

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

FOLLOW-UP MISSION

TO

GERMANY

Cologne, Germany

6 to 12 November 2022

DEPARTMENT OF NUCLEAR SAFETY AND SECURITY
DEPARTMENT OF NUCLEAR ENERGY



IAEA

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

ARTEMIS



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REMEDICATION (ARTEMIS) MISSION
TO
GERMANY**

Mission dates: *6-12 November 2022*

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Organized by: *IAEA*

ARTEMIS REVIEW TEAM

Mr Patrice François	ARTEMIS Team Leader (France)
Mr Geert Volckaert	Reviewer (Belgium)
Mr Kai Hämäläinen	Reviewer (Finland)
Mr Paolo Gui	Reviewer (Italy)
Ms Candida Lean	Reviewer (UK)
Mr Gerard Bruno	IAEA Team Coordinator
Mr Vladimir Michal	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 18 August 2021, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) of Germany, requested the International Atomic Energy Agency (IAEA) to organize and carry out, in November 2022, an Integrated Review Service for Radioactive Waste and Spent Fuel, Decommissioning and Remediation (ARTEMIS) follow-up mission.

The purpose of the ARTEMIS follow-up mission was to review the implementation of the findings identified during the initial ARTEMIS mission organised from 22 September to 4 October 2019, and where appropriate, to address areas of significant change since the last mission including new topics as requested. The initial 2019 ARTEMIS mission was requested by Germany 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).

The follow-up review mission took place at the headquarters of Gesellschaft für Anlagen- und Reaktorsicherheit GmbH (GRS) in Cologne from 7 to 12 November 2022. It has been performed by a team of five senior international experts in the field of decommissioning, radioactive waste and spent fuel management, from multiple IAEA Member States, with three IAEA staff providing coordination and administrative support.

Representatives of German organizations during the mission itself were from the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV), the Federal Office for the Safety of Nuclear Waste Management (BASE), the Federal Company for Radioactive Waste Disposal (BGE), the Company for Storage (BGZ) and GRS on the level of senior management and professional staff.

The scope of ARTEMIS follow-up mission included all aspects and topics covered in the initial 2019 ARTEMIS mission, i.e framework, competent regulatory authority, national programme and its implementation for safe management of radioactive waste. However, the focus was on the topics that had received findings (recommendations and suggestions) during the initial ARTEMIS mission in 2019. The outcomes from the IAEA Integrated Regulatory Review Service (IRRS) mission conducted in Germany in April 2019 were also taken into account, as appropriate, to avoid unnecessary duplication.

To assess progress made since the initial mission to address the recommendations and suggestions, ARTEMIS team received presentations from the German counterparts and conducted a series of discussions to evaluate to which extend the findings of the initial mission could be considered closed and needed to remain opened.

The ARTEMIS team found that Germany has successfully implemented many recommended actions from the 2019 mission. However, out of the 3 recommendations and 12 suggestions identified in the initial mission in 2019, the following 2 recommendations and 2 suggestions still need further work and progress and consequently remain open:

- BMU should update the cost assessment for the national waste management programme in the Cost Report, based on a consistent approach across all activities, including waste retrieval from Asse II mine.
- The Government should analyse risk and uncertainty when updating the cost assessment for all public sector components of the radioactive waste and spent fuel management programme.

- BGE, in consultation with BfE, as appropriate, should consider assessing whether the requirements on the geosphere for NHGW are different from those for HLW and, if they are, taking them into account in the approach to applying the siting criteria.
- BMU should consider making greater use of the radioactive waste inventory to monitor changes in the inventory over time and demonstrate waste minimization

Findings and related considerations supporting above outcomes of the follow-up peer review are summarized in this report.

A press release was issued by the IAEA at the end of the peer review mission.

I. INTRODUCTION

On 18 August 2021, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)¹ from Germany requested the International Atomic Energy Agency (IAEA) to organize and carry out, in November 2022, an Integrated Review Service for Radioactive Waste and Spent Fuel, Decommissioning and Remediation (ARTEMIS) follow-up mission.

The purpose of the ARTEMIS follow-up mission was to review the implementation of the findings identified during the initial ARTEMIS mission organised from 22 September to 4 October 2019, and where appropriate, to address areas of significant change since the last mission including new topics as requested. The initial 2019 ARTEMIS mission was requested by Germany 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).

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

¹ Now Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV)

II. OBJECTIVE AND SCOPE

The objective of the ARTEMIS follow-up mission was to conduct an independent international evaluation of Germany's implementation of the findings identified during the initial ARTEMIS mission on the radioactive waste and spent fuel management programme carried out in 2019.

The scope of the ARTEMIS follow-up mission included all aspects and topics covered in the initial 2019 ARTEMIS mission, i.e framework, competent regulatory authority, national programme and its implementation for safe management of radioactive waste. However, the focus was on the topics that had received findings (recommendations and suggestions) during the initial ARTEMIS mission in 2019.

The outcomes from the IAEA Integrated Regulatory Review Service (IRRS) mission conducted in Germany in April 2019 were taken into account, as appropriate, to avoid unnecessary duplication.

III. BASIS FOR THE REVIEW

A) PREPARATORY WORK AND IAEA REVIEW TEAM

At the request of the Government of Germany, a virtual preparatory meeting for the ARTEMIS follow-up mission, was conducted on 13 of June 2022. The preparatory meeting was carried out by the appointed Team Leader Mr Patrice François, the IAEA coordinator and deputy coordinator Mr Gerard Bruno and Mr Vladimir Michal respectively, and the team of National Counterparts led by Ms Anke Krause from the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) of Germany.

The ARTEMIS follow-up mission preparatory team had discussions regarding:

- the Terms of Reference for the ARTEMIS follow-up; and
- the specific characteristics and organisation of the ARTEMIS follow-up mission in Germany.

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 follow-up mission in Germany in November 2022.

Ms Anke Krause from the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection of Germany was appointed as the National Counterpart for the ARTEMIS follow-up mission and designated IAEA point of contact.

Germany provided IAEA with the Advance Reference Material (ARM) for the review in September 2022.

B) REFERENCES FOR THE REVIEW

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, 6 November 2022 in Cologne, directed by the ARTEMIS Team Leader Mr Patrice François, supported by the ARTEMIS Team Coordinator Mr Gerard Bruno and the Deputy Team Coordinator, Mr Vladimir Michal.

The ARTEMIS entrance meeting was held on Monday, 7 November, with the participation of the representatives of BMUV, the Federal Office for the Safety of Nuclear Waste Management (BASE), the Federal Company for Radioactive Waste Disposal (BGE), BGZ Company for Storage (BGZ) and Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) gGmbH senior management and staff. Opening remarks were successively made by Mr Gerrit Niehaus, Director General for nuclear safety and radiation protection of BMUV, Mr Gerard Bruno and Mr Patrice François. BMUV representatives together with the regulatory authority (BASE) and operators (BGE, BGZ, KTE) gave an overview of the German radioactive waste management context.

During the ARTEMIS follow-up mission, a review was conducted for all review topics within the agreed scope with the objective of reviewing the Government's response to the recommendations and suggestions indentified during the initial mission.

