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

MISSION

TO

ITALY

Rome, Italy

1-10 October 2023

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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REPORT OF THE

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

TO

ITALY

Mission dates: *1-10 October 2023*
Location: *Rome, Italy*
Organized by: *IAEA*

ARTEMIS REVIEW TEAM	
Mr Paul McClelland	ARTEMIS Team Leader (Canada)
Ms Elisabeth Salat	Reviewer (France)
Mr Darius Lukauskas	Reviewer (Lithuania)
Mr Sandi Viršek	Reviewer (Slovenia)
Ms Fiona Neall	Reviewer (United Kingdom)
Ms Christine Gelles	Reviewer (United States of America)
Mr Gérard Bruno	IAEA Team Coordinator
Mr Stefan Mayer	IAEA Deputy Team Coordinator
Ms Kristina Nussbaum	IAEA Admin. Assistant

IAEA-2023

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

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EXECUTIVE SUMMARY

At the request of the Government of Italy, the International Atomic Energy Agency (IAEA) organized an Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation (ARTEMIS) peer review mission. The review mission was hosted by the Ministry of the Environment and Energy Security (MASE).

The objective of the ARTEMIS Peer Review Service is to provide independent expert opinion and advice on radioactive waste and spent fuel management, decommissioning, and remediation, based upon the IAEA safety standards and technical guidance, as well as good international practice. Italy requested this ARTEMIS 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.* Special emphasis was given in the review on the Italian governmental, legal and regulatory framework as well as the national programme for safe management of spent fuel and radioactive waste.

During the preparation of the mission, it was agreed to exclude from the scope of the review the radioactive waste generated by activities of Defence administration as well as the management of NORM.

The review, conducted 1-10 October 2023, was performed by a team of six 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.

Italy's radioactive waste management responsibilities arise from the four nuclear power reactors and other fuel cycle facilities, that were in operation until a national referendum called for an end to nuclear power generation in the 1980s. Waste arisings in the nuclear field now relate to the decommissioning of facilities from this former nuclear power programme. Waste from past operations and decommissioning are in storage at the sites. Other radioactive waste relates to the operation of research reactors, research laboratories and experimental facilities, and from activities in medicine, industry and other uses.

Italy's overall status and plans for radioactive waste management include storage of waste at temporary storage sites near decommissioned nuclear power reactors and other nuclear facilities; and plans to establish a National Repository. The latter would be comprised of a near surface disposal facility for very low level and low level waste, a centralized storage for intermediate level waste, high level waste and spent fuel, as well as a technology research park. The search for a suitable site, considering geological, environmental, and safety factors, is currently the main focus of the National Programme.

The ARTEMIS Review Team considered that the Italian counterparts are aware of the challenges of safely managing the country's radioactive waste and are clearly committed to addressing them.

The formal documentation of Italy's policy is within the National Programme for Spent Fuel and Radioactive Waste Management (2019). An updated National Programme (2023) was developed by Italy, however it has not yet been formally approved and issued.

The National Programme (2019) does not describe plans for the development of a geological disposal. The draft National Programme (2023) includes provisions for geologic disposal.

To maintain and further improve the safe management of radioactive waste and spent fuel in Italy, the ARTEMIS Review Team made several recommendations as follows:

- The Government should approve without undue delays the 2023 National Programme, that includes geological disposal as a final destination for spent fuel and high-level radioactive waste.
- The Government should ensure that the process for authorization of closure of the near surface disposal facility requires update of the safety report as part of the application.
- The Government should compile and publish an R&D programme that is clearly linked to the activities defined in the National Programme.
- ISIN should implement its own R&D programme to build its expertise to review safety cases for the activities in the National Programme.
- The Government should review and revise if needed the schedule for the implementation of the National Programme and confirm that it is realistically achievable.
- The Government should take measures to ensure that the time constraints imposed on preparation and review of the safety case and safety assessment for the National Repository will not compromise safety.
- The Government should ensure the improvement of cost estimate associated with all activities in the National Programme with consideration that:
    - activities scheduled in the near term have a cost estimate of high enough confidence to support execution;
    - the cost estimate for the National Programme includes all foreseeable costs, including those that may result from foreseeable risks and delays;
    - a robust cost estimate for the geological disposal implementation is developed as the programme for the implementation is better defined.
- ISIN should fully identify the regulatory resources needed according to the scope of National Programme and plan for acquiring those resources.
- The Government should ensure that ISIN has the necessary resources to execute its duties according to the National Programme.

The ARTEMIS Review Team also identified 10 suggestions addressed to the Government, the regulator or the operator, related among other things to regulatory control, involvement of interested parties, feasibility of the geological disposal, human resources and funding mechanisms.

The ARTEMIS also identified a good practice for the broad-based, collaborative training and development programme for nuclear professionals established in Italy between many entities.

The ARTEMIS Review Team commended the Italian counterparts for the professionalism displayed by all staff and their commitment to safety. Acting upon the findings of the ARTEMIS Review Team will further support this commitment to safety.

Italy is encouraged to make the review public and to take the findings of the review into account.

I. INTRODUCTION

On 5 August 2020, the Permanent Mission of Italy to the United Nations, requested the International Atomic Energy Agency (IAEA) to organize and carry out, in 2023, an Integrated Review Service for Radioactive Waste and Spent Fuel, Decommissioning and Remediation (ARTEMIS) review.

