existing regime of spent fuel and radioactive waste management. The intergration will require at least expansions and/or lifetime extentions of several radioactive waste management facilities. Also new interim spent fuel storage capacity will be needed.

Small amounts of spent fuel from the Paks NPP and Budapest Research Reactor have been returned to the Soviet Union and later to the Russian Federation. The fuel was delivered subject to such conditions that any secondary waste from its processing will not be returned to Hungary. The remaining spent fuel from the Budapest Research Reactor and the Training Reactor is planned to be returned to the Russian Federation without any secondary waste from its processing returning to Hungary.

Institutional waste is generated in small quantities by each waste producer. The institutional waste is typically in the form of disused sealed sources as well as low and intermediate activity level radioactive waste from operational activities or decommissioning.

The National Program specifies the following waste management steps and responsible parties, from generation to disposal:

- All licence holders with activities leading to the production of radioactive waste, are responsible for all management steps until its transfer - including but not limited to the collection, volume reduction, conditioning, packaging - as well as ensuring that the waste handed over satisfies the relevant waste acceptance requirements.
- Transport of spent fuel and radioactive waste is provided mainly by PURAM. except for transport of spent fuel from Paks NPP to SFISF, which is provided by Paks NPP.
- The responsibility of PURAM covers the additional management steps related to radioactive waste, up to and including the final disposal and active institutional control after closure of the facilities.

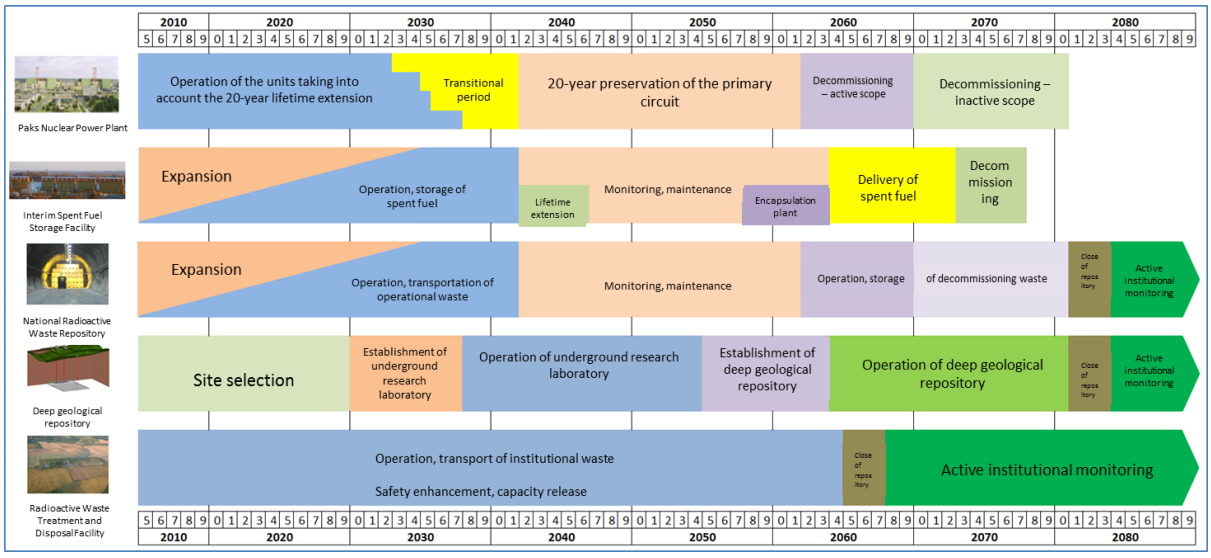

Figure 1: *The schedule of activities related to the management of spent fuel and radioactive waste generated in Paks NPP and the disposal facilities at Bátaapáti and Püspökszilágy (National Programme for Spent Nuclear Fuel and Radioative Waste management, 2016)*

According to the Article 5/C of Act CXVI of 1996 on Atomic Energy, the Government should approve an updated national program every 5 years. The development of the national program and preparation of its revisions is the responsibility of the minister for Innovation and Technology (ITM). Prior to the acceptance of the national program, it was assessed and underwent preliminary evaluation by the Expert Committee of CNFF. Opportunity was also provided under the SEA process for commenting on the programme both on the national and international level.

ARTEMIS observation

The ARTEMIS Review Team notes that the national program describes all spent fuel and radioactive waste management activities and the interactions between the activities in a comprehensive and detailed manner.

The current national program was written in 2015 and accepted by the Government in 2016. An update of the national program was envisaged to complete in 2021. The update was postponed to take into account the development of the Paks II NPP project, which is expected to have a significant effect on the updated program, and to accommodate findings from the IAEA ARTEMIS peer review in the first quarter of 2022. The ARTEMIS Review Team considers that the development of the Paks II NPP project is likely to have significant impact on the currently planned and foreseen activities in the program as well as the interdependencies between the different stages of radioactive waste and spent fuel management under the program.

The ARTEMIS review team notes that interested parties were given an opportunity to comment on the first version of the national program, as it was subject to a Strategic Environmental Assessment (SEA). It was also noted that for future updates of the national program the result of the consultation with ministry responsible for environmental issues will determine whether the update should be subject to an SEA. The ARTEMIS Review Team considers that the potential added value of allowing interested parties an opportunity to comment also on the updated version of the program should be taken into account. It is further noted that the management of institutional waste from small producers is described in general terms in the National Program. A more detailed description could serve to enhance the understanding of how this type of waste is integrated in the overall programme.

The chosen strategy for decommissioning of Paks NPP is deferred dismantling including 20-years of preservation of the primary circuit (see Figure 1), the importance of competence development and knowledge preservation in order to safely manage the facility and undertake decommissioning should be acknowledged. This aspect is addressed elsewhere in the present review.

The reference scenario for the back-end of the nuclear fuel cycle (i.e. direct disposal of the spent fuel), is the basis for cost estimates of the programme. Likewise, this is addressed elsewhere in the present review.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *Article 5/C of Act CXVI of 1996 on Atomic Energy states that Government shall approve the national program every five years. The current national program was written in 2015 and accepted by the Government in 2016. The update of the national program was postponed in order to include developments in the Paks II NPP construction licence.*	
(1)	**BASIS: GSR Part 1 (Rev. 1) Requirement 1 states that** *"The government shall establish a national policy and strategy for safety, the implementation of which shall be subject to a graded approach in accordance with national circumstances and with the radiation risks associated with facilities and activities, to achieve the fundamental safety objective and to apply the fundamental safety principles established in the Safety Fundamentals. […]"*
(2)	**BASIS: NW-G-1.1 Chapter 12 states that** *"Policies and strategies may need to be updated from time to time. The following considerations may help in structuring such updating. […]* *12.2. NEW NATIONAL CIRCUMSTANCES* *Consideration should be given to any new national, political or technical circumstances that might require amendment of the policy and strategy, for example: […]* *— The closure or opening of nuclear facilities that might create new waste streams to be managed;* *— Delays in developing waste storage/disposal facilities;* *[…]* *12.4. POLICY AND STRATEGY UPDATING* *"Based on this review, and if appropriate, changes to national policy and strategy for spent fuel management and radioactive waste management should be made."*
S2	**Suggestion: The Government should consider approving an updated national program without undue delay taking into account the Paks II project, and other relevant and technical circumstances.**

2.2 MILESTONES AND TIMEFRAMES

Hungarian position

The national program contains milestones until the end of active institutional control of the repositories and outlines milestones for the implementation of specified activities in the context of the 5-year framework as key performance indicators. The program presents a schedule of activities related to the management of spent fuel and radioactive waste from Paks NPP, decommissioning of nuclear facilities and active institutional control of waste disposal facilities (Figure 21 in the national program).

