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

MISSION

TO

DENMARK

Roskilde, Denmark

1-9 May 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

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REPORT OF THE

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REPORT OF THE

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

TO

DENMARK

Mission dates: *1-9 May 2022*
Location: *Roskilde, Denmark*
Organized by: *IAEA*

ARTEMIS REVIEW TEAM	
Mr Stefan Theis	ARTEMIS Team Leader (Switzerland)
Mr Matthias Hackstein	Reviewer (Germany)
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Ms Merle Lust	IAEA Deputy Team Coordinator
Ms Kristina Nussbaum	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 14 December 2016, the Resident Representative of Denmark to the IAEA, requested the International Atomic Energy Agency (IAEA) to organize and carry out an Integrated Review Service for Radioactive Waste and Spent Fuel, Decommissioning and Remediation (ARTEMIS) review.

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 Denmark, 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 four senior international experts in the field of management of spent fuel and radioactive waste, supported by IAEA staff providing coordination and administrative assistance.

Preparatory meeting was held in December 2021. Review of the Advanced Reference Material (ARM) was carried out in the first quarter of 2022. The ARTEMIS review mission was conducted from 1 to 9 May 2022.

Denmark has no nuclear power plants but manages waste from the ongoing decommissioning of six nuclear facilities at Risø, including three research reactors, a hot cells facility, a fuel fabrication plant, and a waste treatment plant. The decommissioning waste is treated and stored by Danish Decommissioning (DD), a state-owned company managing also radioactive waste from the use of radiation sources in medicine, industry and research in Denmark.

During the ARTEMIS mission the team comprised of senior international experts in the field of radioactive waste management and decommissioning from the Germany, Italy, Lithuania and Switzerland held discussions with the representatives of the Danish Ministry of Health, Danish Health Authority (DHA), the Danish Ministry of Higher Education and Science, the Danish Agency for Higher Education and Science, the Danish Emergency Management Agency (DEMA), and DD.

The ARTEMIS Review Team very much appreciated additional documentation presented by the Danish counterparts to address the expert's questions during the mission, continuous and open manner of discussions and intention to use whatever comment from the Team as input for the process of continuous improvement of waste management in Denmark.

Based on these exchanges, covering subjects such as the Danish national policy for waste, the waste inventory, and safety assessments, as well as a visit to the facilities at Risø site, the ARTEMIS Review Team noted that Denmark has developed and implemented a robust and well-functioning system for maintaining and further enhancing the safety and effectiveness of spent fuel and radioactive waste management. However, the Team prepared recommendations (R) and suggestions (S) into a draft report which was handed over at the official exit meeting.

Parliamentary Resolution B90/2018 (B90) is considered by the Team as a key document for translating political and strategic decisions into an executable national waste management program.

Uncertainties for management options for some waste types due to pending decisions and the financing of associated treatment steps should be eliminated in due time.

With the aim of introducing all radioactive material without intended further use into the radioactive waste management system, DD should be obliged to accept any notified radioactive material including from non regulated use.

The Team has identified specific areas where licensees could receive even better support for their undertakings, if the regulatory body would specify all their requirements for waste treatment, storage and disposal facilities during their entire life-time in guidances.

The key implementing organization for the National Programme is DD, which has already established a strategy (described as DD strategy hereafter). This was presented during the mission and could serve as a master plan for the implementation of the National Programme. To serve this purpose from the DD strategy the implementation plan for disposal can be developed.

To ensure the timely execution of the National Programme and the provision of necessary services and products the Team recommends corresponding control and assurance procedures.

Optimization in radiation protection, especially minimization of professional exposure can be supported by adjusting operations foreseen during waste transfer activities and establishing waste acceptance criteria (WAC) for disposal as soon as possible.

Sustainable support for the financing of waste management activities is and will be based on open communication and regular update of the cost estimations on the best available information basis.

A long term human resources and competence management plan will support the strategic decision by DD to become and maintain the status of the national competence center for waste management even during the foreseeable transition phases of the future.

In summary, the ARTEMIS Review Team considers that the Danish system for management of spent fuel and radioactive waste has a well-developed infrastructure, provides robustness, effectiveness and safety now and in the future. Denmark 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

At the request the Resident Representative of Denmark to the IAEA, the International Atomic Energy Agency organized an ARTEMIS review of the Danish Policy on Spent Fuel and Radioactive Waste Management. The objective of the ARTEMIS Peer Review Service is to provide independent expert opinion and advice on radioactive waste and spent nuclear fuel management, decommissioning and remediation, based upon the IAEA Safety Standards and technical guidance, as well as international good practice. Denmark requested this review to fulfil its obligations under Article 14.3 of the Council Directive 2011/70/Euratom of 19 July 2011 establishing a *Community Framework for the Responsible and Safe Management of Spent Fuel and Radioactive Waste* ("*Waste Directive*").

The review was performed by a team of four 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 December 2021, and the receipt and review of Advanced Reference Material in February 2022, in May 2022 the ARTEMIS Review Team evaluated the Danish strategy for the management of all types of radioactive waste and spent fuel, including aspects of decommissioning.

II. OBJECTIVE AND SCOPE

The ARTEMIS review provided an independent international evaluation of the Radioactive Waste and Spent Fuel Management Strategy of Denmark, requested in line with the obligations of the *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 *Waste Directive*, the overall strategy for the management of all types of radioactive waste in Denmark.

III. BASIS FOR THE REVIEW

A) PREPARATORY WORK AND IAEA REVIEW TEAM

At the request of the Government of Denmark, a preparatory meeting for the ARTEMIS Review mission, was conducted on 14 December 2021 online. The preparatory meeting was carried out by the appointed Team Leader Mr Stefan Theis, the IAEA coordinator and deputy coordinator Mr Andrey Guskov and Ms Merle Lust, and the team of National Counterparts led by Mr David Ulfbeck from the DHA, Radiation Protection, with participation of representatives of the Ministry of Health, Ministry of Higher Education of Science, DD and Danish Emergency Management Agency.

The ARTEMIS mission preparatory team had discussions regarding:

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

IAEA staff presented the ARTEMIS principles, process and methodology. This was followed by a discussion on the work plan for the implementation of the ARTEMIS review in Denmark in May 2022.

Mr David Ulfbeck was appointed as the National Counterparts for the ARTEMIS mission and designated IAEA point of contact.

Denmark provided IAEA with the ARM for the review on 15 February 2022.

B) REFERENCES FOR THE REVIEW

The articles of the *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, 1 May 2022 in Roskilde, directed by the ARTEMIS Team Leader Mr Stefan Theis, the ARTEMIS Team Coordinator Mr Andrey Guskov and the Deputy Team Coordinator, Ms MerleLust.

The ARTEMIS entrance meeting was held on Monday, 2 May 2022, with the participation of the DD, the DHA, Radiation Protection, the DEMA, the Ministry of Health and Ministry of Higher Education and Science senior management and staff. Opening remarks were made by Mr Andreas Jull Sørensen (Ministry of Health), Mr Kristoffer Brix Berthelsen (Ministry of Higher Education and Science), Mr David Ulfbeck (DHA, Radiation Protection), Ms Mette Øhlenschlæger (DHA, Radiation Protection), Mr Ole Kastbjerg Nielsen (DD) and Mr Stefan Theis, ARTEMIS Team Leader.

During the ARTEMIS mission, a review was conducted for all review topics within the agreed scope with the objective of providing Danish 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 Monday, 9 May 2022. Opening remarks were made by Mr Kristoffer Brix Bertelsen, Senior Adviser, Ministry of Higher Education and Science. A presentation of the results of the Review Mission was given by the ARTEMIS Team Leader Mr Stefan Theis. Closing remarks were made on behalf of the IAEA by Mr Peter Johnston, Director of the 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

Danish position

According to the ARM, the Government of Denmark established the national policy for decommissioning and the management of different classes of radioactive waste through the adoption of Parliamentary Resolution B48/2003 (B48) on the Decommissioning of Nuclear Facilities at Risø Research Centre and Parliamentary Resolution B90/2018 (B90) on a Long-Term Solution for Denmark's radioactive waste, based upon proposals of the Ministry of Science, Technology and Development (current name: Ministry of Higher Education and Science). Fundamental principles for radiation protection and safety, including protection of people and the environment, protection outside of national borders, protection of future generations are mentioned as important conditions for the parliamentary resolution. In addition, elements of the policy are established in Parliamentary Resolution B103/1985, Radiation Protection Act 23/2018, Nuclear Installations Act 170/1962, Executive Orders 669/2019 and 670/2019, Circulars No. 9654/2020 and No. 9261/2022.

The national policy must be implemented observing the fundamental principles for radiation protection and safety that are embedded in the Radiation Protection Act, which imply that exposure to radiation must be justified, to be as low as reasonably achievable and below specified limits, while placing primary responsibility on licensees using ionizing radiations. According to the Radiation Protection Act, the fundamental safety principles apply to any use of radiation or radioactive source, including the management of radioactive waste. Also, policy must be implemented observing the specific waste management principles: ultimate responsibility of the licensees, graded approach, due consideration of interdependencies among waste management phases, waste minimization, financial compensation, avoiding unjustified burden to future generations as well as ensuring transparency and public participation.