Italy's request for the ARTEMIS mission was made to satisfy 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 (hereinafter the *EU Waste Directive*).

The review was performed by a team of six 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 March 2023, and the receipt and review of Advanced Reference Material in August 2023, in October 2023 the ARTEMIS Review Team evaluated the Italian national framework, strategy and national programme for fulfilling the country's obligations for safe and sustainable management of spent fuel and radioactive waste.

II. OBJECTIVE AND SCOPE

The ARTEMIS review provided an independent, international evaluation of the Italian governmental, legal and regulatory framework, national programme and its implementation for safe management of spent fuel and radioactive waste.

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

The ARTEMIS review addressed the Italian governmental, legal and regulatory framework, national programme and its implementation for safe management of spent fuel and radioactive waste.

It was agreed to exclude the radioactive waste generated by activities of Defence administration and the management of NORM from the scope of the review.

Results from the IAEA Integrated Regulatory Review Service (IRRS) mission to Italy conducted in November 2016 were taken into account, if relevant and appropriate.

III. BASIS FOR THE REVIEW

A) PREPARATORY WORK AND IAEA REVIEW TEAM

A preparatory meeting for the ARTEMIS Review, was conducted on the 14th of March 2023 online. The preparatory meeting was carried out by the appointed Team Leader Mr Paul McClelland, the IAEA coordinator and deputy coordinator Mr Gerard Bruno and Mr Stefan Mayer respectively, and the team of National Counterparts led by Mr Mario Dionisi from the the National Inspectorate for Nuclear Safety and Radiation Protection (ISIN), with participation of representatives of the Ministry of Environment and Energy Security (MASE), SOGIN, the Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA) and JRC Ispra.

The meeting participants had discussions regarding:

- the Terms of Reference for the ARTEMIS review; 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 Italy in October 2023.

Mr Mario Dionisi was appointed as the Liaison Officer of the National Counterpart for the ARTEMIS mission and designated IAEA point of contact.

Italy provided IAEA with the Advance Reference Material (ARM) for the review on 1 August 2023.

B) REFERENCES FOR THE REVIEW

The review was made in accordance with Version 2.0 of the guidelines for the ARTEMIS review service. The Italian responses to the ARTEMIS self-assessment questionnaire were used as a key basis for the review, together with the rest of the ARM and materials presented during the review mission and the associated discussions. In accordance with the Statute of the IAEA, the ARTEMIS review was made against the IAEA Safety Standards. Other IAEA publications were considered where relevant. The complete list of IAEA publications for this review is provided in Appendix E.

C) CONDUCT OF THE REVIEW

The initial Review Team meeting took place on Sunday, 1 October 2023 in Rome, directed by the ARTEMIS Team Leader Mr Paul McClelland, the ARTEMIS Team Coordinator Mr Gerard Bruno and the Deputy Team Coordinator, Mr Stefan Mayer.

The ARTEMIS entrance meeting was held on Monday, 2 October 2023, with the participation of the Ministry of Environment and Energy Security (MASE), the National Inspectorate for Nuclear Safety and Radiation Protection (ISIN), SOGIN, ENEA and JRC Ispra senior management and staff. Opening remarks were made by Mr Mariano Giuseppe Cordone (Director, Nuclear Division MASE), Mr Gian Luca Artizzu (CEO, SOGIN), Mr Alessandro Dodaro (Director, Fusion and Technology for Nuclear Safety and Security Department, ENEA), Mr Laurent Jerrige (Director of JRC Decommissioning), Mr Gerard Bruno (IAEA Team Coordinator), and Mr Paul McClelland (ARTEMIS Team Leader).

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

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

The ARTEMIS Exit Meeting was held on Tuesday, 10 October 2023. Opening remarks were made by Mr Mariano Giuseppe Cordone (Director, Nuclear Division, MASE), Mr Maurizio Pernice (Director ISIN), Mr Gian Luca Artizzu (CEO, SOGIN), Mr Gilberto Dialuce (President, ENEA), and Mr Paolo Peerani (Deputy Director of JRC Decommissioning). A presentation of the results of the Review Mission was given by the ARTEMIS Team Leader Mr Paul McClelland. Closing remarks were made on behalf of the IAEA by Ms Anna Clark, Section Head, Waste and Environmental Safety Section, Division of Radiation, Transport and Waste Safety, Department of Nuclear Safety and Security.

An IAEA press release was issued.

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

1.1. NATIONAL POLICY

Italian position

Italy has well-defined national policies for the safe and effective management of spent fuel and radioactive waste management, including management of disused sealed radioactive sources. Interim spent fuel and waste management responsibilities are held by the operators of authorized nuclear installations. These operators bear financial responsibility, also, for future management and/or disposal of the radioactive wastes and materials. There is a clear policy for future disposal of VLLW and LLW in near surface disposal and future consolidated interim storage of ILW, HLW and spent nuclear fuel for a period of up to 50 years (potentially extendible to 100 years). While there is a stated policy for future geologic disposal of ILW, HLW and spent nuclear fuel, it has not yet been determined whether a regional, international solution or a national solution will be pursued. Most Italian spent nuclear fuel was transported to either France or the United Kingdom for reprocessing, and the resulting HLW will be returned to Italy in the future when the CSA within the planned National Repository is available.