ARTEMIS observation

The ARTEMIS Review Team notes that some delay has occurred in implementation of activities. For example, the installation of the cementing technology in the treatment of radioactive waste in Paks NPP, the retrieval of the radioactive waste in the Safety Upgrading Programme in RWTDF and the implementation of the surface research to select the site for a deep geological disposal facility have all been delayed. While the delays do not yet seem to significantly affect the overall schedule for implementation of the program, such delays may over time affect the implementation of other activities due to the integrated nature of the program.

2.3 PROGRESS INDICATORS

Hungarian position

Hungary applies the milestones of the particular programme items as key performance indicators to monitor the progress of the national program. Since the national program is revised every five years, the indicators were identified for the period between 2015-2020 as shown in section 10 (Table 20) of the national program.

Between updates of the national program, PURAM prepares and revises annually medium- and long-term plan (MLTP) for activities related to spent fuel and radioactive waste management, including decommissioning, to be financed from the CNFF. PURAM reports the progress of the past period, justifies the needed changes and updates the tasks to be implemented as per the MLTP. Assessment and preliminary evaluation of the MLTP is then performed by the Expert Committee of CNFF and HAEA and subsequently sent for approval by the minister for Innovation and Technology.

ARTEMIS observation

While milestones and key performance indicators may provide information on the progress of implementation within one line of activities in the national program, the use of these milestones as indicators for progress on the scale of the entire program does not necessarily provide sufficient information to assess overall progress. For this purpose, a more integrated approach for assessing progress both at the scale of individual nuclear and waste management facilities and at the scale of the entire national program, should be considered.

3. INVENTORY OF SPENT FUEL AND RADIOACTIVE WASTE

Hungarian position

In Hungary, radioactive waste is defined in Act CXVI of 1996 on Atomic Energy as such radioactive material which is not used anymore and which cannot be managed as conventional waste because of its radiation protection characteristics. Similarly, spent fuel is defined as nuclear fuel irradiated in a nuclear reactor, which has been permanently removed from the reactor and which, because it can be recycled (reprocessed) outside the reactor, is not considered as radioactive waste or, if it is not to be reprocessed, is considered as radioactive waste and its final disposal shall be provided.

The Governmental Decree No. 487/2015 (Radiation Protection Decree) lays down the rules for the classification of radioactive waste. Radioactive waste is classified according to the activity and half-life characteristics of the material.

High activity level radioactive waste is radioactive waste for which the heat production shall be taken into account during storage and disposal. Radioactive waste producing more than 2 kW/m^3 of heat or with a total activity content correponding to Category 1 in the Physical Protection decree shall always be classified as high activity level radioactive waste.

Classification of radioactive wastes as low or intermediate activity level is performed on the basis of activity concentrations and referring to the specific exemption activity concentrations. The exemption levels (general and specific exemption activity concentrations) are provided in the Radiation Protection Decree. Low and intermediate activity level radioactive waste generates sufficiently little heat to be disregarded for the purposes of storage and disposal.

Low and intermediate activity level radioactive waste can be further classified as short-lived and long-lived waste.

a) Short-lived low and intermediate activity level radioactive waste contains only a limited amount of radionuclides with half-lives exceeding 30 years as averaged over the total amount of waste.
b) Long-lived low and intermediate activity level radioactive waste contains radionuclides with half-lives exceeding 30 years in quantities exceeding the limits determined for short-lived radioactive waste.

In 2018 the Hungarian Government introduced the subclass of very low activity level radioactive waste. The subclass applies to the radioactive waste, in which the activity concentration for the isotopes with less than 30 years half-life is less than fifty times the specific exemption activity concentration, and activity concentrations for the isotopes with half-lives exceeding 30 years that do not exceed the general exemption activity concentration.

Hungarian legislation allows the release of low activity substances from regulatory control (clearance). The release from regulatory control is either based on a notification or a licencing procedure.

In the reference scenario for the back-end of the fuel cycle, spent fuel originating from Paks NPP is directly disposed in the domestic deep geological disposal facility. Considering the 50-year service life of the four units of the Paks NPP and the 60-year service life of the Paks II NPP units, the foreseen combined amount of spent fuel is nearly 5,000 t $_{HM}$. In alternative scenarios, spent fuel is reprocessed abroad and resulting vitrified high activity level radioactive waste is to be disposed of in a deep geological disposal facility. If all spent fuel was reprocessed from the Paks NPP until their final shutdown, an estimated 500 tons of such vitrified radioactive

waste would be generated. However, the type and quantity of the end products from reprocessing very much depend on the contract for the reprocessing service.

Approximately 5 m^3 of high activity level radioactive waste is generated on a yearly basis during the operation of Paks NPP. Until the end of the service life for Paks NPP (50 years) and Paks II NPP (60 years) and following their decommissioning, the generation of 519 m^3 of high activity level radioactive waste is foreseen. The operational high activity level radioactive waste is currently stored in the Paks NPP site and will be managed during decommissioning of the NPP. The waste will be re-characterized and may be re-classified at that stage for final disposal purposes. During the operation and decommissioning of the Budapest Research Reactor and the Training Reactor no high-level radioactive waste is currently expected to be generated.

The estimated amount of low- and intermediate activity level radioactive waste to be disposed of in NRWR is 87,870 m^3. For the RWTDF, the expected amount of low- and intermediate activity level radioactive waste for disposal is 5,830 m^3. Preliminary estimates suggest that more than 80% of the decommissioning wastes of the Paks NPP and 89% of the decommissioning waste of the Paks II NPP would fall into the subclass of very low activity level radioactive waste. Thus, the expected volume of very low activity level radioactive waste from decommissioning of the Paks and Paks II NPP is estimated at 54,000 m^3, out of a total estimated amout of 87,870 m^3.

Based on the analysis of waste deliveries made in the recent years, PURAM assessed that about 10-15 m^3 of radioactive waste and 400-500 disused sealed radioation sources are supplied annually by the license holders for interim storage or final disposal. RWTDF (operational until 2067), will need to accomodate storage and disposal of approximately 600 m^3 of institutional waste in addition to the quantities expected to be generated in the Budapest Research Reactor and the Training Reactor.

HAEA is responsible for establishing and maintaining a registry system for radioactive materials (RAM) and a Nuclear Material Accounting and Control system (NMAC).

RAM includes information on e.g. sealed radioactive sources, unsealed radioactive sources, other radioactive material and radioactive waste. RAM holds information from local registers of owners and holders of radioactive material.

NMAC system is based on nuclear balance areas (MBA). Hungary has 10 MBAs, which include e.g. Spent Fuel Interim Storage Facility (SFISF) and Radioactive Waste Treatment and Disposal Facility (RWTDF). The organization possessing nuclear material shall maintain a local accountancy system for nuclear materials. National registry systems serve as a basis of regulatory oversight activities.

The national program presents an inventory of all spent fuel and radioactive waste as well as estimates for future quantities, including those from decommissioning. The inventory is established by PURAM with HAEA´s contribution and using the inputs of the main spent fuel and radioactive waste producers. The national inventory presented in the advanced reference materials was compiled according to the waste classification system of 2015 and will be updated together with the National Programme in 2022.

The national inventory contains information on i) the volume of radioactive wastes per waste stream, specifying amounts already disposed in the waste repositories, ii) the conditioned waste volumes to be disposed of (m^3) per type, as well as volumes of non-conditioned wastes if possible, iii) the amount and location of spent fuel in storage.

ARTEMIS observation

The Hungarian system of classification may be correlated to the classification schemes presented in IAEA Safety Standard Series No. GSG-1 Classification of Radioactive waste, but the Hungarian classification system refers to activity concentration criteria compatible with operational management systems rather than long term safety. Nonethless the Hungarian classification system provides a consistent basis for creating a national inventory as a planning tool for current and future activities in the framework of the strategy. As such, the Hungarian classification system is suited for its purpose.