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

The ARTEMIS Exit Meeting was held on Saturday, 12 November 2022. Closing remarks were made by Mr Gerrit Niehaus, Director General for nuclear safety and radiation protection of BMUV. A presentation of the results of the Review Mission was given by the ARTEMIS Team Leader Mr Patrice François. Closing remarks were made by the IAEA coordinator Mr Gerard Bruno.

An IAEA press release was issued.

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

1.1. NATIONAL POLICY

There were no findings in this area in the original ARTEMIS mission.

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

Original mission RECOMMENDATIONS AND SUGGESTIONS	
<p>Observation: <i>To ensure effective delivery of the National Programme, regular monitoring of overall performance, including the achievement of targets, is important. The current approach sets only longterm milestones for project implementation. This does not make the underpinning plans transparent.</i></p>	
(1)	<p>BASIS: GSR Part 2 Requirement 4 states that <i>”Senior management shall establish goals, strategies, plans and objectives for the organization that are consistent with the organization’s safety policy. [...]</i></p> <p><i>4.3. Goals, strategies, plans and objectives for the organization shall be developed in such a manner that safety is not compromised by other priorities.</i></p> <p><i>4.4. Senior management shall ensure that measurable safety goals that are in line with these strategies, plans and objectives are established at various levels in the organization.</i></p> <p><i>4.5. Senior management shall ensure that goals, strategies and plans are periodically reviewed against the safety objectives, and that actions are taken where necessary to address any deviations.”</i></p>
(2)	<p>BASIS: GSR Part 1 (Rev. 1) Requirement 10 states that <i>“The government shall make provision for the safe decommissioning of facilities, the safe management and disposal of radioactive waste arising from facilities and activities, and the safe management of spent fuel.</i></p> <p><i>Decommissioning of facilities and the safe management and disposal of radioactive waste shall constitute essential elements of governmental policy and the corresponding strategy over the lifetime of facilities and the duration of activities [3, 7]. The strategy shall include appropriate interim targets and end states.”</i></p>
(3)	<p>BASIS: SSG-16 para. 2.89 states that <i>“The government should inform all interested parties regarding decisions on the implementation of a nuclear power programme, including the long term national and international commitments to maintain nuclear safety and the necessity of measures such as establishing new organizations, building new national infrastructure and making financial provision for radioactive waste management and spent fuel management.</i></p>

Original mission RECOMMENDATIONS AND SUGGESTIONS	
	<i>Information should be provided to the public, local governments, committees representing local interests, industry, news media, non-governmental organizations and neighbouring States.”</i>
(4)	BASIS: GSR Part 5 Requirement 6, states that <i>“Interdependences among all steps in the predisposal management of radioactive waste, as well as the impact of the anticipated disposal option, shall be appropriately taken into account.”</i>
R1	Recommendation: The Government should establish a process to monitor regularly the progress of the national decommissioning and radioactive waste and spent fuel management programme, including the associated costs, timeframes and interdependencies between projects.
S1	Suggestion: Given the long timescales of the projects, the Government should consider establishing additional shorter-term interim targets as key performance indicators.

Changes since the initial ARTEMIS mission

Recommendation 1:

Based on the advance reference material (ARM) and presentations during the review mission, the German government has established and developed a monitoring system for its national decommissioning and radioactive waste and spent nuclear fuel management programme (the National Programme). BGE, the operator for the disposal facilities and responsible for high level waste (HLW) site selection, and BGZ, operator for the radioactive waste and spent fuel storage facilities that formerly belonged to the utilities, report to BMUV quarterly on the progress and annually on the business plans. This reporting is not publicly available, but the content of BGE’s quarterly report was presented to the ARTEMIS Review Team during the mission. It contains a section for each major project of BGE which covers the progress, delays, reasons for delays, project risks and risk management. The report also includes time schedules, critical milestones for each project and finance and resource estimates for the next 5 years.

The progress reports are reviewed by BMUV, which usually gives feedback to the operators via a dialogue-based process. Operators respond to the questions in writing and update the next quarterly report accordingly. During the review mission, BMUV explained to the ARTEMIS Review Team that there are also procedures for more formal interventions but these have not been used so far.

BGE reports quarterly to BASE on the progress of the HLW site selection process. BASE and BGE communicate in parallel with this reporting, with formal dialogue at the management level and informal dialogue at the technical level. BASE also monitors observations from the public and complementary sources of information to cover stakeholder participation in the site selection process.

Reporting requirements for decommissioning projects are stipulated in the decommissioning licenses and set in the operating rules. Monitoring of the progress is done by BMUV based on the monthly, quarterly and annually delivered reports by the utilities and EWN. Federal and Länder level regulators also meet biannually in the Working Group Decommissioning of the Länder Committee for Nuclear Energy to exchange information on the decommissioning

activities. In parallel with the progress reporting, GRS has established a national decommissioning database on the progress of NPP decommissioning projects. Progress on the decommissioning of nuclear power plants (NPP) is monitored by the Federal Office for Economic Affairs and Export Control (BAFA) from a financial perspective. Progress on the decommissioning of the state-owned research facilities is monitored by the Federal Ministry of Education and Research (BMBF), with support from GRS.

Interdependencies between different projects are monitored at the ministry level as outlined in the National Programme and presented during the review mission. The Länder Committee for Nuclear Energy is an important forum for competent authorities in the waste management and decommissioning area. The ARTEMIS Review Team considers that the interdependencies on radioactive waste and spent nuclear fuel management and decommissioning projects are managed at a federal level. However, there is room for improvement since there are several federal institutions which have their own responsibilities in the area.

Status of Recommendation 1

Recommendation 1 is closed.

Changes since the initial ARTEMIS missions

Suggestion 1:

The ARTEMIS Review Team focused on long-term projects and the status of the short-term interim targets within those. The German counterparts presented clear and detailed time schedules with short-term interim targets for the Asse II mine waste retrieval preparation and for the commissioning of the Konrad disposal facility.

BGE presented short term targets for the site selection process for HLW disposal. BGE informed the ARTEMIS Review Team that these targets will be developed to cover the rest of the Phase 1 soon. No interim targets are set yet for Phases 2 and 3.

The ARTEMIS Review Team considered that the goal for selecting a HLW disposal site by 2031 is challenging. The issue was discussed during the review mission and the German counterparts explained that the year 2031 in Stand AG is set as an objective. Without this flexibility the ARTEMIS Review Team would strongly suggest creating a realistic time schedule for the whole site selection process as soon as possible. However, because of the flexibility in the end date, short-term interim targets for Phases 2 and 3 can be developed when the phase 1 of the siting process has produced enough information to set the goals for the rest of the phases. As a side note, the ARTEMIS Review Team noticed that there is an inconsistent interpretation of the binding strength of the year 2031 in Stand AG section 1 between stakeholders.

The overall time schedule for the decommissioning of all the NPPs is given in the implementation report of Directive 2011/70/EURATOM. The ARTEMIS Review Team was informed that more detailed plans for each decommissioning project are included in license applications and updated in the progress reports.

Status of Suggestion 1

Suggestion 1 is closed.

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

There were no findings in this area in the original ARTEMIS mission.