This formal documentation of Italy's policy is within the National Programme for Spent Fuel and Radioactive Waste Management (2019). An updated National Programme (2023) was developed by Italy, but has not been formally approved and issued. Italy shared the draft National Programme (2023) in the Advance Review Material.

The National Programme (2019) does not describe plans for the development of a geological disposal. The National Programme (2023) cannot be formally approved and issued until a Strategic Environmental Assessment as well as a consultation of some national actors (Ministry of Health, State-Regions-Municipalities Unified Conference and ISIN) are completed. The draft National Programme (2023) includes provisions for geological disposal, and it is Italy's position that the draft National Programme (2023) is unlikely to be significantly revised.

ARTEMIS observation

The ARTEMIS Review Team observes the National Programme (2019) and the draft National Programme (2023) to be well structured, presenting the national policy, and integrating the numerous actors within the Italian system.

Within the draft National Programme (2023), a dual path for development of a geological disposal is described. The ARTEMIS Review Team understands Italy's basis for continuing to evaluate and encourage development of a regional, international solution, but advises that activities on both paths should be pursued concurrently and continuously until a decision is made. The ARTEMIS Review Team observed a significant number of major interdependences within the draft National Programme (2023) related to availability of interim storage and disposal capabilities, which are addressed in subsequent chapters and findings of this report.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *The National Programme (2019), which is the most recent approved programme, does not describe plans for the development of a geological disposal. Italy introduced a draft National Programme (2023) in the ARM and as it is not yet formally approved, it was taken into consideration as a draft.*	
(1)	**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. […]"*
(2)	**BASIS: GSR Part 5 Requirement 2 states that** *"To ensure the effective management and control of radioactive waste, the Government shall ensure that a national policy and a strategy for radioactive waste management are established. […]. The policy and strategy shall be compatible with the fundamental safety principles and with international instruments, conventions and codes that have been ratified by the State. The national policy and strategy shall form the basis for decision making with respect to the management of radioactive waste."*
(3)	**BASIS: SF-1 (Rev. 1) Principle 7, para. 3.29 states that** *"Radioactive waste must be managed in such a way as to avoid imposing an undue burden on future generations; that is, the generations that produce the waste have to seek and apply safe, practicable and environmentally acceptable solutions for its long term management. […]."*
R1	**Recommendation: The Government should approve without undue delays the 2023 National Programme, that includes geological disposal as a final destination for spent fuel and high-level radioactive waste.**

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

Italian position

The safe and effective management of spent fuel and radioactive waste is defined within Italian legislation.

As far as the governmental, legal and regulatory framework for safety is concerned, it should be noted that the Italian government has issued and regularly updated over time a substantial set of laws, largely as a transposal of Euratom directives. The main relevant acts are Lgs. Decree n.101/2020, Lgs. Decree n.31/2010 and Lgs. Decree n.45/2014.

Lgs. Decree No. 101 of 31 July 2020 on *"Implementation of Directive 2013/59/Euratom, laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom and reordering of sector legislation in implementation of Article 20(1)(a) of Law No. 117"*, as supplemented and amended by Lgs. Decree No. 203 of 25 November 2022, constitutes the reference act regulating nuclear installations and activities as well as the use of ionizing radiation, including the safe and effective management of spent fuel and radioactive waste.

Lgs. Decree No. 45/2014 is of particular relevance, as it integrated and updated prior decrees and Acts. It instigated establishment of the new competent authority, Inspectorate for Nuclear Safety and Radiation Protection (ISIN), which was achieved through additional legislative actions; ISIN was fully established in August 2018. Leg. Decree 45/2014 also specifics the preparation and contents of the National Programme for Spent Fuel and Radioactive Waste Management and its subsequent updates every three years.

Although Italy had existing provision defining the classification of radioactive wastes (which was largely based on the US NRC classification scheme), pursuant to Lgs. Decree 45/2014, a 2015 Ministerial Decree established a revised waste classification system that is currently in force.

Italy's legislative system defines the following responsibilities:

- The Ministry of the Environment and Energy Security (MASE) is the governmental authority responsible for licensing processes for nuclear facilities, including those related to spent fuel and radioactive waste management.
- ISIN is the independent competent regulatory authority responsible for providing binding technical advice for authorization, granting approvals and conducting inspections.
- SOGIN S.p.A, a key implementer, is a wholly state-owned company, comprised of two functionally separate divisions with independent technical and economic management – one responsible for nuclear facility decommissioning and one responsible for repository development. Italy indicated during the Review that Italian law dictates that the repository organization of SOGIN must became a separate legal entity when the National Repository become operational.
- ENEA carries out research and development activities and also manages an Integrated Radioactive Waste Management Service for management of wastes and disused sources from the medical sector, industry and scientific research.

The authorization procedure for the siting, construction and operation of the National Repository is established in the Lgs. Decree n, 31/2010 (Arts 27 and 28). Also the main application documents to be submitted by the implementer are defined. As far as closure of the disposal facility of the National Repository, the same Lgs. Decree anticipate that a dedicated Decree has to be established to define the related authorization procedure.