Although HAEA helped to compile the spent fuel and radioactive waste inventory established by PURAM, the radioactive materials registry system and the nuclear material accounting and control system comprises information which could be useful for further development of the inventory.

The ARTEMIS Review Team also notes that decommissioning the Budapest Research Reactor and the Training Reactor might also generate high activity level radioactive waste or and long-lived radioactive wastes which require disposal in the deep geological disposal facility.

The ARTEMIS Review Team also notes that although the inventory in the reference scenario for closing the back end of the fuel cycle (direct disposal of the spent fuel) is presented, inventory estimates corresponding to alternative scenarios are not clearly presented, and need to be updated when a decision on the back-end of the fuel cycle is made.

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

Hungarian position

Management of spent fuel

In Hungary, spent fuel is generated in three facilities: the Paks NPP, the Budapest Research Reactor and the Training Reactor.

The Budapest Research Reactor has been operating since 1959. After an upgradein 1986 operations resumed in 1992. The operational license granted in 1993 for an indefinite period and is subject to a periodic safety review every ten years. Two reviews were completed since 2003.

Currently, only low enriched fuel is in use at the Budapest Research Reactor. The spent fuel is stored in pool at the site of the Budapest Research reactor. Two such pools are in operation, the internal spent fuel storage next to the reactor and the external spent fuel storage pool outside of the building. The external storage pool is currently empty. The spent fuel elements were repatriated to the country of the manufacturer (i.e. the Russian Federation) in 2008, 2009 and 2013; the government of the United States of America provided partial financial support to implement those arrangements. The repatriation of the fuel was completed with such conditions that no secondary waste has to be accepted by Hungary; thus this amount is excluded from the national inventory. Decommissioning of the Research reactor should start in year 2023 but operation might be extended on the basis of a periodic safety assessment.

The Training Reactor is a light water moderated, pool type reactor with current licensed thermal power of 100 kW, and has been operating since 1971. Operation of the Training Reactor is planned until 2027. The Training Reactor has the technical solution needed for the movement of spent fuel within the building. The national policy states that the endpoint for spent fuel is repatriation with the condition that products of the processing remain in the Russian Federation. In harmony with the final shut-down date of the Budapest Research Reactor and the Training Reactor, the technical, legal and financing conditions of the transport have to be finalised. Should it be decided not to pursue repatriation, then it will be subject to long-term interim storage and its management has to be ensured. The concept for disposal in a deep geological disposal facility can accommodate for this approach.

Four VVER-440 type reactors operate at Paks NPP. In accordance with the initial approval of the technical design of Paks NPP, a return agreement for the spent fuel stored for three to five years in pools at the nuclear power plant was accepted by the Soviet Union. Subsequent reprocessing may take place in a way ensuring that in all products from the processing remain in the Soviet Union. Between 1989 and 1998, based on the Hungarian Soviet interstate contract, 2 331 spent fuel assemblies were repatriated. In the summer of 2014, 30 cased damaged fuel assemblies were repatriated, in four TUK6 containers, to the Russian Federation. During the service life of Paks NPP, five fresh fuel assemblies were repatriated without irradiation. Radioactive waste will not return to the territory of Hungary from the management of the above listed spent and fresh fuel repatriated to the Russian Federation.

Currently, the spent fuel assemblies, after their removal from the reactor core, are taken to spent fuel storage pools located at the reactors. After a minimal storage time determined according to the characteristics of the given assembly (enrichment, burn-up, residual thermal power), the spent fuel assemblies can be moved to the SFISF. The transportation to the SFISF is performed on rail, in C30 container (30 spent fuel assemblies at a time) in a wet environment.

The licence holder of SFISF is PURAM. The SFISF is a modular, vault type facility, which provides dry storage of the spent fuel assemblies. The storage facility is a surface building, where the assemblies are removed from water filled containers and dried with a drying machine, and then placed, one by one with the use of the refuelling machine in tightly closed steel tubes. The storage tubes are in vertical positions, in vaults surrounded by reinforced concrete walls. The reinforced concrete vaults surrounding the storage tubes provide sufficient shielding against ionizing radiation. Storage takes place under dry conditions and cooling is supplied through natural circulation of air. In the storage tubes a nitrogen gas storage environment is provided in which the pressure is continuously monitored. The facility can be extended modularly, according to the spent fuel removal needs of Paks NPP.

Currently, the licences of the of SFISF do not allow the acceptance of untight fuel assemblies identified as non-leak-tight. 8 such assemblies (as per January 1, 2020) are stored in the spent fuel pool of the nuclear power plant. Paks NPP and PURAM have elaborated jointly a concept for the management of these assemblies. The concept incorporates the vacuum drying of untight assemblies, the closure to tight cases and their placement in a container after the shut-down of the units, within the reactor hall.

Management of radioactive wastes

The PURAM is responsible for collection and further management of institutional radioactive waste in Hungary. This includes the transportation of the radioactive wastes to the RWTDF as well as management including characterization, treatment, conditioning interim storage or disposal. The operational activities were extended, as of spring 2007, with a so called safety improvement demonstration programme, in the frame of which the radioactive waste from 4 vaults were removed, segregated, conditioned and re-disposed or placed in storage if present day disposal requirements were not met. Based on the experience on the demonstration programme the larger scale safety improvement program continues.

According to present plans, the decommissioning and final closure of the RWTDF may occur after the removal of long-lived radioactive waste from the site, between about 2064-2067.

During operation of the Paks NPP solid and liquid radioactive wastes are generated, and arrangements should provide for their collection and management. The major sources of solid radioactive waste include protective clothing, equipment, tools, plastic foil becoming contaminated during operation and maintenance; as well as the contaminated or activated equipment, piping, heat insulation, etc. removed from the operating facility. In addition, solid waste such as sludge and debris, scrap metals, cables from the architectural adjustments are also managed.

The volume reduction of compactable radioactive waste takes place in a 500 kN press, during which the volume of waste treated is reduced, on the average, to one-fifth. The non-compacted radioactive waste is put in 200 litres drums, with the optimal utilization of the volume. The active sludge is settled in 200-liters metal drums and then their liquid content is removed. After the treatment steps mentioned above, the solid radioactive waste is put into interim storage on the site of the nuclear power plant.

In the operational practice of Paks NPP, radioactive waste with a surface dose rate exceeding 10 mSv/h is classified as " high level" waste. During operation of the NPP, on an annual basis relatively small quantities (5 m^3 / year) of such radioactive waste is generated, and placed in interim storage in dedicated tube wells in the reactor halls of the nuclear power plant. All low and intermediate activity level waste is disposed in the NRWR.

Small amounts of contaminated oil are collected in 200-liters metal drums, then the radioactive isotopes are removed via gravity filtration through diatomaceous earth layer, and after verification the decontaminated oils are released and treated as inactive waste.

The water-based liquid wastes produced in the NPP's primary circuit are collected by a special channel system for transfer to the drainage system. The collected drainage liquid after settling, mechanical filtration and chemical treatment is concentrated through evaporation.

The residual evaporation concentrates (evaporation residue), the spent ion exchange resins, the evaporator acid solution, and – in 200-liters drums – the oily diatomaceous earth arising from the treatment of contaminated oils are put into interim storage in the controlled zone of the NPP in separate tanks.

In order to significantly reduce the volume of liquid radioactive waste, a LRWTT was put into operation in the Paks NPP. With the operational application of this technology, the evaporation residue representing most of the liquid radioactive waste - after removal of caesium and cobalt isotopes, as well as the recovery of boric acid content - are discharged after checks to the environment, together with the other waters from the primary circuit authorized for discharge. Boric acid recovered in the form of borax is released as inactive hazardous waste for disposal. During processing, secondary radioactive waste is produced (cobalt recovery post-filter, caesium filter column, etc.), the interim storage of which takes place in 200 litre drums or special containers. Also, Paks NPP is developing a technique for cementation of liquid radioactive waste. The technique will be used for grouting steel containers with four drums of solid waste.