B48 formed the basis for the current policy on decommissioning and management of radioactive waste assigning to the state owned undertaking DD the responsibility for decommissioning of nuclear facilities at Risø Research Centre in order to release the site for unrestricted use within the timeline of up to 20 years (2003-2023).

B90 aims to implement a national long-term solution for Denmark's radioactive waste. B90 resolution specifies the objectives for management and disposal of radioactive waste streams and assigns DD as a national radioactive waste management organisation. According to B90 the solution for the radioactive waste management is identified in the continued safe storage in a dedicated storage facility until the geological disposal in a facility to be commissioned at the latest by 2073. A short-term goal is therefore represented by the construction of a new radioactive waste storage facility. In medium-term, geological studies are planned at a depth of up to 500 m in order to identify suitable conditions for a deep geological disposal facility. B90 specifies that recommended locations for deep geological disposal facility can be identified after an analysis, considering geological, physical as well as socio-economic factors and, in particular, on the basis of a voluntary participation of local municipalities/communities. In parallel, the exploration of possibilities for an international solution for the disposal of long-lived radioactive waste will be pursued as established in B90, until an act on the planning of deep geological disposal facility is passed.

According to B90, also a disposal solution of the NORM waste could be considered, which is currently stored in waste producers' facilities. The issue of management and disposal of NORM in a common Nordic disposal facility was discussed by members of the Nordic Council. On 11 November 2021 the Nordic Council adopted Recommendation 36/2021 asking Nordic Council of Ministers to consider the identification of suitable sites for one or more joint Nordic disposal facilities for NORM waste, identification and remediation of legal and regulatory obstacles for import/export of NORM between member states, initiation of establishment of the joint financing of one or more NORM disposal facilities and establishments of procedures to ensure the safe management and handling of NORM transportation between member states. However, the Nordic Council of Ministers decided not to accommodate Recommendation 36/2021. Consequently, the handling and disposal of NORM will be considered on a national level. However, the option to reach an agreement on a common solution on disposal of NORM waste on bilateral base remains.

The ARTEMIS Review Team is also informed that this specific issue of NORM has been discussed in the IRRS mission to Denmark 2021 and addressed in the Recommendation R3 of the IRRS Report.

The ARTEMIS Review Team has also been informed that the Ministry of Health has taken initiative to setup a cross-sectoral working group intended to include authorities, municipalities and NORM industry operators, with the purpose of defining overall policy goals for NORM waste management in order to elaborate a proposal for a new parliamentary resolution. The primary aim is to ensure safe pre-disposal management and disposal of NORM waste originating from industrial off-shore oil and gas activities.

ARTEMIS observation

The ARTEMIS Review Team noted that the Danish policy established by B48, B90 and B103/1985, Radiation Protection Act 23/2018, Nuclear Installations Act 170/1962, Executive Orders 669/2019 and 670/2019, Circular No. 9654/2020 and No. 9261/2022 contains all elements of the policy in a manner consistent with the recommendations of IAEA Safety Standards.

The ARTEMIS Review Team also noted that the management of NORM waste is not dealt with in the existing policy documents, although B90 stipulates that *"final repository could also be considered for housing NORM waste"*.

This issue has been identified in the IRRS mission to Denmark 2021 and addressed in the Recommendation R3 of the IRRS Report. Hence, the findings of ARTEMIS Review Team will be fully addressed once the above mentioned IRRS mission recommendation will be implemented.

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

Danish position

As Denmark is a member of the European Union and the European Atomic Energy Community the law and regulations have been amended in order to transpose into the national regulatory framework the Euratom Directives. EU regulations are directly applicable in Denmark.

Within the Danish national framework, in addition to *The Constitution*, the Danish legal hierarchy comprises:

- Acts (and Consolidation Acts) establishing authorities, obligations, prohibitions and framework of action. Acts are typically proposed (bills) by ministers, considered and eventually passed by Parliament. Consolidation Acts, adopted by the relevant minister, are administrative summaries of original acts and their subsequent amendments;
- Executive Orders setting administrative regulations based on one or more (consolidation) acts and issued either by a ministry or an appointed authority. An executive order may contain rules that are binding on both citizens and authorities;
- Circulars, issued by a ministerial department for example, setting administrative regulations, typically containing provisions aimed at hierarchically lower-ranking institutions such as authorities and agencies. Circulars, unlike executive orders, cannot directly bind citizens or authorized parties.

The Parliament can adopt Parliamentary Resolutions: these are policy decisions, which are binding for the Government.

The Radiation Protection Act, applies to any activity and any exposure situation and by inference any facility in which an activity takes place, including nuclear facilities. This act includes the fundamental basis for a framework for safety: responsibility, justification of practices, optimization of exposure, limitation of doses, prevention of accidents and limitation of their consequences, training of workers, protective actions to reduce existing or unregulated radiation risks, administrative regimes, clearance of material, inspection, and appeals against regulatory decisions.

The act empowers the DHA to lay down detailed rules for radiation protection. It also gives DHA the legal basis to perform inspections and to grant, amend, revoke or deny an authorization.

The types of facilities and activities regulated and their administrative regime (notification, license and license with conditions) are further specified especially in *Executive Order no. 669/2019*.

The Nuclear Installations Act complements *The Radiation Protection Act* by defining a nuclear facility, nuclear fuel and radioactive by products. It confers:

- The Minister of Health (originally the Prime Minister) the authority to grant or refuse the approval for a nuclear installation or exempt an installation from such license;
- Jointly DEMA and DHA – the "Nuclear Regulatory Authorities" (NRA) – the authority to inspect and set license conditions or establish operational limits and conditions.

The regulatory body for radiation and nuclear safety in Denmark is composed of two authorities, with specified roles and tasks. Although other organizations do have some

regulatory roles on more specific or limited matters, the main regulatory authorities for radiation and nuclear safety are:

- The DHA, an authority under the Ministry of Health;
- The DEMA, a civilian agency under the Ministry of Defence.

The DHA acts under the Ministry of Health. In accordance with the Radiation Protection Act, the DHA is the national competent authority for regulating the use of radioactive substances including radioactive waste.

The DEMA is responsible for Danish emergency preparedness and acts under the Ministry of Defence. DEMA supervises authorities and municipalities on emergency preparedness.

The Nuclear Regulatory Authorities are authorized to establish limits and conditions for operation and decommissioning, to issue terms necessary to ensure compliance and to access nuclear facilities at any time. The nuclear installations at Risø, including the national storage facilities for radioactive waste, are subject to oversight and inspection by the Nuclear Regulatory Authorities.

The Danish Environmental Protection Agency is part of the Ministry of the Environment. It administers the legislation on environmental protection, which is to ensure clean air, (drinking-) water and soil and good living conditions for people, animals and nature. The Environmental Impact Assessment Act as well as the Planning Act (under the Ministry of the Interior and Housing) are relevant in the planning and siting of facilities such as nuclear facilities or a disposal facility for radioactive waste.

The Agency for Higher Education and Science has the formal responsibility for institutions under the Ministry of Higher Education and Science, including DD.

Existing nuclear installations in Denmark are at a late stage of decommissioning and are operated by a single operator, the DD.

ARTEMIS observation

The ARTEMIS Review Team found the legal, regulatory and organisational framework for waste management to be mostly in line with IAEA Safety Standards.

The Danish policy for safe management of radioactive waste is currently established in Parliamentary Resolutions. The Government has made initial provisions for the safe decommissioning of the nuclear facilities at the Risø site, the safe management and disposal of radioactive waste, and the safe management of spent fuel by the adoption of Parliamentary Resolution B48 and Parliamentary Resolution B90 (see also chapter 1.1).

It is noted that approval for construction of a facility according to the Nuclear Installation Act is needed by the Minister of Health prior to construction and again another approval by the same minister prior to operation. DHA and DEMA provide support to the minister in assessing the applications. The ARTEMIS Review Team considers it a common regulatory approach to grant an approval prior to construction. In contrast, the required license for operation according to the Radiation Protection Act is needed before the beginning of the operation. The licensing process for operation according to the Radiation Protection Act is started officially only after or parallel to the construction of the facility.

Some general requirements are established, e.g., in Executive Order 670 of 1 July 2019. However, regulatory requirements for the different phases of the lifetime of the waste management facilities (New Upgraded Storage Facility (NOL), waste treatment facility and disposal facility) are not sufficiently detailed. Further regulatory requirements and

accompanying guidance documents are therefore needed. This is in particular the case for the future waste treatment facility, but also for, e.g., the ageing management for and subsequent decommissioning of the NOL facility, taking into account that the NOL has to be in operation for several decades. This issue has been also raised by the IRRS mission in relation to regulatory requirements of the disposal facility and a specific recommendation has been addressed to DHA in the IRRS Report (Recommendation R12).

DD intends to apply for approval and a license to operate the NOL with no limitation on the operation period. The ARTEMIS Review Team, taking into account that the period of time for which the facility will be needed is not exactly clear, considers this a prudent approach. Periodic safety reviews have however to be planned to ensure the continued safe operation of the facility.