A total of 33 technical reference guides on nuclear safety and radiation protection have been issued to date, five of which are directly applicable to the safe management of spent fuel and radioactive waste:

- ISIN Technical Guide 29, "Siting Criteria of a near surface disposal facility for low and intermediate level waste" (2014);
- ISIN Technical Guide 30, "Safety and radiation protection criteria for radioactive waste and spent fuel facilities (2020);
- ISIN Technical Guide 31, "Safety and radiation protection criteria for the nuclear installations decommissioning (2022);
- ISIN Technical Guide 32, "Safety and radiation protection criteria for near surface radioactive waste disposal facilities" (2022);
- ISIN Technical Guide No 33, "Safety and radiation protection criteria for radioactive waste management." (2023)

ARTEMIS observation

The ARTEMIS Review Team reviewed the Italian legislative framework and policies related to spent fuel and radioactive management and found the Legal Framework in general to be well defined. Questions regarding the relationship between MASE and ISIN were raised and resolved, with the ARTEMIS Review Team understanding that needed authorizations are directed to and issued by the Nuclear Division of MASE, but only after ISIN's review and provision of binding technical advice or opinion.

The ARTEMIS Review Team made inquiries regarding SOGIN's structure in order to confirm adequate independence between the element generating radioactive wastes and the entity developing the repository. While not an issue currently, formal separation and independence are necessary during repository operations.

The ARTEMIS Review Team observed that the National Repository, as defined in Italian legislation, consists of three capabilities – a near surface disposal facility for VLLW/LLW; mid-long term storage facility for ILW, HLW and spent nuclear fuel; and a Technology Park for R&D activities - to be authorised via a single license. The ARTEMIS Review Team notes that the authorisation of these capabilities during their lifecycle is a complex matter, as some operations are likely to continue longer than others and they support facilities and infrastructure are likely to be shared among the three capabilities. Therefore, the ARTEMIS Review Team advises that future Technical Guidance provide explicit direction on how this complexity will be addressed to ensure all necessary safety considerations are fully addressed.

The ARTEMIS Review Team observed that existing legislative and regulatory framework did not explicitly require the operator of the National Repository to update the Safety Report (safety case) for the near surface disposal facility as part of the application for authorization to close the disposal facility.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *According to the provisions of legal framework the closure of the near surface disposal facility is subject to prior authorization. Currently there are no provisions in the legal framework to request update of the Safety Report and to be presented together with the application for the closure the near surface disposal facility.*	
(1)	**BASIS: GSR Part 1 (Rev.1) Requirement 24, para. 4.33 states that** *"Prior to the granting of an authorization, the applicant shall be required to submit a safety assessment, which shall be reviewed and assessed by the regulatory body in accordance with clearly specified procedures. […]"*
(2)	**BASIS: SSR 5 Requirement 2 states that** *"The regulatory body shall establish regulatory requirements for the development of different types of disposal facility for radioactive waste and shall set out the procedures for meeting the requirements for the various stages of the licensing process. It shall also set conditions for the development, operation and closure of each individual disposal facility and shall carry out such activities as are necessary to ensure that the conditions are met.*
R2	**Recommendation: The Government should ensure that the process for authorization of closure of the near surface disposal facility requires update of the safety report as part of the application.**

The ARTEMIS Review Team observed that technical guidance related to the development of procedures for clearance of materials and release of sites from regulatory control is missing. However, during discussions ISIN confirmed that is is under development.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *Guidance on procedures to demonstrate compliance of the material with the established clearance levels or site release is not yet developed. Such a guidance, detailing procedures of release of installations, sites and materials from regulatory control is currently under development by ISIN.*	
(1)	**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. […]."*
(2)	**BASIS: GSR Part 6 Requirement 5 states that** *"The regulatory body shall regulate all aspects of decommissioning throughout all stages of the facility's lifetime, from initial planning for decommissioning during the siting and design of the facility, to the completion of decommissioning actions and the termination of authorization for decommissioning."*

(3)	**BASIS: WS-G-5.1 para. 3.7. states that** *"The regulatory body should establish safety requirements and guidelines for the planning, approval and conduct of cleanup activities, for the management of contaminated material and the waste that arises from this process, and for the release of land, buildings and structures from regulatory control. The responsibilities of the regulatory body should also include: (a) Establishing, promoting and adopting criteria and guidance for the cleanup and release of sites as a part of decommissioning activities; […]"*
S1	**Suggestion: ISIN should consider completing the development and issuance of guidance without undue delay, detailing procedures for release of installations, sites and materials from regulatory control.**

The ARTEMIS Review Team, in its evaluation of the internal transactions of SOGIN between waste generator and repository programmes, raised potential concerns related to the importance of data quality objectives and the need for a formal process to assure quality of future waste package information. More broadly, the ARTEMIS Review Team discussed with Italy various data systems involving waste inventory details (for various purposes) and how data is transferred between them. The ARTEMIS Review Team was ultimately satisfied with the quality of the SOGIN system (AIGOR) and the new ISIN system (STRIMS) and received assurances that other operators/generators have systems comparable to SOGIN's. It is apparent that waste inventory data needs are defined to meet the near-term purposes of repository planning as well as support compliance with regulatory requirements. However, the ARTEMIS Review Team did not observe explicit plans for the development of a formal, waste certification system to be used for repository operations.