2. NATIONAL STRATEGY FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT

2.1. SCOPE

There were no findings in this area in the original ARTEMIS mission.

2.2. MILESTONES AND TIMEFRAMES

Original mission RECOMMENDATIONS AND SUGGESTIONS	
<p>Observation: <i>BGE’s understanding of how their approach to applying the four types of site selection criteria may change during the three site selection phases has not yet been made clear.</i></p>	
(1)	<p>BASIS: SSG-14 Appendix 1 Siting of Geological Disposal Facilities, para. I.5 states that <i>“The key geoscientific criteria that will be used in support of judgements concerning the potential suitability of a site should be developed by the operator, in accordance with national regulatory requirements. Such criteria might include requirements or preferences for the host rock and surrounding geosphere, e.g. tectonic setting, rock characteristics and groundwater properties. From these criteria, screening guidance should be established for the selection of suitable areas and host rocks and later for the selection of the preferred site(s). It is recognized that, as knowledge improves, the criteria, or any limits placed on the criteria, may change during the siting process.”</i></p>
S2	<p>Suggestion: BGE, in consultation with BfE, as appropriate, should consider publishing the approach to applying the site selection criteria during all three phases in advance of the interim report on sub areas.</p>

Changes since the initial ARTEMIS mission

Suggestion 2:

BGE published its method for applying the siting criteria in Step 1 of Phase 1 of the site selection procedure in the Sub-areas Interim Report Pursuant to Section 13 StandAG (September 2020). The general public and experts were involved in developing the method via online consultations that were held by BGE between November 2019 and August 2020. Some of the information obtained during these discussions prompted an adjustment to the approach to applying the site selection criteria.

The approach to applying the site selection criteria will evolve as the siting progresses. BGE told the ARTEMIS Review Team that it will pursue a similar approach to public consultation on the application of siting criteria in subsequent phases of the site selection process.

BGE is developing a method for applying the siting criteria in Step 2 of Phase 1 of site selection. Public consultation on a discussion concept was carried out online in April and May 2022 via www.forum-bge.de.

In line with the Site Selection Act (StandAG), BASE has not reviewed the initial screening of sub-areas (phase 1 step 1) and the concept for a method for phase 1 step 2. Following application of the siting criteria during Step 2 of Phase 1 of site selection, BGE has to propose regions for surface exploration. BASE will examine the proposal for regions selected for surface exploration. It will establish Regional Committees, commenting procedures and hearings for the review of the proposal. Following this, BASE will make a recommendation for areas for surface exploration to BMUV. The final decision on sites for surface exploration is taken by Bundestag and Bundesrat as federal law.

Status of Suggestion 2

Suggestion 2 is closed.

Original mission RECOMMENDATIONS AND SUGGESTIONS	
<p>Observation: <i>The site selection process aims to identify the site with the best possible safety for the disposal of HLW. Since the requirements on the geosphere of NHGW may be different from those for HLW, the site selection process may not identify the best site for both types of waste.</i></p>	
(1)	<p>BASIS: GSR Part 5 Requirement 2 states that “[...] The policy and strategy shall be appropriate for the nature and the amount of the radioactive waste in the State [...]”</p> <p><i>3.6 The national strategy for radioactive waste management has to outline arrangements for ensuring the implementation of the national policy. It has to provide for the coordination of responsibilities. It has to be compatible with other related strategies such as strategies for nuclear safety and for radiation protection.”</i></p>
S3	<p>Suggestion: BGE, in consultation with BfE, as appropriate, should consider assessing whether the requirements on the geosphere for NHGW are different from those for HLW and, if they are, taking them into account in the approach to applying the siting criteria.</p>

Changes since the initial ARTEMIS mission

Suggestion 3:

The Site Selection Act requires the selection of a site that provides the best possible safety for the disposal of HLW. Additional disposal of negligible-heat generating waste (NHGW) at the same site is possible if the safety of the HLW disposal is not compromised, but this is not a criterion for site selection.

Additional disposal of NHGW at the HLW disposal site would take place in a separate disposal facility (as mandated by § 21(2) EndlSiAnfV), providing separate confinement zones for HLW and NHGW. Under the Site Selection Act, BGE is required to assess whether NHGW can be

disposed of at the same site as the HLW at each phase of the site selection process, taking into account predicted volume requirements. The Act also requires demonstration that any NHGW disposal does not negatively influence the safety of HLW disposal. Safety of NHGW disposal will be assessed independently of the HLW site selection. BASE reviews the site selection process from a science-based perspective and monitors whether the process is proceeding in line with the law.

The inventory of NHGW that could be disposed of at the HLW disposal site will be dominated by waste retrieved from the Asse II mine, plus a smaller volume of NHGW that cannot be disposed of at the Konrad disposal facility. The disposal requirements for waste retrieved from Asse II mine will be defined after retrieval has started and the retrieved waste has been characterised. Waste retrieval from the Asse II mine is planned to start in 2033. Depleted uranium from enrichment is currently stored as nuclear material. If this material is not reused, the expected waste package volume to be disposed of would be up to 100 000 m³. Decisions during the HLW disposal facility site selection process on whether co-location is possible will be, i.a. based on sufficient rock volume. The siting criteria do not take into account the fact that the best disposal concept for HLW may not be suitable for NHGW.

Including the requirements of NHGW disposal in the siting criteria requires a change to the Site Selection Act, which there is no wish to do. Should the selected site for HLW disposal not be suitable for co-location of NHGW disposal then a new solution will be needed. This risk is not included in the National Programme.

Status of Suggestion 3

Suggestion 3 remains open.

Original mission RECOMMENDATIONS AND SUGGESTIONS	
<i>Observation: BGE has considered the conditions that would lead them to recommend that retrieval of waste from the Asse II mine be discontinued but has not made these public.</i>	
(1)	BASIS: SSG-23 para 4.99 states that <i>“Transparency requires openness, communication and accountability. This implies that the safety case and safety assessment should be documented in a clear, open and unbiased way that, for example, recognizes both the features of the disposal system that provide safety benefits and the uncertainties. The aim should be to provide a clear picture of what has been done in the assessment, what the results and uncertainties are, why the results are what they are, and what the key issues are, in order to inform decision makers. To increase transparency, it may also be appropriate to make the safety case documentation available to the public and to ensure that it is prepared in a manner and at a level of detail that is suitable for the intended audience.”</i>
S4	Suggestion: BGE should consider publishing the safety-based conditions that would lead them to recommend that retrieval of waste from Asse II mine be discontinued.

Changes since the initial ARTEMIS mission

Suggestion 4:

Retrieval of waste from the Asse II mine can only be discontinued on the basis of radiological or other safety-related justifications. BGE has revised its technical criteria for the discontinuation of waste retrieval and prepared a procedure for their use. A report will be sent to BMUV and BASE in November 2022 that describes a two-step process for determining an emergency situation. It proposes procedures for determining an emergency decision, introduces early warning levels and redefines the technical criteria, reducing the use of expert judgement in favour of quantitative defined values. The report identifies potential mitigation actions in the case of an emergency, including filling of cavities, emplacement chambers and infrastructure (including shafts), and counterflooding.