Clearance of solid material and waste takes place following authorization by the HAEA.

As a result of the operational incident involving damage to nuclear fuel assemblies in Unit 2 of the Paks NPP in 2003, a number of such types of waste were generated, which were not to be encountered during normal operation. In the course of the management and recovery of the emergency situations significant amounts of spent ion exchange resin, distillation residues, decontamination solution and solid radioactive waste contaminated with alpha emitting isotopes were generated. Most of these have been collected separately and put into interim storage (decontamination solution, distillation residues, large appliances, and solid waste). The LRWTT technology was not applied for the treatment of the evaporation residue affected by the incident.

Waste packages complying with the waste acceptance criteria can be disposed in the disposal facility NRWR. The waste compressed in 200 litre drums is disposed in reinforced concrete containers in the first chamber. A concrete container hosts 9 drums. Grouting of the containers is caried out with inactive cement pulp at the site of the NRWR. Currently PURAM is licensed to operate two disposal chambers. Other part of the disposal facility is under construction. Recently, PURAM in close cooperation with Paks NPP optimise disposal of radioactive waste in chambers: new steel containers and new engineering barrier (reinforced concrete vault with own geometry) were introduced as well as grouting pulp in the containers is produced using liquid radioactive waste at the site of NPP. In the former disposal concept the reinforced concrete container was a part of the engineering barrier system; its functions are now transferred to the reinforced concrete vault built in the disposal chambers. After the filling of the first vault section the empty space between the waste packages will be filled in with self-compacting inactive cement mortar till the top of the chamber wall.

Plans

The national program already includes technical solutions and concepts for management of radioactive waste of Paks II NPP as well as predictions of inventory is made. The treatment and

conditioning of the low and intermediate activity level radioactive waste produced during the operation of the new Paks II NPP units has to be provided by the operator, in compliance with the waste acceptance criteria system. In line with the expectation of the national policy that "the long-term programmes for the final disposal of radioactive waste from the new units shall be developed considering the existing facilities", the disposal of the low and intermediate activity level radioactive waste shall be solved with the extension of the NRWR. Taking into account decommissioning of Paks II NPP and decommissioning of new storage for spent nuclear fuel operation of NRWR can be expected available until 2100-2140.

The decommissioning and closure of the NRWR facility will start after the final disposal of all radioactive waste to be accepted at the site. Every technological system in the technology building as well as the building itself have to be decommissioned (generation of radioactive waste is not expected from other areas of the disposal faclity and the decommissioning of other buildings). During decommissioning, the generation of low-level radioactive waste containing mostly concrete debris and packed in 200 litre drums and thin-wall metallic container in a volume of a few tens cubic meter is assumed. For the final disposal of these wastes, reserve space has to be maintained. The disposal chambers are constructed in several stages; consequently, the entire life cycle of the repository consists of series of staged construction, operation and closure phases. The decommissioning concept plans its realization by dividing it to 6 construction stages.

The subclass of very low activity level radioactive waste has been introduced in Hungary. PURAM elaborated a preliminary technical concept for the construction of a disposal facility designed for accepting this type of waste. The technical concept plan specified the required size of the disposal facility in line with the quantity of waste to be disposed along with a schematic representation of the layout of the facility. In parallel, PURAM completed a preliminary screening to determine suitable sites for the disposal facility. Considering socio-economic factors of screening, an area in vicinity of Paks NPP is considered for selecting aa site in the future.

A final decision on the back end of the nuclear fuel cycle has not yet been made in Hungary; however, the reference scenario that provides basis for the cost estimation of the long-term activities is the direct domestic disposal of the spent fuel in a deep geological repository. Based on the research performed in the meantime, the potential depth range was extended to 500-1000 m. In the reference scenario, the spent fuel is emplaced in the disposal holes deepened in the bottom of the disposal tunnels, similarly to the Swedish KBS-3V concept.

Research and development activity regarding spent fuel and radioactive waste management

The legal background is established in the Atomic Act, which prescribes that the safe use of nuclear energy, including emergency response and the solution of the corresponding research and development (R&D) tasks shall be facilitated with the development of science and technology, coordinated management of research activities, practical application of the outcomes of domestic and international scientific researches, and training and further training of professionals. Both HAEA, PURAM and other licensees carry out their own R&D programmes to support their activities. Topics of R&D are following: regulatory oversight of the safe use of atomic energy; safety and security of the peaceful use of nuclear energy; activities associated with the operation and decommissioning of nuclear facilities; R&D activities associated with spent nuclear fuel and radioactive waste management, including R&D activities associated with investigation of geological formations of deep geological disposal facility. R&D programmes are implemented via domestic programmes as well as participation in international organizations and R&D programmes (IAEA, OECD/NEA, European Union, WENRA).

ARTEMIS observation

The ARTEMIS Review Team observed that the national policy and national program are focused on disposal of radioactive waste. Solutions and plans to implement provisions of the national policy and the national program are in place: PURAM operates SFISF, RWTDF and NRWR, optimizes and improves safety of those facilities based on safety justifications and in support of relevant research and development programmes. PURAM also implements a research and development programme to investigate the potential sites and the bed rock for deep geological disposal. PURAM has in addition started developing a concept for disposal of very low activity level radioactive waste as well as a screening process for selecting a potential site for this waste.

The team noted that the main radioactive waste producer, Paks NPP, contributes to the implementation of provisions in the national policy and the national program. The review team recognised the cooperation between Paks NPP and PURAM as regards improvements in management of liquid radioactive waste as a good example of such contributions. The review team recognized the achievement of Paks NPP in cooperation with PURAM to develop a technology for cementation of evaporation residues and grouting of radioactive waste packages suited for disposal in NRWR. The efforts resulted in a reduction of the number of packages to be disposed of and also in more effective use of the available disposal capacity. Also, Paks NPP has introduced a LRWTT in order to reduce the volume of liquid radioactive waste.

The team noted that a new subclass of radioactive waste, very low activity level waste was introduced in 2018, but that other relevant regulations for management of those waste are not established yet. Conceptual technical solutions have been developed by PURAM for disposal of those waste as well as plans for siting of a near surface disposal facility, scheduled to be commissioned in 2030. However, the team noted that Paks NPP have not yet introduced the segregated management of very low activity level waste in its operations. In this context the team emphasises the importance of predisposal management of radioactive waste taking into account the intended treatment, conditioning processes and anticipated disposal option.

The team noticed that the strategy for decommissioning of Paks NPP is deferred dismantling based on safe enclosure of the primary circuit and other contaminated systems and components for 20 years. The rationale for adoption of this strategy was discussed during the meeting. Subjects discussed included application of modern technologies for decontamination and dismantling and solutions for radioactive waste management. Some specific challenges identified related to knowledge preservation and retaining experienced staff.

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

Hungarian position

The safety of nuclear facilities (including the Paks NPP, the Budapest Research Reactor, the Training Reactor and the Spent Fuel Interim Storage Facility - SFISF), and radioactive waste storage and disposal facilities are regulated through the Government decrees 118/2011 (NSC decree) and 155/2014 (RSC decree), respectively. These decrees specify the safety objectives for the lifecycle stages of spent fuel and radioactive waste management facilities, as well as the documentation necessary to support licensing in these different stages.

The decrees state that the licensee shall submit a safety report on activities related to the operation and safety of nuclear and disposal facilities to the HAEA. For disposal facilities, the safety report shall include provisions for the post-closure phase.