International experience of disposal facility operations – both commercial and State-managed systems – rely on formal and detailed waste certification programs to independently validate that waste received at a disposal facility, in fact, complies with the waste acceptance criteria. The certification programs typically include detailed requirements for waste generators' quality assurance programs and waste inventory data, self-assessment processes, formal independent audit mechanisms and detailed waste manifest procedures, as well as periodic quality checks. These elements of the waste certification program formalize requirements, while also providing transparent, auditable evidence of the compliant operations of the waste disposal system and the "hand-shake" between waste generator and operator. Such formal documentation provides the regulatory authority and the public confidence in the robustness of the management system relied upon to ensure the safe management, transportation and disposal of radioactive waste.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES
Observation: *Additional progress is required in the development of arrangements to validate compliance with waste acceptance criteria upon receipt of waste for emplacement in the repository. Further, international best practices demonstrate that robust quality assurance and quality control programs are necessary to ensure wastes that continue to be generated during repository development will meet the forecast waste acceptance criteria. A formal independent waste certification programme would increase confidence that all waste packages are compliant and can safely be accepted within the facility without issue. While not required today, development and implementation will require several years and therefore should begin soon.*

(1)	**BASIS: GSR Part 5 Requirement 7, para. 3.24 states that** *"To ensure the safety of predisposal radioactive waste management facilities and the fulfilment of waste acceptance criteria, management systems are to be applied to [...] All aspects of processing, handling and storage of waste [...] These activities are required to be supported by means of an effective management system that establishes and maintains a strong safety culture [8, 14]. [...]"*
(2)	**BASIS: GSR Part 5 Requirement 11, para. 4.26 states that** *"The operators' procedures for the reception of waste have to contain provisions for safely managing waste that fails to meet the acceptance criteria; for example, by taking remedial actions or by returning the waste."*
(3)	**BASIS: SSR-5 Requirement 20, para. 5.3 states that** *"Waste intended for disposal has to be characterized to provide sufficient information to ensure compliance with waste acceptance requirements and criteria. Arrangements have to be put in place to verify that the waste and waste packages received for disposal comply with these requirements and criteria and, if not, to confirm that corrective measures are taken by the generator of the waste or the operator of the disposal facility. Quality control of waste packages has to be undertaken and is achieved mainly on the basis of records, preconditioning testing (e.g. of containers) and control of the conditioning process. Post-conditioning testing and the need for corrective measures have to be limited as far as practicable."*
S2	**Suggestion: The Government should consider ensuring a formal waste certification programme between waste generators and repository operator is developed.**

The ARTEMIS Review Team recognizes the critical importance of the timely delivery of the near surface disposal facility to support the decommissioning timelines for Italy's nuclear facilities that were shut down decades ago. Italy reported that delays have been encountered in the development of the National Repository, and its availability is a critical path activity for the decommissioning plans within the draft National Programme (2023). Therefore, continued progress on the siting of the National Repository is vital. In discussions related to the status of the siting program, Italy stated that there are some initial site evaluation criteria identified by the operator that are not directly related to safety (such as for instance limitation on the minimum extension of the area), and that these criteria in the current siting process exclude consideration of areas where the local community may be supportive. (These criteria are distinct from those safety-related exclusion criteria specified in Technical Guide n. 29). The ARTEMIS Review Team observes that all countries developing disposal systems face similar challenges in public acceptance of siting.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *As presented in the ARM and discussed, Italy's engagement strategy related to the siting the National Repository appears to be constrained. It appears that the ongoing process to identify suitable areas preclude consideration of local communities that may be supportive that are currently excluded. Given international experience and the challenges of the National Repository schedule, securing local (government and public) consent is vital.*	
(1)	**BASIS: SSR 5 Requirement 1 states that** *"The government is required to establish and maintain an appropriate governmental, legal and regulatory framework for safety within which responsibilities shall be clearly allocated for disposal facilities for radioactive waste to be sited, designed, constructed, operated and closed […]* *Paragraph 3.7. Matters that have to be considered include:* *d) Defining the overall process for the development, operation and closure of disposal facilities, including the legal and regulatory requirements (e.g. licence conditions) at each step, and the processes for decision making and the involvement of interested parties; […]"*
S3	**Suggestion: The Government should consider reviewing existing legislative constraints around what locations can be considered for siting of the National Repository with the potential to relax where they do not impact safety.**

2. NATIONAL STRATEGY FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT

2.1. SCOPE

Italian position

The Italian national strategy for radioactive waste and spent fuel management is detailed in the National Programme (2019). It considers the management of spent fuel and all types of radioactive waste that are the subject of national legislation, as well as all phases of the spent fuel and radioactive waste management, from the generation to the disposal.

The national strategy is established considering decisions taken in the past:

- decision to reprocess spent fuel from the first years of operation of the Italian nuclear power plants;
- decision in the mid-1990s to terminate the reprocessing of spent nuclear fuel and to proceed with the interim dry storage of the remaining spent fuel for light water-cooled reactors as well as decision to store fuel elements in dual purpose (for transportation and storage) metallic casks in interim storage spaces on nuclear sites;
- decision to initiate the closure of the nuclear cycle and to start a decommissioning programme at the end of the 1990s;
- issued strategic guidelines by the government in 2004 and 2006 to restart reprocessing of the spent fuel stored at the Caorso, Garigliano and Trino plants and the national plants of the nuclear fuel cycle, as well as at the storage sites located throughout the national territory, including fuel fraction owned by SOGIN, deriving from the joint operation of the Superphoenix reactor, except for the "Elk River" fuel, the only fuel that cannot be reprocessed.