The ARTEMIS Review Team notes that, according to para. 2 sub-para. 1 of Circular No. 9261/2022, DD accepts the following waste categories on the basis of a case-by-case evaluation:

1) Radioactive waste from the use of radioactive material in Denmark according to national radiation protection regulations;
2) Radioactive material of Danish origin covered by a retransfer agreement, including sealed radioactive sources in Danish-made equipment no longer in use; and
3) Radioactive material outside of regulatory control, including radioactive material rescued under unforeseen circumstances.

Further, para. 2 sub-para. 2 of the same Circular states that DD can decide to accept radioactive waste or material not covered by sub-para. 1 mentioned above.

The ARTEMIS Review Team notes that there is no obligation for DD to accept waste according to sub-para. 2. Further, it is the understanding of the ARTEMIS Review Team that even waste according to sub-para. 1 may be rejected, depending on the evaluation of the specific case. Taking into consideration that DD is the only state owned operator for the storage and treatment of radioactive waste, it is therefore possible to have radioactive waste streams without a clear disposal or storage path within the Danish legal system. Examples are orphan sources or waste from discontinued practice, e.g., from bankrupt institutions. For certain radioactive waste, the storage and treatment depend on the voluntary decision of DD or the authorities, but not on a legal requirement.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *Applicants, e.g., Danish Decommissioning, are required to submit a demonstration of safety in support of their application for future facilities, e.g., for the NOL and later for a disposal facility. Some general requirements for radioactive waste facilities are found in the Nuclear Installation Act, the Radiation Protection Act and in two executive orders. However, there are no specific guidance documents or specified criteria available for the applicant/licensee.*	
(1)	**BASIS: GSR Part 1 (Rev. 1) Requirement 24, para. 4.34. states that** *"The regulatory body shall issue guidance on the format and content of the documents to be submitted by the applicant in support of an application for an authorization. […]"*
(2)	**BASIS: GSR Part 5 Requirement 3 states that** *"The regulatory body shall establish the requirements for the development of radioactive waste management facilities and activities and shall set out procedures for meeting the requirements for the various stages of the licensing process."*
(3)	**BASIS: GSR Part 5 Requirement 3 para. 3.8 states that** *"To facilitate compliance with regulatory requirements, the regulatory body has to do the following:* *Provide necessary guidance on the interpretation of national standards and regulatory requirements that takes into consideration the complexity of the operations and the magnitude of the hazards associated with the facility and operations; […]"*
R1	**Recommendation: The regulatory body should establish regulatory requirements and guidance documents for the development and authorization of waste management facilities in the different stages of their life-time (siting, design, construction, operation, decommissioning or closure and post-closure, as applicable).**

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *Danish Decommissioning takes a central role in management of institutional radioactive waste in Denmark as sole state owned operator for storage and treatment of radioactive waste. Danish Decommissioning accepts most radioactive waste according to Circular No. 9261/2022. However, Danish Decommissioning does not have the obligation to accept all types of waste. In certain situations, radioactive waste has no legally defined path within the Danish legal system.*	
(1)	**BASIS: SF-1 Principle 2, para 3.9 states that** *"[…] Government authorities have to provide for control over sources of radiation for which no other organization has responsibility, such as some natural sources, 'orphan sources' and radioactive residues from some past facilities and activities."*
(2)	**BASIS: GSR Part 1 (Rev. 1) Requirement 9, para. 2.25 states that** *"Radiation risks may arise in situations other than in facilities and activities that are in compliance with regulatory control. […] Where unacceptable radiation risks arise as a consequence of an accident, a discontinued practice, or inadequate control over a radioactive source or a natural source, the government shall designate the organizations to be responsible for making the necessary arrangements for the protection of workers, the public and the environment. […]"*
(3)	**BASIS: GSR Part 1 (Rev. 1) Requirement 10 states that** *"The government shall make provision for [..] the safe management and disposal of radioactive waste arising from facilities and activities, and the safe management of spent fuel."*
(4)	**BASIS: GSR Part 1 (Rev. 1) Requirement 10 para. 2.30 states that** *"Radioactive waste generated in facilities and activities shall be managed in an integrated, systematic manner up to its disposal."*
R2	**Recommendation: The Government should ensure management of and control over all radioactive waste and designate waste management organizations that are obliged to accept all types of radioactive waste.**

2. NATIONAL STRATEGY FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT

2.1. SCOPE

Danish position

The Danish national strategy is defined in the National Programme. It describes a stepwise approach towards a comprehensive system for safe management of all type radioactive waste, which is based on passive safety features in the long term. The latest version of the National Programme incorporates modifications based on the provisions of Parliamentary Resolution B90. Activities are organised in a such way as to ensure completion of the decommissioning tasks related to the nuclear facilities and transfer of all waste into an upgraded storage facility for storage of up to 50 years. The technical, organisational and political options for management of radioactive waste, including seven dedicated groups of waste referred to as "special waste" are integrated with the activities to identify a site and develop a disposal concept of a geological disposal facility. An international solution for the "special waste" is considered as an alternative option.

The National Programme defines technical areas, which are subdivided into "Waste Management", "Geology & Siting" and "Disposal Solution" areas and the socio-economic area subdivided into "Organisational Framework", "Stakeholder Engagement" and "Finance and Costing". The main areas are further divided into a number of deliverables with multiple interdependencies, which take effect in the short term, mid-term or long term, or extend over several periods.

Implementation of the National Programme rests on the legal and regulatory framework established for the safe management of radioactive waste. The framework assigns responsibility for planning, conducting and the implementation of the National Programme. The execution of the tasks from the national strategy is distributed between a number of different authorities and institutions. The DHA assists the Ministry of Health by contributing to the preparation, evaluation and updating of a national policy and national programme. The Danish Agency for Education and Science assists the Ministry of Higher Education and Science by contributing to the preparation, evaluation and updating of the National Programme. DD is the state enterprise under the Ministry of Higher Education and Science, which is responsible for the decommissioning of the nuclear facilities of the former Research Centre Risø, management and storage of radioactive waste from institutional waste producers (except NORM waste), developing a long-term solution for radioactive waste and also contributes to the revision of the National Programme. However, the primary responsibility for development of a long-term solution rests under the Ministry of Higher education and Science. DD has approved a waste management strategy setting the strategic goals for the period from the begin of operation of NOL to the placement of the waste into the disposal facility. Based on this strategy biennial plans are formulated.

Danish Government continues to explore potential options of entering an intergovernmental agreement on the use of disposal facilities for the "special waste". Regarding the "special waste", the technical requirements and needs for research, development and demonstration necessary to realize options for reprocessing (abroad), export with the purpose of disposal, or inclusion in a disposal solution, must be identified and integrated in the implementation of the National Programme at an early point in time to ensure a timely availability of the chosen management option.

With regard to the exploration of exporting the special waste with the purpose of disposal, the Danish Ministry of Foreign Affairs has conducted consultations with a number of OECD member countries in order to establish whether legal, technical and political conditions exist for the conclusion of a bilateral agreement on disposal of the special waste. However, so far, this has been found not to be the case. In any case, consultations for a bilateral agreement on disposal of the special waste will neither delay nor postpone the development of a disposal facility on Danish soil. DD participates in the EURAD, European Joint Programme on Radioactive Waste Management, in the Strategic Studies Work Package on waste management routes. One of the tasks under this work package is investigating the potential of shared solutions, both regarding pre-disposal and disposal.

Parliamentary Resolution B90 holds provisions for the possibility of including NORM waste in a disposal solution, but explicitly does not include provisions for the management of NORM waste in the period until a disposal solution is established. The policy proposed by a cross-sectoral working group, initiated by the Ministry of Health, with the participation of relevant authorities, municipalities and with the involvement of NORM industry operators will form the basis for establishing corresponding provisions for management of NORM waste in a national programme context.

ARTEMIS observation

The National Programme addresses the strategies, necessary actions and technical solutions to be developed in the short, medium and long terms, aimed to ensuring management of all the radioactive waste of the former Research Centre Risø and management and storage of radioactive waste from institutional waste producers. A period of long storage is envisaged for waste before disposal. The National Programme comprises concepts and plans, R&D activities, human and financial resources for the radioactive waste management. Also, the National Programme addresses developing a long-term solution for radioactive waste, including the economic and financial measures required to carry them out. This approach in terms of the scope of the national strategy is consistent with the recommendations of IAEA Safety Standards. Also, the ARTEMIS Review Team noted that the Danish approach to radioactive waste management considers disposal as final destination of almost all material declared as radioactive waste.

However, NORM waste is an exception in the above mentioned approach. A strategy for the management of NORM waste has not been established yet, and neither a National policy. This issue has been identified in the IRRS mission to Denmark 2021 and is addressed in the Recommendation R3 of the IRRS report.

The National Programme is based on the current radioactive waste inventory and takes into account an estimate of the amount of future radioactive waste. This is in line with the recommendations of IAEA Safety Standards. However, there are remaining uncertainties regarding the characteristics and the inventory of the waste, but the National Programme includes tasks related to re-assessment of the radioactive waste inventory.