BGE has informed the Asse II Monitoring Group and the Nuclear Waste Management Commission (ESK) of the status of the discontinuation criteria. The ARTEMIS Review Team was informed that the report plus a non-technical summary will be published by the end of 2022.

Status of Suggestion 4

Suggestion 4 is closed on the basis of progress made and confidence in effective completion in due time.

3. INVENTORY OF SPENT FUEL AND RADIOACTIVE WASTE

Original mission RECOMMENDATIONS AND SUGGESTIONS	
<p>Observation: <i>The level of detail provided in the inventory for NHGW is limited to numbers and volumes of conditioned waste packages and weights of unconditioned waste (inorganic, organic and miscellaneous waste); there is no information on quantities and volumes, conditioning factors/processes or conditioning assumptions and characteristics for waste streams.</i></p>	
(1)	<p>BASIS: GSR Part 3 Requirement 31, para. 3.131 (e) states that “Registrants and licensees, in cooperation with suppliers, as appropriate: Shall maintain an inventory of all radioactive waste that is generated, stored, transferred or disposed of;”</p>
(2)	<p>BASIS: GSR Part 5 Requirement 8 states that “All radioactive waste shall be identified and controlled. Radioactive waste arisings shall be kept to the minimum practicable.”</p>
S5	<p>Suggestion: To improve transparency on how waste streams are being managed, BMU should consider including additional information and description on NHGW in future revisions of the radioactive waste inventory report.</p>
S6	<p>Suggestion: BMU should consider making greater use of the radioactive waste inventory to monitor changes in the inventory over time and demonstrate waste minimization.</p>

Changes since the initial ARTEMIS mission

Suggestion 5:

A new section (Section 4.1) has been added to the most recent inventory report (inventory status at 31 December 2019) “to enhance transparency on the treatment of radioactive waste streams”. This new chapter gives a qualitative high-level description of how different NHGW streams are treated and conditioned. However, no quantitative information is included on, for example, the volume reduction factors that can be realised through the application of the foreseen waste treatment and conditioning. Typical volume reduction factors for the methods referred to in the Inventory Report are publicly available in the Joint Convention Report 2021 (see Table L-5 Examples of stationary facilities for the conditioning of radioactive waste for own needs and third parties p282-283).

The ARTEMIS Review Team notes that it would be possible to list both raw and anticipated packaged waste volumes for future waste arisings and unconditioned waste based on assumed treatment and packaging scenarios of the operators. The ARTEMIS Review Team also notes that data on radionuclide vectors and specific chemical components are not included in the inventory report. The ARTEMIS Review Team encourages BMUV to add this type of information to future versions of the inventory report to enhance transparency.

Status of Suggestion 5

Suggestion 5 is closed.

Changes since the initial ARTEMIS missions

Suggestion 6:

The most recent inventory report (inventory status at 31 December 2019) includes a short section (Section 4.3) that explains in general terms the differences in inventory data between the current and previous reporting periods. The report states that the masses and volumes have changed, for example as dismantling of NPPs and waste treatment and conditioning progresses, but no quantitative interpretation of the data are provided or examples to demonstrate whether the reported changes are in line with the expected progress. BMUV told the ARTEMIS Review Team that the quantity of ‘product controlled’ waste (P2 and G2) did not significantly change due to difficulties in documenting compliance with updated water legislation.

Transparency in inventory reporting is complicated by the fact that projections of future waste production, treatment and conditioning are only reviewed every 10 years while the Inventory Report is updated every three years in line with the reporting requirements for the EURATOM 2011/70 Directive. BMUV is well aware that, as the operational date of the Konrad disposal facility is approaching, it is important to increase the volumes of ‘product controlled’ waste (that is, the volume of waste ready to be transferred to the Konrad disposal facility). The ARTEMIS Review Team considers that updated projections of future waste volumes should be included in every update of the Inventory Report.

BMUV told the ARTEMIS Review Team that the most recent waste volume projections indicate an increase of the volume of waste to be disposed of 60 000 m³, mainly due to revision of the expected NHGW volumes arising from the dismantling at the Jülich and Karlsruhe research centres and a change in waste treatment strategy at EWN. This volume will have to be considered in the inventory of NHGW that cannot be disposed of at Konrad.

The ARTEMIS Review Team considers that BMUV has demonstrated that it monitors and analyses the changes in inventory data with time. However, BMUV does not use the data in the inventory to determine whether or how its evolution demonstrates waste minimisation by the operators.

Status of Suggestion 6

Suggestion 6 remains open.

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

4.1. DECOMMISSIONING PROJECTS AND STRATEGIES

Original mission RECOMMENDATIONS AND SUGGESTIONS	
<p>Observation: <i>ZBL will be constructed to store radioactive waste coming from BGZ’s on-site NHGW storage facilities before the waste is emplaced in the Konrad facility. The ZBL facility is scheduled to be commissioned in 2027. The ZBL centralized storage facility could also be used to accept NHGW from all waste producers.</i></p> <p><i>Sites where only remain radioactive waste stored in on-site storage facilities operated by BGZ and where decommissioning of NPP is completed should be removed to ZBL to enable the entire sites to be released from regulatory controls within the next decade.</i></p>	
(1)	<p>BASIS: GSR Part 5 Requirement 6, states that <i>“Interdependences among all steps in the predisposal management of radioactive waste, as well as the impact of the anticipated disposal option, shall be appropriately taken into account.”</i></p>
S7	<p>Suggestion: The Government should consider taking benefit from the construction and operation of the ZBL by enabling this facility to accept NHGW from all waste producers and thereby increasing flexibility within the National Programme for radioactive waste management.</p>
S8	<p>Suggestion: BGZ should consider using the ZBL facility in order to remove all waste from sites where, after completion of decommissioning, only NHGW storage facilities will remain under operation to enable the entire sites to be released from regulatory controls.</p>

Changes since the initial ARTEMIS mission

Suggestion 7:

The need for a central reception storage facility is emphasised in the 2021 coalition agreement of the current government. The facility was originally referred to as Zentrales Bereitstellungslager (ZBL) in the Waste Management Transfer Act (§ 3(3) EntsorgÜG). The designation was changed to Konrad Centre of Logistics (LoK) after plans for implementation became more concrete and a siting decision had been reached. BGZ was charged with the siting, planning, construction and operation of LoK. The decision for the site, close to the Würgassen NPP site, was also endorsed by BMUV.

The ARTEMIS Review Team has been informed that the LoK facility will be designed to store 60 000 m³ of radioactive waste (15 000 packages). The licensing phase will start in 2023, the construction phase is planned to start from 2025 and operation from 2028 for 30 years. It is expected that this will result in a reduction of the Konrad disposal facility operational time from the original 40 years to a projected 30 years.

LoK in its current form is designed to serve as the central reception and organising point of radioactive waste to be disposed of in the Konrad disposal facility. It is expected that most of

the radioactive waste destined for disposal at Konrad that is currently stored in Germany (at around 30 storage facilities) will be sent to the LoK by waste producers. Even if direct shipment remains still possible from waste producers, it is expected that a very limited amount of radioactive waste will be sent to Konrad without using LoK (around 1%).