In addition, the licensee shall annually or semi-annually prepare reports on nuclear safety related activities for each facility, including reports on safety related incidents. For disposal facilities, the licensee shall enclose an updated safety case relevant to the stage in the lifecycle of the facility as a basis for obtaining a facility licence. All reports must be submitted to the HAEA.

Every ten years, a periodic safety review (PSR) of each facility is performed by the HAEA, on the basis of a report prepared by the licensee aiming to assess the compliance with safety requirements for the facility. For the Spent Fuel Interim Storage Facility, the latest PSR also considered the adequacy of the Preliminary Safety Case in support of the planned extension of the storage capacity. Concerning disposal facilities, the PSR shall be performed throughout the stages in the lifecycle of the facility until entering the stage of passive institutional control.

More specifically for radioactive waste and spent fuel management activities and facilities, the following examples are mentioned in the self assessement report in the ARM:

Decommissioning Budapest Research Reactor and Training Reactor

Updates to the decommissioning plans of the Budapest Research Reactor and the Training Reactor are included in the Final Safety Analysis Reports.

Spent Fuel Interim Storage Facility

The SFISF, which has been operated by PURAM since 1997, has an operating licence for 24 storage vaults and a construction licence for 4 more vaults from the planned 9 vaults. The operational licence is supported by a Final Safety Analysis Report (FSAR), which contains the safety demonstration of the facility and includes information supporting its future decommissioning. The sections of the FSAR include descriptions of all structures, systems and components, activities and events relevant to the evaluation of the safety of the facility and its operation.

Radioactive Waste Treatment and Disposal Facility

The RWTDF was commissioned in 1976, since 1998 has been operated by PURAM. It is composed of a near-surface disposal facility and an interim storage facility for long-lived waste. The Safety Analysis Report (SAR) includes all aspects relevant to safety such as the waste description, design, construction, operation, closure, decommissioning and post-closure activities. The safety analyses for the operational phase demonstrates that radiation protection criteria for the operating personnel and the public are met. Concerning the post-closure phase

of the repository, SAR identifies the safety functions to be fulfilled, together with the relevant features, events and processes (FEPs), and presents the scenarios considered to evaluate the behaviour of the disposal system.

A safety improvement programme has been carried out in order to retrieve some waste, notably waste containing long-lived radionuclides (e.g. C-14) and disused sealed radiation sources formerly accepted in the absence of waste acceptance criteria, and which might lead to an unacceptable impact with regard to dose constraints in the case of an inadvertent human intrusion after the end of the active institutional control.

National Radioactive Waste Repository

The NRWR is operated by PURAM and its safety analysis is also documented in a SAR. The surface facility part of the NRWR was commissioned in 2008, while the first underground disposal chamber and the necessary sub-surface infrastructure of the facility was commissioned in 2012. The safety analyses demonstrate compliance with safety objectives for the operation and the post-closure phases.

Deep Geological Disposal Facility

Concerning the development of a deep geological disposal facility, PURAM presented a framework programme following Implementing Geological Disposal – Technical Platform (IGD-TP) guidance. A preliminary design based on the Swedish KBS-3V concept was presented in the ARM and to the ARTEMIS Review Team during the mission, together with the results from the initial geological investigations carried out in the intended host rock formation, the Boda Claystone.

ARTEMIS observation

The ARTEMIS team notes that the requirements for developing a safety case are well developed, as well as the regulatory process for assessing it. PURAM provided a safety assessment for each licensed facility. The information presented in the ARM illustrates that the safety demonstration covers all stages of development, construction, operation and decommissioning, as well as the post-closure phase for disposal facilities. The safety reports specify safety principles and criteria, as well as operational limits and conditions. As such, it is documented that the design of the facilities relies on the defence in depth principle.

Complementary information was provided by PURAM in the course of the mission, notably related to the safety assessment of the NRWR facility, detailing the safety assessment methodology covering the characteristics of the site and descriptions of the disposal system, the safety functions, the derivation of scenarios and the use of modeling tools, e.g. for the 3D hydrogeological model. The specificities of the safety assessments of the RWTDF and the SFISF were also presented.

PURAM developed a waste acceptance system which contributes to the safe management of low and intermediate activity level waste from generation to disposal in the NRWR and RWTDF, as waste acceptance criteria (WAC) are derived from safety assessments of disposal facilities and in cooperation with the waste producers.

Based on the provided ARM, the ARTEMIS Review Team noted a comprehensive and thorough application of the safety assessment concepts for design, construction, operation, closure, decommissioning and post-closure activities for licensed facilities.

Regarding the development of the deep geological disposal facility, the ARTEMIS Review Team found, that as the KBS-3V concept was initially developed for crystalline host rocks, it can not be assumed that the disposal concept will be compatible with the investigated

argillaceous host rock, and this should therefore be demonstrated through a preliminary safety case.

PURAM detailed in the course of the mission the safety improvement programme carried out in the RWTDF, presenting notably the intrusion scenarios considered for the long-term safety assessment, the preliminary studies performed to evaluate the feasibility of different safety enhancement options, the criteria for intervention, as well as the main results of a demonstration program carried out on four vaults in RWTDF. The ARTEMIS Review Team considers that the implementation of such comprehensive measures goes beyond the reasonably practicable measures applied in similar cases in other countries and should be acknowledged.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *PURAM proposed disposal of spent fuel in an argillaceous host rock applying a concept similar to the Swedish KBS-3V, which was developed for a crystalline host rock. However, it has not yet been demonstrated that this concept can be adapted to an argillaceous host rock and ensure a sufficient level of confidence in safety.*	
(1)	**BASIS: SSR-5 Requirement 6 states that** *"The operator of a disposal facility shall develop an adequate understanding of the features of the facility and its host environment and of the factors that influence its safety after closure over suitably long time periods, so that a sufficient level of confidence in safety can be achieved."*
(2)	**BASIS: SSR-5 Requirement 6, para 3.30 states that** *"Early in the development of the concept, the data obtained and the level of understanding gained have to assure sufficient confidence to be able to commit resources for further investigations."*
(3)	**BASIS: SSR-5 Requirement 12 states that** *"A safety case and supporting safety assessment shall be prepared and updated by the operator, as necessary, at each step in the development of a disposal facility, in operation and after closure."*
S3	**Suggestion: PURAM should consider demonstrating the compatibility of the KBS-3V concept to the envisaged host rock by developing a preliminary safety case early in the development of the deep geological disposal facility .**

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *As part of the safety improvement program, PURAM has developed and carried out a demonstration program for upgrading the safety of RWTDF. The scope of the safety improvement program has been determined based on a systematic evaluation of feasible options. In the demonstration program, radioactive waste was retrieved from four vaults. It was then characterized, sorted, treated, and re-disposed after removal. Radioactive waste including DSRS not in compliance with WAC were stored pending geological disposal. The demonstration program confirmed the feasibility of retrieval and a significant improvement in long-term safety of the facility. The large scale safety improvement program will be implemented based on the experience of the demonstration program and the updated safety assessment.*	
(1)	**BASIS: SSR-5, Requirement 26, states that:** *"The safety of existing disposal facilities shall be assessed periodically until termination of the licence. During this period, the safety shall also be assessed when a safety significant modification is planned or in the event of changes with regard to the conditions of the authorization […]"*
(2)	**BASIS: SSR-5, Requirement 26, Paragraph 6.3 states that:** *"Disposal facilities that were not constructed to present safety standards may not meet all the safety requirements established in this Safety Requirements publication. In assessing the safety of such facilities, there may be indications that safety criteria will not be met. In such circumstances, reasonably practicable measures have to be taken to upgrade the safety of the disposal facility. Possible options may include the removal of some or all of the waste from the facility, making engineering improvements, or putting in place or enhancing institutional controls."*
GP1	**Good practice: Implementing an exemplary safety improvement programme of an existing disposal facility based on a comprehensive comparison of different options in terms of long term safety assessment and evaluation of radiological risks to workers and the public.**

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

Hungarian position

Financing of spent fuel and radioactive waste management in Hungary is based upon the polluter-pays principle. Section 41 of the Atomic Act, prescribes that costs for management of spent fuel and radioactive waste from nuclear activities, including decommissioning, shall be borne by the licensee, and that costs for management of institutional radioactive waste generated by central budgetary institutions shall be borne by the central budget. Whereas the prime responsibility for safety rests with the licensee, the legislation defines the Hungarian State to be finally responsible for safe and reliable management of spent fuel and radioactive.