2.2. MILESTONES AND TIMEFRAMES

Danish position

The National Programme is comprised by 3 technical and 3 socio-economic areas projected over a timescale ranging from the completion of the decommissioning of the nuclear facilities until commissioning of a geological disposal facility by 2073 at the latest. A milestone for launching the operation of NOL for long term storage (up to 50 years) is 2023. The timescale is divided into short, mid and long term (starting with commissioning of a geological disposal facility) periods, which provides the time frame for the course and completion of the main deliverables defined in the programme.

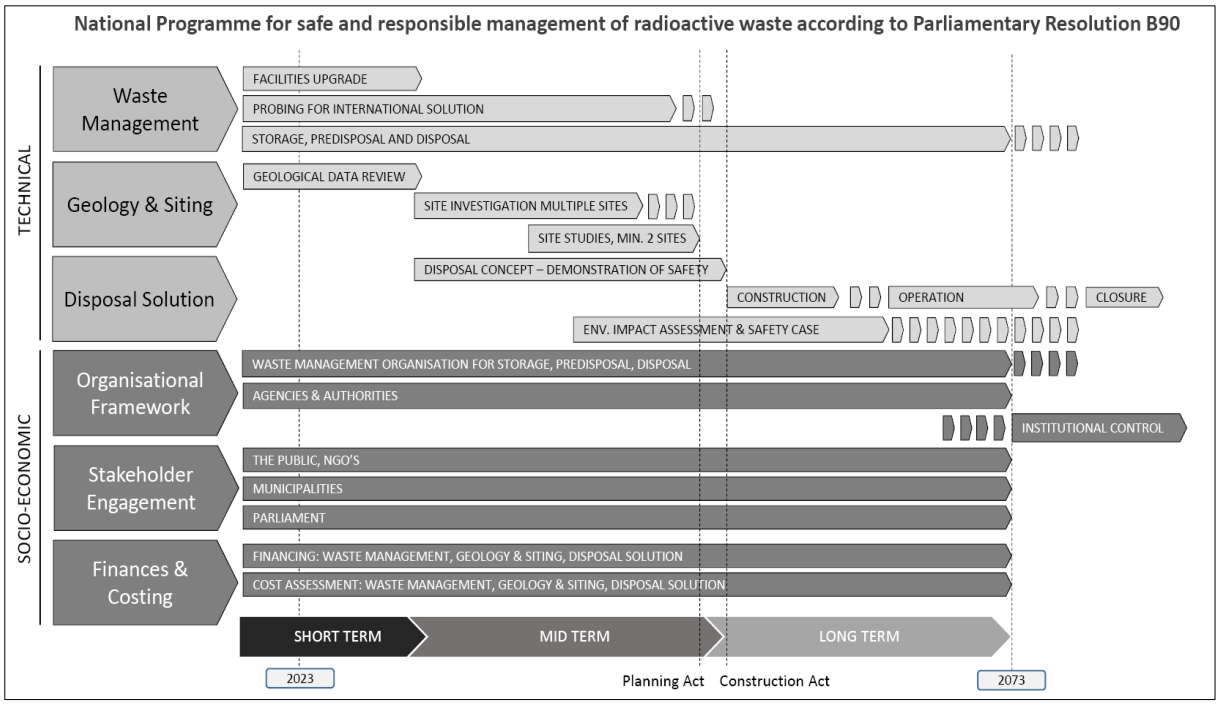

Figure 1. National Programme for the Safe and Responsible Management of Radioactive Waste; Main areas (thick bars), deliveries (thin bars) and terms (bottom bars)
(National Programme for the Responsible and Safe Management of Radioactive Waste, Denmark, Danish Health Authority, 2020)

The main overview of deliverables across areas over a short, mid and long term perspective in the programme is summarized in the list below:

<u>Short- to mid-term</u>

1. Establish an upgraded storage facility, reassessment of radioactive waste inventory, predisposal management and research, development and demonstration activities – taking into account management options for the "special waste".

2. Review and identification of geologies suitable for disposal down to 500 m depth

3. Identify possible disposal concepts including feasibility and barrier system studies

4. Designation of most relevant sites for detailed studies based on the outcome of 1-3 and partnership options.

Mid to long term

1. Proposal for one or more specific type(s) of disposal solution(s) to be established
2. Planning Act (for selected option)
3. Construction Act
4. Safety Case and Environmental Impact Assessment
5. Construction and operation
6. Closure and institutional control

The operational lifetime of existing waste storage facilities it is not defined. However, structures of the buildings are monitored and the buildings are kept in conditions sufficient for current operational activities.

ARTEMIS observation

The National Programme defines essential tasks to achieve the overall goals for the management of radioactive waste over short, mid and long term periods defined in Resolutions B48 and B90. However, it specifies only few milestones related to the overall goals without in-between milestones and end states for a period of 50 years, e.g., to establish NOL by 2023 and to have a Danish waste disposal solution by 2073. Also, according to chapter 5.1.1 it should be understood that a commencement of the NOL construction should be in 2022 and commissioning of operation by August 2026.

A schedule for design, construction and operation of the NOL including licencing and other decisions taking steps is not yet fully defined. The design operational period of existing storage facilities for radioactive waste at the Risø Research Centre is not indicated in the ARM.

The schedule for development of a disposal facility is not clearly defined. A timeframe of the following steps is not defined: (1) site selection (including deliverables indicated in the National Programme), (2) development of the disposal facility concept and WAC, (3) development of design, (4) predisposal management of waste in accordance with WAC for disposal, (5) construction, (6) operation and (7) closure of the disposal facility, timeline for transfer of the waste to disposal facility as well as the relevant milestones for licensing and other decision taking points is not defined. As noted by the ARTEMIS Review Team from the discussions with the Danish counterparts, there are no interim targets and end states neither within the frame of national strategy nor in the plans of DD. The plan for the development of a geological disposal facility by DD does not have interim milestones and end states. It does not include all steps of radioactive waste management and all important elements of the strategy. This issue will be discussed in more detail in chapter 4 of the report. The ARTEMIS Review Team noted, that DD considers 2073 as milestone already for completion of a transfer of all radioactive waste from the Risø Research Centre to disposal facility, but not as start of operation of the facility.

The National Programme indicates a need of re-assessment of the radioactive waste inventory. This activity can have considerable impact on the implementation of the National Programme. However, a schedule for re-assessment of radioactive waste inventory as well as research and development activities is not specified. In several parts of the ARM it is said that the decommissioning strategy calls for the release of all buildings, installations and land previously used by the Risø Research Centre for nuclear operations, research or development, for other uses without restrictions (green field). A milestone for the achievement of the so called "green field" condition of the site is not specified.

2.3. PROGRESS INDICATORS

Danish position

The National Programme identifies technical and socio-economic areas as overall constituents of the programme structure. Within each area, several deliverables (objectives to be achieved) have been defined. Deliverables are achieved through completion of projects and sub-projects, conducted by relevant licensees, contractors, authorities etc. Achievement of objectives are not fixed to a specific point in time, but are linked to short-, mid- and long-term perspectives. The deliverable will be completed through conduct of projects and subprojects defined by the party (organisation) responsible for the deliverable.

Within each project or subproject, milestones and key performance indicators (KPIs) will be defined as per routine project management approach by the organisation (or contractor) undertaking the project or subproject.

KPIs applied within each area may provide quantitative information on the progress towards completing projects or subprojects needed for reaching defined objectives (the deliverable).

However, KPIs applied at the project level do not necessarily provide meaningful information on the progress toward completing the deliverable, as this to a higher degree may depend on acquired milestones or other qualitative factors such as the timely conduct and coordination within the sum of projects and subprojects needed to complete the deliverable.

The progress of activities of DD is monitored by the annual Performance Contract with the Ministry of Higher Education and Science. With regard to the activities performed by Geological Survey of Denmark and Greenland, progress will be monitored according to a project plan for the exploratory geological site investigations. The project plan will be developed on the basis of collaboration with local authorities when the sites for exploratory investigation are identified later in 2022 on the basis of a dialogue between the Ministry of Higher Education and Science and local authorities/communities.

ARTEMIS observation

Considering that National Programme does not establish timeframe for achievement of deliverables or milestones, interim targets or end states for monitoring progress of the National Programme implementation, the progress of implementation of the National Programme is not traceable.