For implementation of the decommissioning and radioactive waste management strategy the Government launched a legislative process envisaging the establishment of a state-owned company that would deal with the completion of the treatment of operating waste, the management of the spent fuel still present in the plants and the start of the dismantling of all nuclear power plants and fuel cycle facilities. For that purpose, SOGIN was established and currently is managing decommissioning of the four Nuclear Power Plants, the industrial fuel production plant, the three fuel cycle facilities (EUREX, ITREC, IPU), and Ispra-1 research reactor. SOGIN is also responsible for the construction and operation of the National Repository, which comprises a near surface disposal facility for disposal of VLLW and LLW and short-lived ILW and a Technology Park for research purposes, as well as CSA for the medium-long term storage of long-lived ILW, HLW and spent fuel.

Some small experimental research reactors are in the final phase of decommissioning, which are managed by the respective administrations and the decommissioning is developed with the operative support of Nucleco, a company controlled by SOGIN.

According to the legal basis MASE is responsible for implementation of the National Programme. The primary responsibility for the safe management of spent fuel and radioactive waste remains with the license holders, as defined by current legislation.

Radioactive waste present on the JRC site will be transferred to the National Repository at the end of the decommissioning activities in accordance with the Settlement Agreement between Italy and Euratom.

The national strategy contains and details nine objectives:

1. decommissioning of nuclear facilities;
2. spent fuel management;
3. safe management of non-electronuclear radioactive waste from medical, industrial and research activities;
4. construction and operation of the National Repository;
5. transport of radioactive waste to the National Repository;
6. disposal of VLLW and LLW and short-lived ILW in the National Repository;
7. medium long-term interim storage of long-lived ILW, HLW and spent fuel at the National Repository;
8. construction of the geological disposal (multinational or national) for the disposal of long-lived ILW, HLW and spent fuel;
9. implementation of the programme for research and development (R&D) activities aimed at the safe management of spent fuel and radioactive waste.

Regarding the JRC Ispra, the Settlement Agreement between Italy and Euratom provides for the transfer of the radioactive waste present on the JRC site to the National Repository at the end of the decommissioning activities, according to a schedule to be agreed in consideration of the availability of the repository itself and according to the financial availability of the European Commission.

Public participation to the decision making process is arranged through the publication of the National Programme outlines on the institutional websites in the framework of the SEA. The public can express their views, which are duly taken into account when preparing the final text of the National Programme. The results the SEA on the National Programme are also made available for public information on the MASE website.

Similarly a policy of transparency and public participation in decision-making processes is implemented with regard to the site selection of the National Repository. In accordance with the site localization procedure for the construction of the National Repository, a National Chart of Potentially Suitable Areas is published by SOGIN. A first public consultation phase was already carried out, which was closed during different sections of a National Seminar (7 September - 15 December 2021). In accordance with the legal acts SOGIN will invite the regions and local authorities from those areas which are suitable for hosting the the National Repository to express their interest and promote bilateral negotiations to enter into negotiations for the purpose of finding an agreement on a site. The expression of interest does not constitute a commitment for the regions or local authorities. In absence of expressions of interest, SOGIN will promote bilateral negotiations with all the regions involved.

ARTEMIS observation

The draft National Programme (2023) addresses the strategies, necessary actions and technical solutions, aimed to ensuring the adequate management of radioactive waste from decommissioning of the Nuclear Power Plants, of fuel cycle research installations, of the industrial fuel production plant and research reactors as well as management of non-electronuclear radioactive waste from medical, industrial and research activities including waste from remediation activities. This is consistent with the recommendations of IAEA safety standards.

The ARTEMIS Review Team noted that the Italian approach to radioactive waste and spent nuclear fuel management defined in the draft National Programme (2023) considers disposal as the final destination of all radioactive waste, addresses developing a long-term solution for radioactive waste, including the financial measures required to carry them out. This approach is in line with the recommendations of IAEA safety standards. However, as noted in section 1, since the draft National Programme (2023) is still not formally approved, it should be concluded that the national strategy does not currently address developing a long-term solution for all types of radioactive waste, until the formal approval of the updated 2023 National Programme is finalized.

The ARTEMIS Review Team observed that Italy has prior and ongoing R&D activities in the field of spent fuel and radioactive waste management. Also, there are various EU and international research programs, in which Italy is taking part. The provided information is more a description of research activities than an integrated R&D programme linked to the National Programme, including defining objectives and the tasks to be achieved, as well as target dates and performance indicators. It is not clear that all needed R&D activities have been planned and some activities may not be planned in time to achieve the objectives of the Natiaonal Programme. It is also stated that the R&D programme will be developed only by the operators and their associated research entities. However, to fulfil its regulatory functions, the regulatory body, where appropriate, should undertake research, and acquire independent assessment capabilities.

The ARTEMIS Review Team also noted that there is an established process to involve the public in the decision-making process in Italy. The public is informed by publication of the draft documents (e.g. SEA of the National Programme, CNAPI, etc.) on the institutional websites and providing possibility to the public to express their views, which are taken into account in final versions of the documents. Once the site for the National Repository has been selected, the operator must initiate an information campaign according to Article 27.12 Lgs. Decree No. 31/2010, which is to be overseen by ISIN.