The ARTEMIS Review Team notes that the LoK facility will be able to accept radioactive waste from all storage facilities operated in Germany (and not only waste coming from storage facilities on NPP sites).

Status of Suggestion 7

Suggestion 7 is closed.

Changes since the initial ARTEMIS mission

Suggestion 8:

The aim of the LoK facility is to facilitate and optimise the placement of radioactive waste to the Konrad disposal facility. The purpose is not to define priorities among existing storage facilities, in particular for the sites which could be released earlier. The capacity of LoK is limited (roughly a fifth of the Konrad disposal facility's capacity: 60 000 m³) and may not allow such approach to be implemented. Nevertheless, it is indicated in the Self-Assessment Report that the way to reduce the number of sites under regulatory control will be considered by BGZ and the competent authorities when both LoK and Konrad facilities will be in operation. At least, it will facilitate an earlier removal of radioactive waste from existing storage facilities. These considerations answer to the suggestion 8.

The ARTEMIS Review Team considers that the use of the LoK facility will allow the earlier removal of radioactive waste from existing on-site storage facilities and could facilitate the release of sites from regulatory control.

Status of Suggestion 8

Suggestion 8 is closed.

4.2. PREDISPOSAL MANAGEMENT OF SPENT NUCLEAR FUEL

Original mission RECOMMENDATIONS AND SUGGESTIONS	
<p>Observation: <i>After completion of NPP decommissioning there will be no infrastructure that can be used to deal with damage to the body of spent fuel casks which requires unloading the spent fuel elements for reconditioning.</i></p>	
(1)	<p>BASIS: SSG-15 para. I.51 states that “Inclusion of a hot cell in the design of a dry spent fuel storage facility should be considered to allow for unloading the cask and subsequent repackaging of the fuel or repairs.”</p>
S9	<p>Suggestion: The Government should consider identifying a contingency plan for the repair of storage casks and the removal of spent fuel elements in case of damage.</p>

Changes since the initial ARTEMIS mission

Suggestion 9:

Information is provided in the Self-Assessment Report to explain what are the contingency plans in case of damage or loss of functions of the primary or secondary lids of the dual purpose-casks for spent nuclear fuel. The repair concept is approved in spent fuel storage facilities. Technical solutions that do not require the removal of the primary lid or to open the cask are possible. Therefore these repairs do not require a hot cell. For this container type an alternative transport configuration with the secondary lid as containment is part of the type B(U) approval. For transport, only one containment of the radioactive material (primary lid or secondary lid) is required according to the IAEA Safety Standard. For this container type an appropriate transport configuration is available or – as addressed below - under consideration. For this container type (apart from CASTOR® HAW28M) a transport configuration with the repair lid is licensed.

The ARTEMIS Review Team has been informed of the development of an alternative solution for the CASTOR® HAW28M, in the situation that the primary lid cannot ensure the leak tightness specified in the design approval of the package. This solution consists of using the second lid as a backup to the containment function of the primary lid. Only one barrier is necessary for transporting the package to the disposal facility. A change in package design approval is required, which is expected to be achieved in 2025. In case of loss of tightness of the primary lid and if this package design cannot be approved for stored CASTOR® HAW28M, a facility will be required to change the seal of the primary lid. A repair lid will be welded to the cask during storage which allows enough time for the licensing and the construction of such a facility.

BGZ considered that a loss of safety function of one of the lids during the current license period of 40 years is unlikely. It considers that the loss of the leak tightness of the two lids at the same time is very unlikely.

The implementation of a back-up infrastructure (hot cell facility for instance) to assure the safety and transportability of the HLW in the future remains under the responsibility of BGZ.

The ARTEMIS Team has been informed that BGZ has launched a research programme to assess the long-term behaviour of spent fuel.

Status of Suggestion 9

Suggestion 9 is closed on the basis of progress made and confidence in effective completion in due time.

Original mission RECOMMENDATIONS AND SUGGESTIONS

Observation: *It cannot be ensured that the HLW disposal facility will be available in time to accept the spent fuel from the planned ESTRAL storage facility which is only envisaged to be licensed until 2051.*

(1) **BASIS:** GSR Part 5 Requirement 6 states that “*Interdependencies among all steps in the predisposal management of radioactive waste, as well as the impact of the anticipated disposal option, shall be appropriately taken into account.*”

S10 **Suggestion:** EWN should consider designing the new ESTRAL storage facility to have a lifetime consistent with the planned availability of the HLW disposal facility which is not expected to begin operation before 2050.

Changes since the initial ARTEMIS mission

Suggestion 10:

During the mission, the ARTEMIS Review Team has been informed that the application for a new replacement transport cask storage facility ESTRAL (Ersatztransportbehälterlager) in Lubmin was submitted by EWN to BASE in May 2019 and a complete set of documents for public consultation – including the safety report – has been provided in 2021. The license application for operating the ESTRAL facility is under review and is intended to be valid until 2051. This is consistent with the commissioning of the HLW disposal facility planned for 2050.

In addition, it is indicated in the Self-Assessment Report that the design of the ESTRAL building has been developed considering a 100-year lifetime to allow a possible renewal of the licence at a later date. EWN expects no technical reasons as to why the facility would not be suitable for a considerably longer operational time than applied for. Nevertheless, this process would require a specific analysis of cask safety for a longer storage period and a licensing procedure. Research to facilitate such analysis has been initiated by the operators as well as by the authorities.

In addition, the Self-Assessment Report states that the receiving storage facility at the HLW disposal facility will also allow for some flexibility in the logistics for the removal of dual-purpose casks from the existing storage facilities, including ESTRAL.

Status of Suggestion 10

Suggestion 10 is closed.

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

5.1. STATUS OF SAFETY CASES FOR THE FACILITIES NEEDED FOR THE SAFE MANAGEMENT, AT ALL STAGES, OF ALL SPENT FUEL AND RADIOACTIVE WASTE

There were no findings in this area in the original ARTEMIS mission.

5.2. PROCESS FOR DEVELOPING AND MAINTAINING A SAFETY CASE AND/OR SUPPORTING SAFETY ASSESSMENTS

There were no findings in this area in the original ARTEMIS mission.