The main indicators for monitoring of the progress of the National Programme seems to be the timely conduction and coordination of deliverables (objectives to be achieved). However, the National Programme states that achievement of objectives are not fixed to a specific point in time, but are linked to short-, mid- and long-term perspectives, which also are fixed to only two milestones: 2023 and 2073. The deliverables will be completed through conduct of projects and subprojects defined by the organisation responsible for the deliverable and having their own milestones and KPIs. However, the link from projects and subprojects KPIs to the indicators of the progress of the implementation of the National Programme is unclear.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *The National Programme defines essential tasks to achieve the overall goals for the management of radioactive waste over short, mid and long term. However, it specifies only few milestones related to the overall goals. The specified milestones are to establish an upgraded storage facility (NOL) by 2023 and to have a Danish waste disposal solution by 2073. The National Programme does not establish milestones for achievement of deliverables or any other interim targets or end states, which could be used for monitoring the progress of its implementation.*	
(1)	**BASIS: GSR Part 1 (Rev.1) Requirement 10, para. 2.28 states that** *"[…] The strategy shall include appropriate interim targets and end states. Radioactive waste generated in facilities and activities necessitates special consideration because of the various organizations concerned and the long timescales that may be involved. The government shall enforce continuity of responsibility between successive authorized parties".*
(2)	**BASIS: GSR Part 1 (Rev.1) Requirement 10, para. 2.30 states that** *"Radioactive waste generated in facilities and activities shall be managed in an integrated, systematic manner up to its disposal. […]".*
R3	**Recommendation: The Government should update the National Programme in order to include appropriate interim targets and end states for the monitoring of programme implementation for all types of radioactive waste.**

3. INVENTORY OF SPENT FUEL AND RADIOACTIVE WASTE

Danish position

The classification of radioactive waste in Denmark follows the IAEA classification of 2009. Classification as very low level radioactive waste (VLLW) can only be done with the explicit approval of the regulatory authority. The national inventory of radioactive waste comprises of low and intermediate level waste. All radioactive waste subject to the government waste management policy is stored by DD at the Risø site.

For national purposes Denmark has been grouping the radioactive waste into 20+ groups in 2011 during a pre-feasibility study. The study was based on a summary and predictions on future waste compiled in 2008 in the so called 'basis for decision' for a Danish disposal facility for low and intermediate level waste, i.e. in the early days of the decommissioning at Risø. This system is continuously used also for planning purposes.

A significant part of the inventory of ILW comprises a small amount of waste, termed "special waste", which has a total inventory of less than 600 TBq according to the National Programme. The special waste consists of seven waste groups, amongst them about 233 kgHM of experimentally irradiated fragments, some remaining unirradiated fuel and the liquid reactor core of the former research reactor DR 1. From the 600 TBq special waste, 35 TBq are long-lived alpha-emitting nuclides.

The mass and material composition of the special waste is relatively well known and shown in Table 2. The fission products, ^{137}Cs and ^{90}Sr, and the actinides, ^{239}Pu and ^{240}Pu, almost exclusively account for the current activity of the DR 1 liquid core solution.

Spent Fuel	Storage facility	Material	Mass/Volume	Activity
Core solution from DR 1	DR 3 building complex	Solution of 20% enriched uranyl sulphate in light water	4.9 kg U 15.8 l	28.4 GBq fission products 0.4 GBq actinides
Experimentally produced and irradiated fragments of spent fuel of power reactor type	The Centralvej Storage	Uranium oxide pellets mostly in zircalloy tube	233 kg U	533 TBq fission products 35 TBq Actinides

Table 1. Specification of the special waste, including the material composition and quantities with regard to mass/volume and activity as of January 2020

(National Programme for the Responsible and Safe Management of Radioactive Waste, Denmark, Danish Health Authority, 2020)

Most of the other radioactive waste in Denmark originates from the decommissioning of the research reactors and associated nuclear facilities at the Risø site. A small part of the waste, less than 10 t per year, originates from applications in industry, medicine and research, which is delivered to DD. The total amount of waste conditioned for disposal and destined for disposal

after completion of the decommissioning projects was estimated at 5 000 – 10 000 m³ in 2008 and 2011 and depends on the decision regarding a long-term solution for the management of existing and continuously produced NORM waste, which is currently being stored at industrial sites under regulatory control but not as part of the national waste management policy. According to more recent estimates in the National Programme (2020), the waste to be disposed of will have a volume of around 15 000 m³ excluding NORM waste.

Following the adoption of B90, DD will establish NOL which will replace the existing five storage facilities for radioactive waste at the Risø site. According to B90, all radioactive waste stored at Risø will be transferred to the upgraded storage facility and will remain stored there until a disposal solution for the waste is operational. The transfer operations are to be performed as fast as possible and only later detailed requalification and eventual reconditioning for disposal are foreseen. An additional, future source of radioactive waste is the increasing number of cyclotrons to be decommissioned. According to previous preliminary studies, referred to in the National Programme, significant amounts of low-activity concrete and steel could result from these activities However, after re-evaluation such additional volume would not compromise the contingency of 20 % of the planned capacity of 15 000 m^3 for NOL.

The data of radioactive waste is, for most waste, available in DD's Waste Management Database ADS. Historical waste is not yet included in the ADS. Furthermore, for two of the storage facilities (Drum storage and Centralvej Storage) the inventory is reported collectively as there is only limited information on many of the individual packages.

Accordingly, some of the radioactive waste needs (re-)assessment. This is planned during the operational phase of the NOL. The re-assessment will address the perspective for each of the waste groups identified.

ARTEMIS observation

Although there is a data base providing some basic information on every waste item, the information on individual characteristics of waste items needs improvement. DD plans to execute a re-assessment programme only after transfer of all the packages into the new storage facility. During the transfer process, the basic measurements for radiation safety are planned to be performed. DD plans to repackage waste if necessary.

The ARTEMIS Review Team acknowledges the need for a timely transfer of radioactive waste from the facilities that have a risk of flooding and/or other safety issues.

At the same time, the ARTEMIS Review Team points out that the transfer process is a good opportunity to improve incomplete information on the radiological content of the individual packages. From an organizational and radiation protection point of view, this would mean a practical application of the principle of optimization by reducing the number of handling procedures and correlated personnel exposure. Such a measurement program should be used not only to fill gaps in documentation, to verify existing information for the purpose of quality assurance and to enhance confidence on storage assessment.

The foreseen re-assessment of waste packages will be performed in a new treatment facility, which still has to be designed. The ARTEMIS Review Team notes that such re-assessment and this new facility are important steps in preparing for disposal. The ARTEMIS Review Team understands that DD plans to re-assess and characterise the waste, focussing on properties relevant for storage. The planned re-assessment and characterization would also be beneficial for qualifying the packages in view of future disposal.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *For some waste packages, especially historical waste, there is only little information available. The inventory of radioactive waste in the drum storage facility and the Centralvej Storage facility are reported only collectively. Danish Decommissioning intends to transfer all existing waste to the NOL without prior re-assessment of the waste, in order to bring the packages into a safer storage facility.*	
(1)	**BASIS: GSR Part 5 Requirement 9 states that** *"at various steps in the predisposal management of radioactive waste, the radioactive waste shall be characterized and classified in accordance with requirements established or approved by the regulatory body."*
(2)	**BASIS: GSR Part 5 Requirement 9, para. 4.10 states that** "*radioactive waste has to be characterized in terms of its physical, mechanical, chemical, radiological and biological properties."*
(3)	**GRS Part 3 para 3.24 states that** *"for occupational exposure and public exposure, registrants and licensees shall ensure that all relevant factors are taken into account in a coherent way in the optimization of protection …."*
R4	**Recommendation: In order to improve inventory data Danish Decommissioning should perform nuclide specific measurements on the individual waste packages in the course of transfer activities to a new storage facility, as appropriate.**

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

Danish position

Since 2003 DD has been conducting decommissioning activities for the major nuclear installations in Denmark, all of them located at the site of the Risø research centre. According to the updated timeline these activities will be terminated before the end of this decade. Facilities and services are in place at DD for predisposal of radioactive waste from the decommissioning as well as from the collection of institutional waste. They are regarded as sufficient on the short term ("establishing phase"). As arisings of specific waste streams in Denmark are limited, DD contracts some treatment services abroad, e.g., incineration of burnable waste.

There are 1060 drums with bituminized waste stored on the Risø site. Bituminization was stopped in 2015 after a fire incident during waste processing. No further waste of this type is expected in the future.

DD chose a contractor to advise on how to deal with problematic waste, including the bituminized waste. A preliminary study will start in May 2022 and is planned to be finished in October 2022.

Currently DD is preparing the license application for the construction and subsequent operation of NOL on the premises of the research center. Once the WAC for NOL are established and the facility is in operation, waste now stored in the 5 existing facilities will sequentially be transferred to the NOL-facility starting with the packages currently stored in locations with higher flooding risk.

For already stored waste packages a need to reassess quality and documentation has been identified, which may include the need for repackaging or reconditioning. Based on the WAC for the NOL-facility any new waste arisings will be conditioned accordingly and directly stored at NOL.

For the transfer, WAC for NOL take into account the requirement to facilitate transfer of all radioactive waste already in storage but ensuring continuous safe conditions for storage at NOL. Liquid waste will not be accepted in the NOL. Reversibility will have also to be ensured. For the subsequent long term storage phase the WAC for NOL will require characterization of stored packages in view of the subsequent disposal.

The safety assessment for the NOL is under preparation as well as the WAC, which shall be finalized as soon as the safety assessment is substantiated. Requalification of existing waste packages and conditioning of new waste according to the WAC for NOL will require the construction of a new waste treatment facility which is deemed necessary anyway on the long term for preparing waste packages for disposal.