However, during discussions the ARTEMIS Review Team observed that Italy is deferring engagement activities related to the geological repository until the National Repository site is finalized. The ARTEMIS Review Team considers that without dialogue with the public regarding future geological disposal, communities being considered for the National Repository may not trust the timelines being proposed for interim storage. International experience demonstrates that comprehensive, active and effective stakeholder engagement strategies are key to planning and implementation of successful waste management and disposal programmes. Transparent, inclusive and continuous engagement practices are needed to establish public trust and move toward consent-based siting.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *An integrated R&D programme was not presented. Ongoing and already planned research activities are not clearly linked to the activities defined in the National Programme. It is not clear that all needed R&D activities have been planned.*	
(1)	**BASIS: GSR Part 1 (Rev.1) Requirement 10, para. 2.32 states that** *"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."*
(2)	**BASIS: GSR Part 5 Requirement 3, para. 3.10. states that** *"To fulfil its regulatory functions, the regulatory body, where appropriate, may undertake research, acquire independent assessment capabilities and participate in activities for international cooperation."*
(3)	**BASIS: SSR 5 Requirement 3, para. 3.13 states that** *"The operator has to conduct or commission the research and development work necessary to ensure that the planned technical operations can be practically and safely accomplished, and to demonstrate this. The operator likewise has to conduct or commission the research work necessary to investigate, to understand and to support the understanding of the processes on which the safety of the disposal facility depends. The operator also has to carry out all the necessary investigations of sites and of materials and has to assess their suitability and obtain all the data necessary for the purposes of safety assessment."*
(4)	**BASIS: SSR 5 Requirement 6 states that** *"Understanding of a disposal facility and confidence in safety The operator of a disposal facility shall develop an adequate understanding of the features of the facility and its host environment and of the factors that influence its safety after closure over suitably long time periods, so that a sufficient level of confidence in safety can be achieved."*
R3	**Recommendation: The Government should compile and publish an R&D programme that is clearly linked to the activities defined in the National Programme.**
R4	**Recommendation: ISIN should implement its own R&D programme to build its expertise to review safety cases for the activities in the National Programme.**

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *The strategy of being silent on geological disposal while engaging the public on the National Repository may undermine public support for siting of National Repository by leaving questions about geological disposal unanswered when seeking public support for high level storage.*	
(1)	**BASIS: SSR 5 Requirement 1 states that** *"The government is required to establish and maintain an appropriate governmental, legal and regulatory framework for safety within which responsibilities shall be clearly allocated for disposal facilities for radioactive waste to be sited, designed, constructed, operated and closed […]* *Paragraph 3.7. Matters that have to be considered include:* *d) Defining the overall process for the development, operation and closure of disposal facilities, including the legal and regulatory requirements (e.g.licence conditions) at each step, and the processes for decision making and the involvement of interested parties; […]"*
S4	**Suggestion: The Government should consider developing a comprehensive strategy for proactive involvement of all interested parties, including the public, that encompasses the full scope of the National Programme, in order to reduce implementation risk for both the National Repository and the geological disposal .**

2.2. MILESTONES AND TIMEFRAMES

Italian position

Decommissioning activities of nuclear installations is planned in two steps according to the End-state status of the installation site: achievement of the brown-field and achievement of the green-field end-state status of the installation's site. Additionally, target dates for completion of the transfer of radioactive waste to the National Repository are defined. Schedule of the decommissioning activities is individual for each nuclear installation. The target dates for achievement of each objective are detailed in Table 1. Those target dates are relative to SOGIN's Whole Life Plan 2020 (PTGvi) and updated, where available, with the data contained in the 2022 Acceleration Plan and are based on SOGIN's latest estimates. SOGIN supports its decommissioning plans with a statistical analysis of uncertainties and project risks (Risk Analysis Modelling), based on past events, determining the confidence intervals within which time deviations (delays) may fall if no mitigation solutions are adopted.

SITE	*Brown-Field*	*Complete transfer of RW*	*Green-Field*
Bosco Marengo	2021	2035	2036
Caorso	2031	2037	2039
Casaccia	2030	2041	2042
Garigliano	2028	2041	2042
Ispra	2034	-	2036
Latina	2042	2042	2043
Saluggia	2037	2039	2041
Trino	2030	2038	2040
Trisaia	2038	2040	2040

Table 1. Estimated brown field and green field target dates for each nuclear facility site

A target date for completion of the transfer abroad of spent fuel for reprocessing and return of the waste, produced by the reprocessing of spent fuel, to Italy in accordance with the 2006 Lucca Agreement, together with its additions, is 2025. In this Agreement the Italian Government has committed to adopting all the necessary measures to create a suitable storage site. The terms for the return to Italy of the resulting waste and the schedule for the transfer of the last 13 tHM must necessarily be renegotiated.

Target dates for site selection, construction, operation, closure and post closure activities of the National Repository and site selection, construction, operation of geological repository as well as international studies on multinational geological repository are defined in Figure 1.