The financing system is based on build-up of a segregated fund with the purpose to cover the costs for management of all spent fuel and radioactive waste arising in the country as well as decommissioning of nuclear facilities. Chapter IV of the Atomic Act contains the financing arrangements. It establishes the Central Nuclear Financial Fund (CNFF) and control of its operation. The financial assets of the CNFF are separately recorded on a single treasury account. The central budget annually contributes to the CNFF with a sum that is calculated adding a percentage (currently three percent) on top of the average base interest rate of the customer's price index of the previous year to keep its value.

Paks NPP provides payments to the fund to cover their part of the costs i.e. management of spent fuel and radioactive waste from operations and decommissioning, including decommissioning costs. Paks NPP must pay equal annual amounts into the Fund until the end of its operating time using the net present value computation method, i.e. the present value of future costs must equal the present value of the amount derived from stock of the CNFF and additional payments of the Paks NPP. If unplanned cost increases arise beyond the period of payments, and thus are not covered sufficiently by the amount available in the CNFF, the Hungarian State as ultimately responsible for the safe and reliable management of spent fuel and radioactive waste generated in Hungary, shall ensure coverage of these costs.

Costs for management of spent fuel and institutional radioactive waste from the the Budapest Training Reactor and the Budapest Research Reactor are covered by contributions from the state budget. Costs for management of institutional waste from small waste generators (e.g. hospitals, laboratories and industrial enterprises) are paid for by the generators when the waste is transferred to RWTDF.

The following principal activities are specified as being paid for by the fund;

i. the final disposal of radioactive waste,
ii. the storage of spent fuel,
iii. the back-end of nuclear fuel cycle and
iv. the decommissioning of nuclear facilities.

PURAM is the national waste management organisation and thus responsible for all activities required for responsible management of spent fuel and radioactive waste in Hungary. PURAM is the licensee for the storage and disposal facility for institutional waste (RWTDF) as well as the disposal facility (NRWR) for low and intermediate activity level waste from PAKS NPP and assumes responsibility for the radioactive waste when transferred to these facilities.

The framework requires PURAM to annually update an overall plan (mid to long term plan, MLTP) for all the activities needed to implement the national program, and to implement activities as specified in the plan. The MLTP includes a budget plan (cost estimates) as the basis

for deciding on payments to the CNFF as well as to justify payments from the CNFF for relevant activities. The Expert Committee of the CNFF reviews the MLTP before being approved by the minister for innovation and technology.

The updated cost estimates are structured per waste stream and associated facilities and activities. They are, as applicable, based on available data for relevant activities. The cost estimates are made with a deterministic method based on conservative assumptions. Estimates of decommissioning costs are structured according to the International Structure for Decommissioning Costing (ISDC). For such future activities for which information is scarce, experience has been acquired from outside of Hungary, e.g. cost estimates for encapsulation and disposal of spent fuel are based on experience in Sweden, and for cost estimation of preceding R&D activities the experience of the Swiss NAGRA was considered.

The current version of the National program as well as the MLTP (and embedded cost estimates) is based on a reference scenario encompassing existing licensed activities, including extended operations with 20 years (in total 50 years) of existing reactors at Paks NPP and the shutdown of the last existing reactor 2037, as well as planned expansions of NRWR and SFISF.

A licence for construction of two new WWER-1200 reactors at the Paks NPP (Paks II) is currently under review and current plans envisage commissioning of the new reactors around 2030. Preliminary cost calculations have already been made for the radioactive waste and spent fuel management activities of Paks II NPP, but not yet considered in the financing system. The rationale for this being that Paks II NPP need not pay into the CNFF until the new units will be put into operation.

ARTEMIS observation

The Hungarian legal framework for management of spent fuel and radioactive waste is well defined and implements the polluter-pays principle. National regulations for the waste management process ensures that roles and liabilities are identified and establish a mechanism to ensure that adequate financial resources are set aside to cover future obligations associated with safe decommissioning and waste management. The framework clearly defines the principle scope of activities as well as spent fuel and radioactive waste arisings that are subject to the financing arrangements.

The national program provides for a more detailed interpretation of what falls within the scope of the financing system. The MLTP, including a budget plan (cost estimates), provides the basis for deciding on yearly contributions to the fund, and to justify payments from the fund for relevant activities. An independent committee, the Central Nuclear Financing Fund Expert Committee, reviews the MLPT, including the cost assessments and budget plan and reviews payments to and from the CNFF for relevant activities.

The ARTEMIS Review Team notices that cost assessment encompasses existing licensed activities, including extended operations for 20 years of existing reactors at Paks NPP and planned expansions of NRWR and SFISF. The current version of the national program as well as the MLTP (and embedded cost estimates) does not include management of spent fuel and radioactive waste expected to arise from operation and decommissioning of the new reactors (Paks II NPP), and associated consequences for other parts of the program and program costs. The team notes the intention to take Paks II NPP related elements into consideration for the envisaged update of the national program. The team concludes that this development should provide for improved realism in base assumptions underpinning the MLTP, and the associated cost assessments should better reflect realistic expectations for future development.

The ARTEMIS Review Team further notices that a future decision for management of spent fuel will take into account future research and developments as well as potential introduction of new technologies. The team concludes that a potential strategic decision to go for reprocessing and recycling would have extensive implications for the overall planning as well as for cost and financing aspects, not least for implementing necessary infrastructure related to pre-disposal as well as disposal of reprocessed waste. The team notes that the cost and financing aspects of different options may provide for decisive input to such decisions.

The team notices as well that the current arrangements foresee payments to the Fund from Paks NPP until the end of its operating time. Should one or more of the reactors be shut down prematurely, the state will in its capacity as finally responsible for the safe and reliable management of spent fuel and radioactive waste cover potential shortage of funds.

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

Hungarian position

HAEA

The HAEA uses the Method Systematic Approach to Training – SAT recommended by IAEA, which allows up-to-date monitoring of the institutional knowledge profile and for identifying training needs. This contributes to transparent planning and implementation of both short and long term training objectives and programmes and supports implementation of the training policy established by HAEA.

In knowledge retention, HAEA has recognized that the available knowledge and the key persons having this knowledge have to be mapped and identified. The procedure on knowledge transfer at the HAEA is currently under development including a mentor system. In order to further develop professional knowledge, the HAEA is committed to support its staff in participation of training aimed at their professional development. The HAEA continuously follows the university educations in the areas of natural science and engineering, and supports the participation of its staff, even in the form of educational contracts. To facilitate the systematic planning of training, the identification of the training needs is made in each organizational unit, together with the justification and expected costs of the trainings. Several training tools are practiced, such as participation in conferences, workshops, professional exhibitions in specific areas of expertise, public service trainings, internal professional training sessions and participation in international events including those organized by the IAEA.

To facilitate its regulatory work, the HAEA utilizes the expertise of external partners, in the form of various studies and other regulatory oversight related services. The HAEA, in the frame of technical support activities, has contracts with professional services which contributes to performing regulatory work at a high professional level and also helps to retaind and sustain expertise of the partners.