Planning for the disposal of an estimated total volume of 14 000-17 500 m^3 is an ongoing process. As stated in parliamentary resolution B90 and the National Programme the disposal facility has to start operation not later than 2073 followed by an operational phase of 50 years. The next steps are:

- involvement of local communities in the selection of two sites for further geological investigations shall be initiated by the Ministry of Higher Education and Science in 2022 and
- Geological invenstigations at 2 selected sites will commence in 2023 and will be subcontracted to the Geological Survey of Denmark and Greenland.

ARTEMIS observation

Although there are some operational services available for the treatment of limited amounts of solid and liquid institutional as well as decommissioning wastes, DD is planning for a new treatment facility. This waste treatment facility is not yet described in the National Programme. It is unclear, to which extent the management of "special waste" shall be covered by the scope of this new facility, as the self-assessment states that also "international solutions" for these waste groups are being considered. There exists no clear decision basis for the selection of the most appropriate conditioning technique for some of the waste groups.

The existing decentralized storage facilities are considered inappropriate for the foreseen long-term storage, either for technical reasons and/or as they are located at the sea shore only a few meters above todays sea level. This is why Denmark plans to transfer such waste to the NOL immediately after it will be licensed for operation; at present NOL is in an advanced planning stage.

The ARTEMIS Review Team notes that even preliminary WAC for disposal do not exist, which would be needed to plan for characterization in compliance with optimization in radiation protection and to perform a qualified conditioning/reconditioning of historic and newly generated waste in due time during long term storage before disposal. In their observation the IRRS team noted that future nuclear facilities are not covered by existing regulatory framework. The ARTEMIS Review Team expects that the necessary legal framework will be addressed in the implementation of IRRS Recommendation R2 in order to ensure that generic WAC can be established by the implementer.

The disposal solution for all of the waste streams still has to be defined on the technical level. Only an endpoint of the establishing phase for a national disposal facility has been defined: start of operation shall be not later than 2073. As -at least for a part of the waste- international disposal options are still under consideration, significant uncertainties exist for a number of boundary conditions. It is not unlikely that such pending decisions and other uncertainties of the planning basis may have retarding effects on the development of the disposal facility.

During the presentations the ARTEMIS Review Team noted that some essential aspects of the National Programme are missing in DD's strategy for the disposal facility as developed up to now and that a full understanding has still to be reached on the complex interdependencies between the various tasks and deliverables needed for the successful conduct of a deep geological disposal project. The ARTEMIS Review Team expects that the necessary legal framework will be addressed in the implementation of IRRS Recommendation R2 in order to ensure DD is fully responsible for establishing the long-term solution for managing radioactive waste.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *Concepts, plans and technical solutions are developed for the waste management steps of the near future. Some strategic and technical decisions are pending, especially those concerning disposal. The deadline, however, is fixed as the disposal facility shall start operation not later than 2073. Decision making in time to reach that goal needs an information basis for which some dedicated research and development is needed.* *The current planning for the geological disposal as presented by DD needs completion -as some important work packages are missing- and refinement -as the timeline is not entirely consistent with the National Programme and existing interdependencies are not indicated. It should cover the whole project period including compilation of design criteria, conducting the site selection process, compiling the knowledge basis including any necessary research and defining milestones for taking decisions between still available options, design, licensing, construction, operation, closure and post closure phase.* *There is no oversight process in place, how the timely implementation of the National programme is controlled.*	
(1)	**BASIS: SF-1 Principle 2 states that** *"An effective legal and governmental framework for safety, including an independent regulatory body, must be established and sustained."*
(2)	**BASIS: SF-1 Principle 2 para 3.9 states that** *"government authorities have to ensure that arrangements are made for preparing programmes of actions […] and for disposing of radioactive waste."*
R5	**Recommendation: To ensure timely operation of the disposal facility the implementer should prepare a comprehensive implementation plan consistent with the National Programme.**
R6	**Recommendation: The Government should establish a compliance assurance procedure for the implementation of the National Programme.**

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *Neither specific nor generic waste acceptance criteria for disposal are available to support the selection of applicable waste treatment procedures. This favours decisions to postpone treatment of waste, thereby increasing the risk of future legacies. The resulting additional handling steps for final conditioning in the future will lead to avoidable personnel exposure.*	
(1)	**BASIS: SF-1 Principle 7, para 3.29 states that** *"Radioactive waste must be managed in such a way as to avoid imposing an undue burden on future generations;[...]"*
(2)	**BASIS: GSR Part 3 para 3.24 states that** *"for occupational exposure and public exposure, registrants and licensees shall ensure that all relevant factors are taken into account in a coherent way in the optimization of protection [....]"*
(3)	**BASIS: GSR Part 5 Requirement 10 states that** *"[...] The processing of radioactive waste shall be based on appropriate consideration of the characteristics of the waste and of the demands imposed by the different steps in its management (pretreatment, treatment, conditioning, transport, storage and disposal). [...]"*
(4)	**BASIS: GSR Part 5 para 4.13 states that** *"The main purpose of processing radioactive waste is to enhance safety by producing a waste form, packaged or unpackaged, that fulfils the acceptance criteria for safe processing, transport, storage and disposal of the waste. Waste has to be rendered into a safe and passive form for storage or disposal as soon as possible [...]"*
(5)	**BASIS: SSG-14 para 3.10 states that** *"The operator has to develop technical specifications [...]. This includes waste acceptance criteria and other controls and limits to be applied during construction, operation and closure."*
R7	**Recommendation: The implementer of the disposal facility should develop generic waste acceptance criteria for disposal and -as soon as a facility specific safety case is available- final waste acceptance criteria on the basis of regulatory body requirements.**

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

Danish position

The Danish legislative system sets the obligation for an undertaking applying for an authorization to submit a safety assessment. This is regulated by the Act on Ionising Radiation and Radiation Protection, Chapter 2, § 5, and by the Executive Order No. 669 (01/07/2019) on Ionising Radiation and Radiation Protection of the Ministry of Health, the DHA. In addition, Chapter 2, § 5 of the Radiation Protection Act entrusts the DHA to lay down detailed rules regarding the compilation of safety assessments, while § 20 of Executive Order No. 669 sets the requirements for licensees to compile a safety assessment commensurate with the nature, scale and complexity of the use of radiation sources or exposure as well as for its continuous update.

Furthermore, for the construction and the operation of a nuclear facility, an approval by the Minister of Health has to be obtained according to the Nuclear Installation Act. Approvals are granted on the basis of Preliminary and Final Safety Analysis reports to be submitted according to Executive Order no. 278 of 27 June 1963 on Protective Measures against Accidents at Nuclear Facilities, §§ 3 and 4.

The same Act also entitles DHA and DEMA to set Operational Limits and Conditions associated to the Approvals. Operational Limits and Conditions for DD are regularly updated.

Activities on decommissioning of nuclear installations and corresponding radioactive waste management are subject to the provisions of the Nuclear Installations Act. In particular, the safe conduct of decommissioning activities and operation of the different storage facilities in the Risø site is regulated by limits and conditions (BfDA), issued by DHA and DEMA, and communicated to DD with a letter of the Ministry of Health in 2003, when the company took the responsibility for decommissioning operations and waste management activities on the basis of the B48 Parliamentary Resolution.

The safety assessment for the installations under decommissioning and for conducting waste management activities, in particular storage, is developed in the Safety Documentation prepared by DD in compliance with BfDA. This documentation covers different topics, including a detailed description of facilities on the site and an assessment of emergency scenarios, such as fire, flooding etc. For a specific facility under decommissioning project and subproject descriptions have to be prepared, which are then reviewed and approved by the DHA and in case of nuclear facility by the DEMA and, for specific operations, complemented with detailed work plans that are transmitted to the DHA and for nuclear facility by the DEMA for information. The working plans are used for by DHA and the DEMA for inspections and as a base of information to monitor the status of the decommissioning process and timeline.

According to Parliamentary Decision B48 the Danish decommissioning strategy envisages the unconditional release of the Risø site (green field). BfDA therefore also require that a final decommissioning report and a final clearance report have to be prepared and defines their content.

In relation to existing waste storage facilities in the Risø site the DD documentation comprises a safety analysis of incidents scenarios and also less probable events (accident scenarios). BfDA establish safety requirements for the safe storage of waste in the dedicated facilities. As reported in the ARM the existing storage facilities are neither built nor suitable for long-term storage of radioactive waste. In particular, design margins against flooding events are also quite small as demonstrated in 2013 when as result of a severe storm water level raised quite above the normal

level. Specific emergency preparedness provisions are put in place. Existing storage facilities in the Risø site also do not have enough capacity to store all the radioactive waste generated by the decommissioning operation.