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

Original mission RECOMMENDATIONS AND SUGGESTIONS	
<p>Observation: <i>The 2015 Cost Report, part of Germany’s National Programme, does not reflect current progress in the implementation of the National Programme and does not include a complete overall cost assessment (e.g. retrieval of Asse II mine waste, ZBL).</i></p>	
(1)	<p>BASIS: GSR Part 1 (Rev. 1) Requirement 10, para. 2.33 states that <i>“Appropriate financial provision shall be made for:</i></p> <p><i>(a) Decommissioning of facilities;</i></p> <p><i>(b) Management of radioactive waste, including its storage and disposal;</i></p> <p><i>(c) Management of disused radioactive sources and radiation generators;</i></p> <p><i>(d) Management of spent fuel.”</i></p>
(2)	<p>BASIS: GSR Part 6 Requirement 9, para. 6.2 states that <i>“The cost estimate for decommissioning shall be updated on the basis of the periodic update of the initial decommissioning plan or on the basis of the final decommissioning plan. The mechanism used to provide financial assurance shall be consistent with the cost estimate for the facility and shall be changed if necessary.”</i></p>
(3)	<p>BASIS: GSR Part 6 Requirement 4, states that <i>“Responsibilities of the government for decommissioning</i></p> <p><i>The government shall establish and maintain a governmental, legal and regulatory framework within which all aspects of decommissioning, including management of the resulting radioactive waste, can be planned and carried out safely. This framework shall include a clear allocation of responsibilities, provision of independent regulatory functions, and requirements in respect of financial assurance for decommissioning. [...]</i></p> <p><i>— Establishing a mechanism to ensure that adequate financial resources are available when necessary for safe decommissioning and for the management of the resulting radioactive waste.”</i></p>
R2	<p>Recommendation: BMU should update the cost assessment for the national waste management programme in the Cost Report, based on a consistent approach across all activities, including waste retrieval from Asse II mine.</p>
S11	<p>Suggestion: BMU should consider updating the Cost Report more frequently (less than 10 years) with additional details on assumptions and cost breakdowns.</p>

Changes since the initial ARTEMIS mission

Recommendation 2:

BMUV provided the ARTEMIS Review Team with a draft copy of the “*Report on costs and financing of the management of spent fuel and radioactive waste*” (dated 23 August 2022). The scope of the updated overall cost assessment now includes the LoK facility construction cost (€ 355.1 million). Costs for the Asse II mine retrieval/disposal and for NHGW disposal (excl. Konrad) are still not developed, even as a preliminary estimates. For the HLW disposal facility an estimate (limited to the private sector) has been provided in the Stress Test report dated 2015 and it is not included in the draft Cost Report nor updated. BMUV explained that the private sector produces more than approx. 95% (in tonnes heavy metal equivalent) of the HLW in Germany and that the NPP/utilities paid approx. € 8.3 billion into the fund for this purpose (site selection and HLW repository) (cf. draft Cost Report, Page 9, footnote “Stresstest”, Annex 1). BMUV explained, that these figures are still the best and reliable ‘at completion costs’. Beyond that, estimated costs for the HLW disposal facility only partially cover the site selection process and the remaining costs of facility construction/operation. Updated costs for the storage of private operators’ waste are estimated from BGZ only for the timeframe 2022-2026.

The ARTEMIS Review Team noted that BGE published a retrieval plan for the Asse II mine in which “*all measures to be taken for the retrieval of radioactive waste from the mine are described in a coherent manner*” on 27 March 2020. BMUV emphasised that total project costs for the retrieval itself and the later disposal activities of the Asse II mine cannot be reliably estimated at the present time. The ARTEMIS Review Team recognises the challenge of developing such cost estimates but consider this information crucial to have a complete overview of the cost of the National Programme.

Cost figures provided in the report have been partially updated to reflect the current progress of implementation of the National Programme without a consistent approach. For example, the Konrad disposal facility cost estimate now reflects the current project schedule (expected operation 2027) and the cost figures for the Public Sector have been revised. The ARTEMIS Review Team noted that the cost figures for private operators are estimates from 2015 (“*decommissioning/dismantling of nuclear power plants and packaging of radioactive waste – € 19.7 billion*”) and 2014 (“*packaging of spent fuel and radioactive waste from reprocessing as well as the packaging of other radioactive waste - € 9.9 billion*”). With reference to disposal costs, the ERAM closure cost estimate still refers to 2007 values (“*€ 1.2 billion ± 30% for backfill material, sealing measures, costs of machinery, operating costs, infrastructure above and below ground, etc*”). During the discussion it was noted that private operators’ updated figures (estimate at completion) are annually reported in the “*Bericht nach § 7 des Transparenzgesetzes – Rückbau von Kernkraftwerken*”. The latest issue of this report dated 4 November 2021 was provided to the ARTEMIS Review Team (in German) during the mission.

The ARTEMIS Review Team was informed that, as general approach, costs are estimated in detail for the 5-year time frame required for the budget preparation process and that ‘at completion costs’ are not always assessed. In this context, BMUV explained that the costs calculated in the stress test for the vast majority of the disposal of the nuclear waste (NPP/utilities) are still the best ‘at completion costs’ and reliable cost calculations. The ARTEMIS Review Team considered that estimating/updating project ‘at completion cost’, even in a preliminary form, is a key element for the monitoring of the overall programme and its funding system.

Status of Recommendation 2

Recommendation 2 remains open.

Changes since the initial ARTEMIS missions

Suggestion 11:

The ARTEMIS Review Team was informed that the Cost Report will be updated in future with a three-year periodicity, as stated in the “*Programme for the responsible and safe management of spent fuel and radioactive waste*”. The draft version of the Cost Report includes no significant additional details or cost breakdowns, for example, there is missing information on reference year of the estimates, inflation details (if applied), uncertainty/risks details (if applied) and cost profile over time. Increasing the level of cost detail and breakdown (e.g by facility or activity) would improve clarity and transparency.

During the discussion in the review meeting, BMUV said that additional details and breakdowns will be provided in the final version of the Cost Report.

Status of Suggestion 11

Suggestion 11 is closed on the basis of progress made and confidence in effective completion in due time.

Original mission RECOMMENDATIONS AND SUGGESTIONS	
Observation: <i>Risk and uncertainty analyses are not undertaken as part of the cost assessment for all public sector components of the radioactive waste and spent fuel management programme.</i>	
(1)	BASIS: GSR Part 1 (Rev. 1) Requirement 10, para. 2.33 states that “ <i>Appropriate financial provision shall be made for:</i> <i>(a) Decommissioning of facilities;</i> <i>(b) Management of radioactive waste, including its storage and disposal;</i> <i>(c) Management of disused radioactive sources and radiation generators;</i> <i>(d) Management of spent fuel.</i> ”
(2)	BASIS: GSR Part 6 Requirement 9, para. 6.2 states that “ <i>The cost estimate for decommissioning shall be updated on the basis of the periodic update of the initial decommissioning plan or on the basis of the final decommissioning plan. The mechanism used to provide financial assurance shall be consistent with the cost estimate for the facility and shall be changed if necessary.</i> ”
(3)	BASIS: SSG-47 para. 6.5 states that “ <i>The cost estimate for decommissioning should cover all actions required to plan and perform the decommissioning. There will be additional costs for other actions, which might be included as part of the decommissioning, depending on the national legal framework. These typically include financing for the management of waste from operation, pre-decommissioning actions during the transition phase, waste storage and disposal, and spent fuel management.</i> ”
(4)	BASIS: SSG-47 para. 6.8 states that “ <i>With regard to the accuracy and associated uncertainties of the decommissioning cost estimate, there are typically three types of cost estimate made during the lifetime of the facility:</i>