To facilitate oversight of licensees in the area of competence building, the Ministerial decree 55/2012. NFM identifies the job positions requiring authority certification. The authority certifying exam is conducted pursuant to a procedure prepared by the licensee (Paks NPP and PURAM) and approved by the authority. A representative of the HAEA always attends the authority certifying exams performed by licensees and records experiences in an inspection report. Information on re-trainings is also provided to the HAEA in the annual plan of the licensee.

PURAM

The safety policy of PURAM declares the commitment of the company management towards assuring sufficient human resources for safe operation and declares that the tasks are performed by employees having adequate qualification and certification. These commitments are supported by the training policy, which declares that the company employees should possess the qualifications required and prescribed for their job and that they know and implement the most advanced knowledge needed for the performance of their tasks. One of the tools to attract young people to join PURAM is to provide them with educational contracts to students of relevant natural science and engineering disciplines to support and continue education at the university level.

In particular, PURAM elaborated a long-term work force management plan for the safety important job positions. This plan analyses the demographic distribution of the employees and

identifies the anticipated retirements. It determines the medium and long-term tasks and identifies the human resources needed for their completion.

PURAM performs its tasks through generations, therefore the management of the company handles the establishment of an effective knowledge and information retention system as a top priority. PURAM undertakes an active role in the WP-IDKM working group handling long term information, data and knowledge retention under the aegis of the OECD/NEA. Furthermore, PURAM requested the IAEA to conduct a Knowledge Management Assist Visit, which was performed in the period of October 19-22, 2020. PURAM performed a self-assessment of its knowledge management system, based on the maturity assessment questionnaire provided by the IAEA. Based on the maturity assessment and the mission conducted on-line, the experts assigned by the IAEA provided recommendations and suggestions. These will be included by PURAM into its own knowledge and information retention system, which has to form an integrated part of PURAM´s radioactive waste management activities.

Paks NPP

During 2016-2020 period, Paks NPP introduced a knowledge management process within its management system. This knowledge management process was established on the basis described in IAEA publications NG-T-6.10 (Knowledge management and its implementation in Nuclear Organizations) and NG-T-6.11 (Knowledge loss risk management in nuclear organizations). Knowledge preservation survey and interviews were carried out, an action plan prepared and knowledge potential index developed. Currently identification of key knowledge holders and their self-assessment are carried out. Various knowledge management tools indicated in IAEA safety documents are used to facilitate achievement of set objectives.

ARTEMIS observation

The new legal status of the HAEA aims at more independency, notably in order to better control its budget and to improve its attractiveness for new employees. The recent increase in the number of staff and planning of staffing are based mainly on the operation and decommissioning schedule of Paks NPP, as well as the commissioning of Paks II NPP. However, it was observed that important regulatory tasks lie ahead for the HAEA regarding spent fuel and radioactive waste management such as; completion of the liquid waste cementation facility, extension of NRWR, safety enhancement of RWTDF, siting of the deep geological disposal facility, development of regulations for very low activity level subclass of radioactive waste, review of submittals on the concept and siting for disposal for this waste and the upcoming decommissioning activities of Paks NPP. These challenges will require resources and competences in assessment and licensing of different facilities and activities in different stages of its life cycle.

It was observed by the ARTEMIS Review Team that the HAEA and main licensees have established recruitment, competence development and knowledge management processes using various internationally recognized tools. It is obvious that those activities and tools are to be used for solving current and medium-term challenges. Also it was seen that extensive cooperation takes place between PURAM and Paks NPP in current activities of radioactive waste and spent fuel management. However, the challenges in proactively mapping out and developing necessary human resources required to undertake upcoming tasks from 2030 and beyond, as described in the national program were highlighted. In this regard competence development, in particular for decommissioning of Paks NPP, becomes crucial.

The ARTEMIS Team noticed that there are several potential TSOs that can be contracted as technical support for safety assessment by both the HAEA and PURAM, however there are internal procedures in place at the HAEA to limit potential conflic of interests (such as a contractual obligation to declare that the TSO has not been approach by other parties to carry out support activities in the scope of the particular contract).

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *HAEA staffing was increased in order to meet the demands primarily associated with the licensing of Paks II NPP. However, additional specific competences will be needed for the assessment and licensing of deep geological and very low activity level radioactive waste disposal facilities throughout their development.*	
(1)	**BASIS: GSR Part 1 (Rev. 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."*
(2)	**BASIS: SSR-5 Requirement 2, para. 3.9 states that** "[The regulatory body] *has to maintain competent staff, to acquire capabilities for independent assessment and to undertake international cooperation, as necessary, to fulfil its regulatory functions."*
(3)	**BASIS: GSR Part 1 Requirement 9 states that** *"Senior management shall determine the competences and resources necessary to carry out the activities of the organization safely and shall provide them."*
S4	**Suggestion: The HAEA should consider assessing and developing its resources and competences to fulfil its responsibilities related to the safety of radioactive waste and spent fuel management, in particular with regard to the development of deep geological and very low activity level radioactive waste disposal facilities.**

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *PURAM's management system for competence development and knowledge preservation supports its activities related to spent fuel and radioactive waste management. However, the upcoming decommissioning of Paks NPP requires particular attention towards maintaining and strengthening the relationship with Paks NPP to collect and ensure the preservation of knowledge about the facility to be decommissioned.*	
(1)	**BASIS: GSR Part 6 Requirement 7 states that** *"The licensee shall ensure that its integrated management system covers all aspects of decommissioning."*
(2)	**BASIS: GSR 6 Requirement 7, para. 4.4 states that** *"… Provisions shall be made to ensure that institutional knowledge about the facility is obtained and made accessible and, as far as possible, that key staff from the facility are retained."*
S5	**Suggestion: PURAM should consider strengthening its management system to support its activities related to the decommissioning of Paks NPP, in particular to ensure that knowledge about the facility is collected, preserved, and available for further use.**

APPENDIX A: TERMS OF REFERENCE

1. Introduction

On 3 July 2018, the Hungarian Atomic Energy Authority (HAEA) requested the IAEA to organize and carry out, in 2021, the Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation (ARTEMIS) peer review mission in Hungary, as required of all EU Member States by Article 14.3 of the European 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.

On 22 March 2021, the Hungarian Atomic Energy Authority (HAEA) requested the IAEA to postpone the mission to the end of the first quarter of 2022 due to the impact of the COVID-19 international situation.

2. Objective

The ARTEMIS review will provide an independent international evaluation of Hungary's radioactive waste and spent fuel management programme.

The review, organized in the IAEA by the Department of Nuclear Safety and Security and the Department of Nuclear Energy, will be performed on the basis of 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.

3. Scope

The given ARTEMIS review will evaluate the Hungarian national programme and the national framework for executing country's obligations for safe and sustainable radioactive waste and spent fuel management.

Out of scope topics are:

- Environmental remediation;
- Management of residues from mining and milling; and
- NORM in general.

Results from the 2015 IRRS mission and 2018 IRRS Follow-up mission to Hungary will be taken into account as far as possible.

4. Basis for the review

The ARTEMIS review will be based on the relevant IAEA Safety Standards and proven international practice and experiences, following the guidelines of the ARTEMIS review service.

5. Reference material

The review will cover all documentation submitted by National Counterpart for the considered scope of the review, with a focus on the national programme, as well as the results of self-assessment, which should be based on the provided questionnaire.

The provisional list of reference material is provided in the Annex 1 (such a list is subject to updates and should be finalized by submission of the advance reference material).

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.

The National Counterpart is the Hungarian Atomic Energy Authority (HAEA). The National Counterpart Liaison Officers for the review are Mr István Lázár (for professional aspects) and Ms Barbara Baller (for organizational aspects).