As said in other chapters of this report the construction of a new storage facility is planned. This facility is planned to accommodate all the waste in storage for 50 years, in the wait that a geological disposal will be made available. The ARTEMIS Review Team has been informed that a safety case of this new storage facility is under preparation by DD as part of a Preliminary Safety Report to be presented to the regulatory body – jointly DHA and DEMA – in order to get the approval for construction. The safety case will provide demonstration that the new facility will be adequately protected against rising water level, severe meteorological conditions, such as the development of a hurricane, the preservation of climate control to minimize corrosion of waste drums, as well as specific security related events, etc. A Guide setting up General requirement for contents of safety assessment, issued by the DHA, is in place and it is applicable also to the construction of a new radioactive waste storage facility. The necessary specific requirements for the new storage facility have been however defined by DHA and DEMA and provided to DD in dedicated workshops in order to facilitate the application for approval of construction under the provisions of the Nuclear Installations Act.

In relation to the disposal facility to be realized at the latest by 2073 according to the national policy the preparation of the safety case has to be started, being the siting process still to be initiated and waiting for a decision on selected site.

The construction of a disposal facility is subject to a licensing procedure according to Executive Order 670/2019 §5 and a specific safety assessment has to be submitted according to Executive Order 669/2019 §20.

ARTEMIS observation

For decommissioning activities already in progress no general guidance had been issued by the Regulator addressing decommissioning of nuclear facilities. In this regard the IRRS report states that since DD is the only operator of a nuclear facility in Denmark, based on the principle of graded approach DHA and DEMA have instead established BfDA which are specific requirements addressing the waste management and decommissioning activities performed by DD. BfDA include in fact details that could appear in regulations based on IAEA Safety Standards for decommissioning. An example is the standard content of the documentation to be prepared by the licensee for the safety assessment of decommissioning projects as reported in section 2 of the BfDA. Furthermore, in this section it is also stated that the safety assessment should be prepared in accordance with the pertaining IAEA Safety Standards. The IRRS team report states that being DD the only licensee involved in the decommissioning of nuclear installations compiling of and use of specific requirements instead of developing specific regulatory documents for decommissioning is in line with applying graded approach in regulation. In this regard, taking also into account the small dimension of the Danish nuclear programme, the ARTEMIS Review Team shares the observation in the IRRS team report.

The ARTEMIS Review Team has however noted that for the waste management installations to be developed in the future (i.e. a new storage facility, a waste treatment facility and geological disposal facility) guidance on the format and content of the documents to be submitted by DD in support of the application for authorization addressing safety case aspects in the different phases of the lifetime of each installation have not been developed by the regulatory body. The ARTEMIS Review Team has noted that this issue has also been addressed in the IRRS Report and shares the Recommendation R8 that the IRRS team has formulated.

The ARTEMIS Review Team also observed that regulatory requirements covering specific safety criteria, including those related to the performance of the safety assessment, and associated guidance documents for the development and authorization of new waste management facilities have also not been developed yet by the regulatory body. This issue is covered by Recommendation 1 in this report.

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

Danish position

Apart from the institutional radioactive waste all other radioactive waste in Denmark originates from activities of state institutions at the research center Risø. Hence the financing of all waste management steps is under the responsibility of the state. The costs and their timely occurrence are correlated to three major groups of activities:

a. The decommissioning of shut down installations (to be finalized in 2023), short term;
b. Upgrading of existing storage facilities and licensing, installation and start up of the NOL, including preparation and transfer of existing waste to this facility, mid-term; and
c. Planning, site selection, licensing, installation and operation of the final repository, long term.

The responsibility for cost calculation, planning and execution for activities a) and b) and – partly – c) has been appointed. It is understood that the involved organisations bear their own expenses in execution of their responsibility from the annual budgets unless there is a specific government project financing available. For the project implementation of NOL and the disposal facility, financing will be provided from the reserve fund, a budget position established as a consequence of decisions B48 and B90, which is especially dedicated to the projects of the National Programme. In this framework the implementation project for the disposal facility might be regarded as a "high risk" project.

ARTEMIS observation

The mechanisms to plan and ensure financial provisions for managing radioactive waste in Denmark are comparable to those in other countries where such responsibility lies exclusively with the state. Operational and institutional costs are planned in the annual budgets of the corresponding government organisations and a specific budget position, the reserve fund for costly and/or long term projects, has been established. The successful execution of the decommissioning projects so far gives evidence for the adequacy of installed financing procedures.

The ARTEMIS Review Team noticed that the recent update of the cost estimations in the National Programme (2020) is still based on a feasibility study prepared in 2011 with only minor adaptions, e.g., application of some scaling factors. They are not based on best available information. The ARTEMIS Review Team considers the calculational basis for estimating the financial risks insufficient.

The ARTEMIS Review Team recognizes a significant cost risk in the fact that there seems to be no provision for the costs which will arise from the management of NORM waste stored at the industrial producer sites and which is still produced continuously. The ARTEMIS Review Team highlights that in the process of updating the National Policy and National Programme according to IRRS Recommendation 3 and Recommendation 3 of this report also the appropriate financial provisions shall be considered.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *Cost estimations for the development of the disposal are to a large extend based on a feasibility study of 2011. The corresponding implementation plan has not yet been developed by Danish Decommissioning. This fact is already covered by Recommendation 5.*	
(1)	**BASIS: GSR Part 1 (Rev.1) Requirement 10 states that** *"Provision for the decommissioning of facilities and the management of radioactive waste and of spent fuel, para 2.33. states that "appropriate financial provision shall be made for:* *(a) …* *(b) Management of radioactive waste, including its storage and disposal;* *(c) …"*
S1	**Suggestion: As soon as a comprehensive implementation plan for the disposal project is available, the Government should consider updating the corresponding cost estimation and implement a procedure for periodic review and update. Risks and uncertainties should be accounted for according to the stage of the project.**

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

Danish position

The implementation of the Danish National Programme for the radioactive waste management has its main actors in the DD, as national implementer, and the regulatory body, whose functions are exploited by the DHA and DEMA.

In order to accomplish its tasks, Section 10 (Organization) of the DD Safety Documentation stipulates qualification requirements and competences for all relevant staff units. As specific educational and training programmes are not offered by Danish Universities, DD has developed its own educational programme for new staff.

For the short term, in order to maintain the necessary competences and skills, starting from 2022 and every two years a *waste management plan* will be prepared indicating the current needs for expertise, skills and resources. These plans are expected to provide what is needed in order to properly implement the task related to the construction and operation of the new storage facility. The ARTEMIS Review Team has also been informed that in 2022 DD intends to apply a stronger intelligent Customer approach with the aim of having sufficient in-house knowledge to understand and define project needs and requirements in order to select the appropriate contractor for a given task.

For the long term DD will have to manage an important transformation phase with the view of becoming a National Centre of Competence for RW management including disposal. DD is aware that new competences will be needed to develop and implement a disposal solution and that recruitment of new staff might be difficult in the future. In this regard possibilities for collaboration between Nordic and other countries are also investigated.

In relation to the regulatory body the ARTEMIS Review Team has been informed that Circular No. 9654/2020 §4 for DHA and Circular No. 9450/2020 §4 for DEMA stipulates that the two authorities assist the Ministry of Health by maintaining and further developing expertise and qualifications related to safe radioactive waste management through training or other staff competence development arrangements, as needed for the National Programme for maintaining safety and radiation protection. The issue of competences, resources and skills of the regulatory body has been addressed during the IRRS mission. A general recommendation addressed to DHA on the development of a human resources plan in relation to the entire spectrum of its regulatory responsibilities has been formulated in the IRRS Report (Recommendation R4). In relation to DEMA and the regulatory task expected to be performed in connection with the new waste management facilities, a specific suggestion on the future competence needs has also been formulated in the IRRS Report (Suggestion S5). In particular, DEMA should consider finalising the identification of competences required for the review and assessment of the safety of such facilities, and ensuring all competences are available in due time. Furthermore, a suggestion has also been addressed to the Government to enhance the existing funding mechanism for DHA (Suggestion S1). DHA has informed the ARTEMIS Review Team that a new position related to radioactive waste management will be advertised.

ARTEMIS observation

First elements of a strategic plan for the development of necessary competences have been defined by DD in connection with the Waste Management Plan 2022. The long duration in time for the development of a disposal facility however indicate the need to prepare a strategic plan

for competences management (identification of needed skills according to the implementation plan of the facility, recruitment, training, management of generations transition) and to regularly review and updated it on the basis of relevant progresses in the definition of the implementation plan. In this regard the long storage period of the waste has also to be taken into account.

As far as the regulatory body is concerned the ARTEMIS Review Team acknowledges and shares the recommendation and suggestions on competences and skills development formulated in the IRRS report.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *Danish Decommissioning is aware that several competences will be needed to develop and implement a geological disposal facility. First elements on competences needed have been defined in the DD's strategy. The long duration in time required for the development of the disposal facility however suggests the need to establish a strategic plan for competences development and to regularly update it on the basis of relevant progress in the definition of the DD implementation plan of geological disposal facility.*	
(1)	**BASIS: SF-1 Principle 1 states that** *"The prime responsibility for safety must rest with the person or organization responsible for facilities and activities that give rise to radiation risks."*
(2)	**BASIS: SF-1 Principle 1, para 3.6 states that** *"The licensee is responsible for:* *—Establishing and maintaining the necessary competences;* *—Providing adequate training and information; […]"*
S2	**Suggestion: Danish Decommissioning should consider establishing the strategic plan for competence management according to the needs identified in the implementation plan for development of the geological disposal facility, review and regularly update it.**

APPENDIX A: TERMS OF REFERENCE

ARTEMIS Review of the National Radioactive Waste Management Programme of Denmark

Terms of Reference

1. Introduction

On 14 December 2016, the Resident Representative of Denmark to the IAEA, requested the International Atomic Energy Agency (IAEA) to organize and carry out an Integrated Review Service for Radioactive Waste and Spent Fuel, Decommissioning and Remediation (ARTEMIS) review. Denmark requested the ARTEMIS review to satisfy its obligations under 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).