Original mission RECOMMENDATIONS AND SUGGESTIONS

	<ul style="list-style-type: none"> • <i>An order of magnitude estimate — this type of cost estimate can be utilized prior to receiving the operating licence and is based on the initial decommissioning plan.</i> • <i>A budgetary estimate — this type of cost estimate is based on the data provided in revisions of the decommissioning plan.</i> • <i>A definitive estimate — this type of cost estimate can be utilized after the completion of detailed planning of the decommissioning actions, and is based on the data provided in the final decommissioning plan and in the associated working level documentation (procedures).”</i>
(5)	<p>BASIS: SSG-47 para 6.10 states that “<i>Cost estimates and financial provisions should be reviewed periodically and should be adjusted as necessary to allow for proper consideration of inflation and other factors, such as technological advances, waste management costs or regulatory changes, especially in the case of a deferred dismantling strategy where decommissioning might be completed only decades after shutdown of the facility.</i>”</p>
R3	<p>Recommendation: The Government should analyse risk and uncertainty when updating the cost assessment for all public sector components of the radioactive waste and spent fuel management programme.</p>

Changes since the initial ARTEMIS mission

Recommendation 3:

Based on the information provided during the review meeting, uncertainties and risks are not systematically assessed and reported in the cost figures for all public sector components of the radioactive waste and spent fuel management programme. In some cases, operators evaluate these figures separately, but this information is not included or disclosed in the Cost Report. No example calculations were provided during the review meeting by BMUV, BGZ² and EWN/KTE.

The ARTEMIS Review Team was informed that projected total costs are expected to increase further in the coming years since the planning basis on which the cost estimate is based is, for some parts, still subject to large uncertainties.

Considering the wide scope of the National Programme under public funding liability, the ARTEMIS Review Team considers that an analysis of risk and uncertainty would be beneficial when updating the cost assessment for the whole of the National Programme.

The Government faces a risk that costs for radioactive waste management (e.g. storage and disposal) will be greater than estimated and uncertainties and risk analysis is considered beneficial.

Status of Recommendation 3

Recommendation 3 remains open.

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² BGZ is a state owned company under private law

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

Original mission RECOMMENDATIONS AND SUGGESTIONS	
Observation: <i>The various organizations involved in radioactive and spent fuel management independently pursue research programmes.</i>	
(1)	GSR Part 1 (Rev. 1) Requirement 10, para 2.32 states that “ <i>The government shall make provision for appropriate research and development programmes in relation to the disposal of radioactive waste, in particular programmes for verifying safety in the long term.</i> ”
(2)	GSR Part 1 (Rev. 1) Requirement 10, para 4.45 states that “ <i>In the process of its review and assessment of the facility or activity, the regulatory body shall take into account such considerations and factors as:</i> <i>(15) Relevant research and development plans or programmes relating to the demonstration of safety;</i> ”
S12	Suggestion: The Government should consider enhancing the coordination of research, development and demonstration activities for the management of spent fuel and radioactive waste to ensure they are commensurate with the needs of waste management operators and regulators.

Changes since the initial ARTEMIS mission

Suggestion 12:

The Government issued its Strategy for Competence Building and the Development of Future Talent for Nuclear Safety in 2020. It includes 6 areas of action to maintain and develop nuclear expertise, which includes research and development as well as international engagement.

Responsibilities for nuclear safety and waste management research were reorganised in 2021. BMUV now has responsibility for:

- departmental research to develop the scientific basis for BMUV’s work and preparation of an annual research plan, and
- independent research carried out under the Project Funding Programme for Nuclear Safety Research for Nuclear Facilities, which implements the research policy objectives published in the Federal Government’s 2018 7th Energy Research Programme in the field of nuclear safety and waste management research.

BMUV’s nuclear safety and waste management research programmes are complemented by the promotion of basic nuclear safety research by BMBF, including:

- institutional funding of the Helmholtz Association through the NUSAFE-Programme on nuclear waste management, safety and radiation research, and
- project funding, including the research funding programme on decommissioning and dismantling (FORKA).

BASE has a legal obligation to pursue its own regulatory research in radioactive waste management. It maintains a research strategy, which provides a 10-year vision, and an underpinning research agenda, which specifies research topics and provides the linkage between the strategy and individual projects. BASE developed both documents in consultation with expert stakeholders and the interested public. The research strategy, research agenda and research project outputs are published. BASE held the first of its planned biennial international research symposiums on safety of nuclear waste disposal in 2021.

Regulations require the coordination of all Government research and development activities. This facilitates identification of synergies between research areas and avoidance of duplication. Coordination activities include:

- use of the Federal Research Coordination Database,
- Joint Project Committees for the review of planned BMUV and BMBF projects,
- regular inter-ministry meetings with subordinated authorities, federal companies and other research organisations,
- the work of competence groups that allow information and expertise exchange between research institutes, universities, expert organisations and implementors in the fields of nuclear technology (KVKT), repository research (DAEF) and radiation research (KVSF), and
- BMUV is developing an inventory of research in the field of radioactive waste management.

Status of Suggestion 12

Suggestion 12 is closed.

APPENDIX A: TERMS OF REFERENCE

Terms of Reference

1. Introduction

On 18 August 2021, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) from Germany, requested the International Atomic Energy Agency (IAEA) to organize and carry out, in November 2022, an Integrated Review Service for Radioactive Waste and Spent Fuel, Decommissioning and Remediation (ARTEMIS) follow-up mission.

The purpose of the ARTEMIS follow-up mission is to review the implementation of the findings identified during the initial ARTEMIS mission organised from 22 September to 4 October 2019, and where appropriate, to address areas of significant change since the last mission including new topics as requested. The initial 2019 ARTEMIS mission was requested by Germany 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).

The review will be led by the IAEA by the Department of Nuclear Safety and Security who will be supported by the Department of Nuclear Energy. The review will be conducted by an international team of experts selected by the IAEA.

2. Objective

The ARTEMIS follow-up mission will provide an independent international evaluation of Germany's implementation of the findings identified during the initial 2019 ARTEMIS mission national framework.

3. Scope

The scope of ARTEMIS follow-up mission will include all aspects and topics covered in the initial 2019 ARTEMIS mission, i.e framework, competent regulatory authority, national programme and its implementation for safe management of radioactive waste.

The outcomes from the IAEA Integrated Regulatory Review Service (IRRS) mission conducted in Germany in April 2019 will be taken into account, as appropriate to avoid unnecessary duplication.

4. Basis for the review

The ARTEMIS follow-up mission 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 ARTEMIS follow-up mission will cover all documentation submitted by Germany for the considered scope of the review. The National Counterpart requesting a follow-up mission should provide adequate (updated) Reference Material to demonstrate the progress and implementation of measures that have been made since the finalization of the primary Review Report.

Germany will provide a description of the way each one of the recommendations and suggestions raised during the initial 2019 ARTEMIS mission has been addressed, with supporting documentation as reference material for the mission.

Germany indicated during the preparatory meeting that no major changes have taken place in the German's Radioactive waste and spent fuel management programme. The focus of the self-assessment is therefore on the suggestions and recommendations of the initial 2019 ARTEMIS mission.

The ARM from the initial ARTEMIS mission is also made available to the follow-up ARTEMIS Team.

In the case of new topics to be included in the scope of the follow-up mission, the ARM will also give full information related to the extended parts according to the guidance applicable to initial missions.

The provisional list of reference material is provided in the **Annex 1** (this 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 review, including the review mission, will be English.