The timeline for the key steps of the review process is provided below:

- Self-assessment: questionnaire was made available to Hungary as of September 2020.
- Preparatory Meeting: 1 October 2020 (WebEx meeting).
- The reference material (in English) and the results of the self-assessment questionnaire will be provided to the IAEA as soon as they are available and not later than **31 December 2021**.
- Questions based on the preliminary analysis of the reference material and the self-assessment results will be provided by the review team by **15 February 2022**.
- Peer review mission: **20-29 March 2022 (10 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 noon: drafting and delivering of the draft report (Review Team);
    - Sunday afternoon: Delivery of draft report/recommendations to the Counterparts for fact checking;
    - Monday: discussions between the Review Team and the Counterparts and finalization of draft report;
    - Tuesday: delivery of the draft mission report and closure.

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 of:

- Five qualified and recognized international experts from government authorities, regulatory bodies, waste management organizations, and technical support organizations with experience in the safe management of radioactive waste and spent fuel;
- Two IAEA staff, to coordinate the mission. The Coordinator of the ARTEMIS review is Mr Andrey Guskov from the Waste and Environmental Safety Section of the Department of Nuclear Safety and Security. The deputy coordinator is Ms Amparo Gonzales Espartero from the Nuclear Fuel Cycle and Materials Section of the Department of Nuclear Energy.
- One IAEA staff for administrative support.
- A senior member of IAEA staff from the Department of Nuclear Safety and Security will oversee the closure of the review meeting.

The peer review team will be led by a Team Leader, assisted by a Deputy Team Leader, comprising from the review team as defined in the ARTEMIS draft guidelines. The Team

Leader will be Mr David Ulfbeck from the Danish Health Authority. The IAEA will inform the National Counterpart regarding the composition of the proposed review team prior to submission of reference material.

The review mission may include the presence of up to two observers, including the possibility of an observer from the EC. The National Counterparts will be notified of any proposed observers; the presence of any observers must be agreed in advance of the mission.

8. Reporting

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

Prior to its finalization, the ARTEMIS Review Report will be delivered to the National Counterpart for fact-checking, being the Hungarian Atomic Energy Authority (HAEA).

9. Funding of the peer review

The mission will be funded by the IAEA, while the HAEA will cover local costs.

These Terms of Reference have been agreed between the IAEA and the HAEA during the preparatory meeting 1 October 2020 and updated on 15 April 2021 due to mission's postponement.

Annex 1: List of reference material

- Responses to the ARTEMIS Self-assessment Questionnaire
- National Policy for SNF and RAW management
- National Programme for SNF and RAW management
- Regulations and legislation:

  1.) Act CXVI of 1996 on Atomic Energy

  2.) Govt. Decree 155/2014. (VI. 30.) on the safety requirements for facilities ensuring interim storage or final disposal of radioactive wastes and the corresponding authority activities /with all of the Volumes/

  3.) Govt. Decree 118/2011 (VII. 11.) on the nuclear safety requirements of nuclear facilities and on related regulatory activities /with relevant Volumes/

  4.) Govt. decree 487/2015. (XII. 30.) on the protection against ionizing radiation and the corresponding licensing, reporting (notification) and inspection system

  5.) Govt. decree 112/2011. (VII. 4.) on the scope of authority of the Hungarian Atomic Energy Authority in relation to European Union obligations and international obligations in connection with atomic energy, on the designation of co-authorities contributing to the regulatory proceeding of the Hungarian Atomic Energy Authority, on the scale of fines and on the scientific council assisting the work of the Hungarian Atomic Energy Authority

  6.) Govt. Decree 213/2013. (VI. 21.) on the Special Committee of the Central Nuclear Financial Fund

  7.) Govt. Decree 215/2013. (VI. 21.) on the designation, activities and financial resources of an organization responsible for certain tasks relating to radioactive waste and spent fuel management

- National Report of Hungary to the 7th Review Meeting of the Contracting Parties to Joint Convention
- National Presentation of Hungary to the 6th Review Meeting of the Contracting Parties to Joint Convention
- IRRS mission and IRRS follow-up mission reports to Hungary
- Last 2011/70/EURATOM National Report

APPENDIX B: MISSION PROGRAMME

Time	Sun, 20 March	Mon, 21 March	Tue, 22 March	Wed, 23 March	Thurs, 24 March	Fri, 25 March	Sat, 26 March	Sun, 27 March	Mon, 28 March	Tue 29 March
9h00 – 10h00	Arrival of Team Members	**Opening** General presentation	Inventory	Concepts, Plans and technical solutions (continue)	Cost estimates and financing Capacity building	**Presentation of Suggestions and Recommendations to Counterparts**	Drafting of the report	**Draft report to be sent to the Counterparts for fact checking** ***by 13h00***	**Internal reflection of comments**	Delivery of final draft report **EXIT MEETING**
10h00 - 12h00		National Policy and Framework							**Discussions with the Counterparts on the draft report**	
12h00 - 13h00		Lunch	Lunch	Lunch	Lunch	Lunch			Lunch	Lunch
13h00 – 16h00		National Strategy	Concepts, Plans and technical solutions	Safety case and safety assessment	**Finalization of Suggestions and Recommendations**	Drafting of the report		**Sightseeing (Team Members)** Counterparts review the draft report	Finalising draft report	Departure of Team Members
16h30 - 17h30	Artemis team meeting (at hotel)	Team meeting	Team meeting	Team meeting						
17h30 – 22h00		Drafting of the report	Drafting of the report	Drafting of the report					**Official dinner**	

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	R1	**Recommendation: The Government should provide the mechanism for when and on what basis the decision shall be made on the back-end of the nuclear fuel cycle.**
		S1	**Suggestion: HAEA should consider completing development of safety regulations for management of very low activity level radioactive waste including disposal.**
2.	NATIONAL STRATEGY FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT	S2	**Suggestion: The Government should consider approving an updated national program without undue delay taking into account the Paks II project, and other relevant and technical circumstances.**

Area		R:Recommendations S: Suggestions G: Good Practices	Recommendations, Suggestions or Good Practices
5.	SAFETY CASE AND SAFETY ASSESSMENT OF RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT ACTIVITIES AND FACILITIES	S3	**Suggestion: PURAM should consider demonstrating the compatibility of the KBS-3V concept to the envisaged host rock by developing a preliminary safety case early in the development of the deep geological disposal facility .**
		GP1	**Good practice: Implementing an exemplary safety improvement programme of an existing disposal facility based on a comprehensive comparison of different options in terms of long term safety assessment and evaluation of radiological risks to workers and the public.**
7.	CAPACITY BUILDING FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT – EXPERTISE, TRAINING AND SKILLS	S4	**Suggestion: The HAEA should consider assessing and developing its resources and competences to fulfil its responsibilities related to the safety of radioactive waste and spent fuel management, in particular with regard to the development of deep geological and very low activity level radioactive waste disposal facilities.**
		S5	**Suggestion: PURAM should consider strengthening its management system to support its activities related to the decommissioning of Paks NPP, in particular to ensure that knowledge about the facility is collected, preserved, and available for further use.**

APPENDIX D: LIST OF ACRONYMS USED IN THE TEXT

ARM – Advance Reference Material

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

CNFF – Central Nuclear Financial Fund

HAEA – Hungarian Atomic Energy Authority

IAEA – International Atomic Energy Agency

ILW – Intermediate Level Waste

IRRS – Integrated Regulatory Review Service

ITM – Ministry for Innovation and Technology

LRWTT – Liquid Radioactive Waste Treatment Technology

NRWR– National Radioactive Waste Repository

PURAM –Public Limited Company for Radioactive Waste Management

RWTDF – Radioactive Waste Treatment and Disposal Facility

SFISF - Spent Fuel Interim Storage Facility

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, Disposal of Radioactive Waste, IAEA Safety Standards Series No. SSR 5, IAEA, Vienna (2011).

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

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

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

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

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

[14] 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).

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

[16] 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).

[17] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Glossary – Terminology used in Nuclear Safety and Radiological Protection, IAEA, Vienna (2018).

[18] 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).