2. Objective

The ARTEMIS review, performed by an international peer review team selected by the IAEA, will provide an independent international evaluation of Denmark's radioactive waste and spent fuel management programme, based on the relevant IAEA Safety Standards and proven international practices.

3. Scope

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

It was agreed to exclude:

1. All radioactive waste management subject to the provisions of the autonomous authority of the respective self-governments of the Faroe Islands and Greenland.
2. The remediation of sites affected by residues from past activities, as such sites have not been identified in Denmark.

Results from the IAEA Integrated Regulatory Review Service (IRRS) mission to Denmark conducted from 29 August to 8 September 2021 will be taken into account, where relevant and appropriate to avoid unnecessary duplication.

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, including the results of a national self-assessment, which should be based on the ARTEMIS self assessment questionnaire provided by the IAEA.

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 shall be submitted in English.

Reference material for the purpose of the ARTEMIS review shall be submitted to the ARTEMIS mission webpage on the Global Nuclear Safety and Security Network (GNSSN) of the IAEA.

6. Modus operandi

The working language of the mission will be English.

The National Counterpart is the Danish Ministry of Health. The National Counterpart Liaison Officer for the review is Mr David Ulfbeck from the Danish Health Authority, Radiation Protection.

The ARTEMIS review mission will be conducted from 1 to 9 May 2022 at the premises of Danish Dekommissioning, Frederiksborgvej 399, in Roskilde, Denmark. The provisional schedule for the review mission is provided in **Annex 2**.

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

- Self-assessment questionnaire: available to Denmark as of 5 May 2021
- Preparatory Meeting: **14 December 2021** (WebEx meeting)
- Notification by IAEA to the Counterparts on the review team composition: by **15 February 2022**.
- Submission of reference material: 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 by **15 February 2022** (including the completed self-assessment)
- Submission of questions from the review team to the Counterpart based on preliminary review of the reference material: by **8 April 2022**

- Peer review mission: **1 to 9 May 2022** (9 days):
    - Sunday: arrival of experts and their meeting.
    - Monday to Wednesday: interviews/exchange/discussion with Counterparts on the basis of preliminary analysis and drafting of recommendations and suggestions.
    - Thursday: finalization of recommendations and suggestions - presentation and discussions of recommendations/suggestions/good practices with the Counterparts.
    - Friday: drafting of the report, informing the Counterparts when the draft report is going to be submitted (Review Team).
    - Saturday: delivery of draft report to the Counterparts for fact checking -
    - Sunday: internal reflection of comments by Review Team - discussions with the Counterparts and finalization of draft report by Review Team.
    - Monday: delivery of final draft report – exit meeting – closure.

7. International peer review team

The IAEA will convene a team of international experts to perform the ARTEMIS review according to the ARTEMIS Guidelines and these Terms of Reference. The team will consist of:

- Four qualified and recognized international experts from government authorities, regulatory bodies, waste management organizations, or technical support organizations with experience in the safe management of radioactive waste.
- Two IAEA staff to coordinate the mission. The Coordinator of the ARTEMIS review is Mr Andrey Guskov of the Department of Nuclear Safety and Security of IAEA. The Deputy Coordinator is Ms Merle Lust of the Department of Nuclear Energy of IAEA;
- One IAEA staff for administrative support.

A senior staff member from the Department of Nuclear Safety and Security of IAEA will oversee the closure of the review.
The peer review team will be led by Mr Stefan Theis, ENSI, Switzerland, Team Leader from the review team. 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 Counterpart 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, represented by the Danish Health Authority, Radiation Protection.

9. Funding of the ARTEMIS review

The cost estimate for the ARTEMIS review includes travel costs, per diem of the peer review team (external experts and the IAEA staff) in line with the IAEA Financial Regulations and Rules.

The peer review will be funded by the Government of Denmark. The cost of the ARTEMIS review is estimated to the amount of 32 000 EUR, to be paid to the IAEA as voluntary contribution before the start of the mission. Denmark is aware that the review cost includes 7% programme support costs.

If the actual cost of the ARTEMIS review exceeds the estimated voluntary contribution, Denmark agrees to cover such additional cost to the IAEA. Similarly, if the actual cost is less than the estimated voluntary contribution, any excess will be refunded to Denmark through the MO Danish Health Authority

These Terms of Reference were agreed on 14 December 2021 between the IAEA and the Danish Health Authority on behalf of the Ministry of Health, during the preparatory meeting held on-line.

APPENDIX B: MISSION PROGRAMME

Time	Sun, 1 May	Mon, 2 May	Tue, 3 May	Wed, 4 May	Thurs, 5 May	Fri, 6 May	Sat, 7 May	Sun, 8 May	Mon, 9 May
8h30 – 10h00	Arrival of Team Members	**9h00 Opening** General presentation	Inventory Concepts, Plans and technical solutions	Cost estimates and financing Capacity building	**Finalization of Recommendations and Suggestions**	Drafting of the report	**Draft report to be sent to the Counterparts for fact checking**	Internal reflection of comments **Discussions with the Counterparts on the draft report**	Delivery of final draft report **EXIT MEETING**
10h00 - 12h00		National Policy and Framework							
12h00 - 13h00		Lunch	Lunch	Lunch	Lunch	Lunch	Lunch	Lunch	Departure of Team Members
13h00 – 16h00		National Strategy	Safety case and safety assessment	Site visit	**Presentation and discussions of Recommendations and Suggestions with the Counterparts**	Drafting of the report Informing the Counterpart when the draft report is to be submitted for fact checking	Counterparts review the draft report	Finalising draft report	
16h30 - 17h30	Artemis team meeting	Team meeting	Team meeting	Team meeting			Social event* (*- subject to Counterparts)		
		Drafting of the report	Drafting of the report	Drafting of the report					

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	The regulatory body should establish regulatory requirements and guidance documents for the development and authorization of waste management facilities in the different stages of their life-time (siting, design, construction, operation, decommissioning or closure and post-closure, as applicable).
		R2	The Government should ensure management of and control over all radioactive waste and designate waste management organizations that are obliged to accept all types of radioactive waste.
2.	NATIONAL STRATEGY FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT	R3	The Government should update the National Programme in order to include appropriate interim targets and end states for the monitoring of programme implementation for all types of radioactive waste.
3.	INVENTORY OF SPENT FUEL AND RADIOACTIVE WASTE	R4	In order to improve inventory data Danish Decommissioning should perform nuclide specific measurements on the individual waste packages in the course of transfer activities to a new storage facility, as appropriate.

	Area	R:Recommendations S: Suggestions G: Good Practices	Recommendations, Suggestions or Good Practices
4.	**CONCEPTS, PLANS AND TECHNICAL SOLUTIONS FOR SPENT FUEL AND RADIOACTIVE WASTE MANAGEMENT**	R5	To ensure timely operation of the disposal facility the implementer should prepare a comprehensive implementation plan consistent with the National Programme.
		R6	The Government should establish a compliance assurance procedure for the implementation of the National Programme.
		R7	The implementer of the disposal facility should develop generic waste acceptance criteria for disposal and -as soon as a facility specific safety case is available- final waste acceptance criteria on the basis of regulatory body requirements.
6.	**COST ESTIMATES AND FINANCING OF RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT**	S1	As soon as a comprehensive implementation plan for the disposal project is available, the Government should consider updating the corresponding cost estimation and implement a procedure for periodic review and update. Risks and uncertainties should be accounted for according to the stage of the project.
7.	**CAPACITY BUILDING FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT – EXPERTISE, TRAINING AND SKILLS**	S2	Danish Decommissioning should consider establishing the strategic plan for competence management according to the needs identified in the implementation plan for development of the geological disposal facility, review and regularly update it.

APPENDIX D: LIST OF ACRONYMS USED IN THE TEXT

ARM – Advance Reference Material

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

B48 – Parliamentary Resolution B48/2003 on the Decommissioning of Nuclear Facilities at Risø Research Centre

B90 – Parliamentary Resolution B90/2018 on a Long-Term Solution for Denmark's radioactive waste

DD – Danish Decommissioning

DEMA – Danish Emergency Management Agency

DHA – Danish Health Authority

IAEA – International Atomic Energy Agency

IRRS – Integrated Regulatory Review Service

KPIs – key performance indicators

NOL – New Upgraded Storage Facility

VLLW – very low level radioactive waste

WAC – waste acceptance criteria

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).