The National Counterpart is the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection of Germany. The National Counterpart Liaison Officer for the review is Ms Anke Krause.

The ARTEMIS review mission will be conducted from **6 to 12 November 2022** in Cologne, Germany. 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:
- Preparatory Meeting: **13 June 2022** (WebEx meeting).
- Notification by IAEA to the Counterparts on the review team composition: by **June 2022**.

- Submission of reference material: available to Germany as soon as they are available and not later than **8 September 2022**.
- Submission of questions from the review team to the Counterpart based on preliminary review of the reference material: by **17 October 2022**.

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:

- Five 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 Gerard Bruno from the Waste and Environmental Safety Section of the Department of Nuclear Safety and Security of IAEA. The Deputy Coordinator is Mr Vladimir Michal from the Decommissioning and Environmental Remediation Section 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 a Team Leader from the review team, Mr Patrice François (IRSN, France). The IAEA will inform the National Counterpart regarding the composition of the proposed review team prior to submission of reference material.

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

8. Reporting

The outcomes of the peer review will be documented in a final ARTEMIS Review Report that will summarise the work of the review and contain conclusions on the way the findings (recommendations, suggestions) have been addressed and any recommendations, suggestions and good practices that could be identified on new topics the mission would cover following agreement with Germany. 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.

9. Funding of the ARTEMIS review

The ARTEMIS follow-up mission will be funded by Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection of Germany. The costs for the services will be limited to the travel costs and per diem of the peer review team (external experts and IAEA staff) in line with IAEA Financial Regulations and Rules.

The cost of the ARTEMIS follow-up mission is estimated to the amount of 24 000 EUR, to be paid to the IAEA as voluntary contribution before the start of the mission. Germany is aware that the review cost includes 7% programme support costs.

If the actual cost of the ARTEMIS follow-up mission exceeds the estimated voluntary contribution, Germany 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 Germany through the Counterpart.

These Terms of Reference were agreed on 24.06.2022 between the IAEA and the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection, on behalf of the Government of Germany, during the preparatory meeting held on-line.

APPENDIX B: MISSION PROGRAMME

Time	Sun, 6 Nov	Mon, 7 Nov	Tue, 8 Nov	Wed, 9 Nov	Thur, 10 Nov	Fri, 11 Nov	Sat, 12 Nov
9:00-10:30	Arrival of the ARTEMIS review team members	Opening General presentations / group photo/	3. Inventory	7. Capacity Building - Expertise, Training, Skills	Presentation of Recommendations and Suggestions to the Counterparts and discussions	Site visit	Discussions with the Counterparts on the draft report
10:30-11:00		Coffee break	Coffee break	Coffee break	Coffee break		Coffee break
11:00-12:30		1. National Policy and Framework	4. Concepts, Plans and Technical Solutions	Any further discussions, if required, or drafting of the report	Drafting of the report		Finalizing the draft report
12:30-13:30		Lunch	Lunch	Lunch	Lunch		Lunch
13:30-14:45		2. National Programme (strategy)	6. Cost Estimates and Financing	ARTEMIS team meeting Finalization of Recommendations and Suggestions	16:00 Draft report to be sent to the Counterparts		13:30-15:00 Delivery of final draft report - Closure
14:45-15:00		Coffee break	Coffee break				
15:00-16:00		Discussion	Discussion	18:00 Guided tour and official dinner	Counterparts review the draft report		Departure of the Team Members
16:30		ARTEMIS team meeting at the hotel	ARTEMIS team meeting at the hotel	ARTEMIS team meeting at the hotel			
		Drafting of the report	Drafting of the report				

APPENDIX C: RECOMMENDATIONS (R) AND SUGGESTIONS (S) FROM THE 2019 ARTEMIS MISSION THAT REMAIN OPEN

Area		R:Recommendations S: Suggestions	Recommendations/Suggestions
2.	NATIONAL STRATEGY FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT	S3	BGE, in consultation with BfE, as appropriate, should consider assessing whether the requirements on the geosphere for NHGW are different from those for HLW and, if they are, taking them into account in the approach to applying the siting criteria.
3.	INVENTORY OF SPENT FUEL AND RADIOACTIVE WASTE	S6	BMU should consider making greater use of the radioactive waste inventory to monitor changes in the inventory over time and demonstrate waste minimization.
6.	COST ESTIMATES AND FINANCING OF RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT	R2	BMU should update the cost assessment for the national waste management programme in the Cost Report, based on a consistent approach across all activities, including waste retrieval from Asse II mine.
		R3	The Government should analyse risk and uncertainty when updating the cost assessment for all public sector components of the radioactive waste and spent fuel management programme.

APPENDIX D: LIST OF ACRONYMS USED IN THE TEXT

ARM	Advance Reference Material
ARTEMIS	Integrated Review Service for Radioactive Waste and Spent Fuel, Decommissioning and Remediation
BAFA	Federal Office for Economic Affairs and Export Control (<i>Bundesamt für Wirtschaft und Ausfuhrkontrolle</i>)
BASE	Federal Office for the Safety of Nuclear Waste Management (<i>Bundesamt für die Sicherheit der nuklearen Entsorgung</i>)
BfE	Federal Office for the Safety of Nuclear Waste Management (<i>Bundesamt für kerntechnische Entsorgungssicherheit</i>)
BGE	Federal Company for Radioactive Waste Disposal (<i>Bundesgesellschaft für Endlagerung mbH</i>)
BGZ	BGZ Company for Storage (<i>BGZ Gesellschaft für Zwischenlagerung mbH</i>)
BMBF	Federal Ministry of Education and Research (<i>Bundesministerium für Bildung und Forschung</i>)
BMUV	Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (<i>Bundesministerium für Umwelt, Naturschutz, nukleare Sicherheit und Verbraucherschutz</i>)
DAEF	German Association for Repository Research (<i>Deutsche Arbeitsgemeinschaft Endlagerforschung</i>)
ERAM	Morsleben disposal facility (<i>Endlager für radioactive Abfälle Morsleben</i>)
ESK	Nuclear Waste Management Commission (<i>Entsorgungskommission</i>)
ESTRAL	<i>Ersatztransportbehälterlager</i>
EWN	<i>EWN Entsorgungswerk für Nuklearanlagen GmbH</i>
GRS	<i>Gesellschaft für Anlagen- und Reaktorsicherheit gGmbH</i>
HLW	High Level Waste
IAEA	International Atomic Energy Agency
IRRS	Integrated Regulatory Review Service
KVKT	Alliance for Competence in Nuclear Technology (<i>Kompetenzverbund Kerntechnik</i>)
KVSF	Alliance for Competence in Radiation Research (<i>Kompetenzverbund Strahlenforschung</i>)
LoK	Konrad Centre of Logistics (<i>Logistikzentrum Konrad</i>)
NHGW	Waste with negligible heat generation (sometimes referred to as Negligible or Non Heat Generating Waste)
NPP	Nuclear Power Plant
ZBL	Central reception storage facility (<i>Zentrales Bereitstellungslager</i>)

APPENDIX E: IAEA REFERENCE MATERIAL USED FOR THE REVIEW

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