TIMELINE

ACTIVITIES	from	to
Decommissioning of nuclear installations	2000	2043
Siting of the National Repository	2014	2025
Single-phase authorization process	2025	2027
Realization of the National Repository infrastructures	2027	2032
Entry in operation of the National Repository / waste transfer	2032	2070
Closure of the disposal facility and beginning of long-term surveillance	2070	2075
Post-closure activities / long-term surveillance	2075	2380
International studies for a multinational geological repository	<<<<	2050
Beginning of studies and territorial analysis for a national geological repository	2030	2050
Choice between multinational or national geological repository	2050	
Multinational geological repository option:		
Prosecution of studies and realization	2050	>>>
National geological repository option:		
Selecting one or more sites for field studies	2050	
Conducting field studies on the selected site/s	2050	2060
Final site selection following field studies results	2060	
Realization of the national geological repository	2060	2070
Waste transfer, beginning of segregation and disposal	2070	>>>

In accordance with the draft the National Programme (2023) transfer of radioactive waste and spent fuel produced in Italy to the National Repository shall be completed by 2055. Transfer agreement to the National Repository of radioactive waste and spent fuel from the JRC Ispra site in compliance with the commitments between Italy and Euratom expected by 2028. The transfer of the "Elk River" spent fuel from the pool to the dual purpose casks on site is scheduled to take place in 2026. Subsequently they will be transferred to the long-term storage in the CSA.

Regarding the R&D activities to support the National Programme following activities are foreseen:

a. completion of the research and development program aimed at the safe management of radioactive waste and at decommissioning by 2045;

b. starting from 2030, implementation of a study and research program aimed at locating the disposal site in geological formation on the national territory (2030-2045);

c. starting from 2045, launch of a research and investigation program for the qualification of the site intended for the creation of a national geological repository (Underground Research Laboratory).

Regarding the management of nuclear materials recovered from the reprocessing of the fuel covered by the contracts between SOGIN and the UK Nuclear Decommissioning Authority (NDA), on 5 October 2021 the Italian Government authorized SOGIN to sell to NDA all the uranium and plutonium it holds in the UK. The agreement was signed on 29 December 2022

and was sent to the Euratom Supply Agency for its approval, required under Article 52 of the Euratom Treaty.

ARTEMIS observation

The draft National Programme (2023) defines essential tasks to achieve the overall goals for the management of radioactive waste and the spent fuel and defines essential milestones for implementation of those tasks. This is consistent with the recommendations of IAEA safety standards. However, the ARTEMIS Review Team considers the schedule for decommissioning of the major nuclear facilities is too optimistic, taking into account international experience, especially since several such projects are running in parallel in the period before the National Repository is available.

The ARTEMIS Review Team considers that the target dates for implementation of the National Repository and geological repository projects are too optimistic (e.g. the National Repository to be operational in 9 years when a site is not yet selected; and implementation of the geological repository within 20 years after a strategy and site is not selected). Some milestones defined in the draft National Programme (2023) could be initiated earlier (e.g. development of technical guidance for geological repository by 2035, drafting of the research programme by 2032, beginning of the studies and territorial analysis for geological repository in 2030, identification of the implementing operator and the authorization procedure for the construction of a possible national geological repository by 2040). The milestones are based on a deterministic schedule and are not supported by a robust analysis of schedule risk. In order to have confidence in the ability to achieve such schedule, a robust analysis of the risks impacting the ability to deliver to schedule should be undertaken, and appropriate mitigation activities identified and pursued at earliest opportunity.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *The timelines in the National Programme for the National Repository are too optimistic. The timelines for the geological repository are unlikely to be achieved considering the delayed start in comparison to international experience. In order to decrease uncertainties possibly having impact to implementation of the geological repository project, the initial activities should be started earlier (e.g. issuance of regulatory guidance for geological repository, development of research programme).*	
(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: NW-G-1.1 para. 11.6 states that** *"Control mechanisms should be established for ensuring the timely implementation of strategy […] This results in the establishment of tools for the supervision of strategy implementation."*
R5	**Recommendation: The Government should review and revise if needed the schedule for the implementation of the National Programme and confirm that it is realistically achievable.**

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
S5	**Suggestion: The Government should consider commencing the preliminary studies of the feasibility of a national geologic repository without undue delay.**

2.3. PROGRESS INDICATORS

Italian position

MASE is responsible for the development of the National Programme and has the function to define the main objectives and the corresponding time phases, providing the strategic directions and the licenses to operators (making use of the technical and independent advice of ISIN) and for the monitoring the progress made. MASE also is responsible for implementation and monitoring of progress of the National Programme. The Regulatory Authority for Energy, Networks and the Environment (ARERA) monitors the process from the point of view of the economic regulation, defining the main objectives with the related timescales and providing the strategic guidelines.

SOGIN presents to MASE by 31 December of each year a technical report on the progress of the activities and on the actions and the times envisaged for their execution. The MASE reports on progress to the Government and Parliament, through detailed reports and periodic hearings at competent Parliamentary Commissions. Regarding the economic regulation of decommissioning activities, ARERA monitors the process and formulates proposals and reports to the Government and Parliament.

The progress monitoring of the draft National Programme (2023) is performed using intermediate milestones and the Key Performance Indicators (KPIs) related to the final objectives of the programme. There are 27 milestones defined in the draft National Programme (2023) linked to the 9 established objectives. Each milestone has KPIs to monitor progress of the implementation of the milestone.

Starting from 2013, every 3 years SOGIN prepares and updates the PTGvi, containing physical and financial results to be achieved until the complete closure of the nuclear cycle, together with progress indicators. Some of the National Programme KPIs relating to decommissioning of nuclear facilities and related radioactive waste are directly linked to PTGvi. Based on those indicators the achievement of objectives is verified, any deviations indicated, and the recovery actions implemented. SOGIN is also implementing an information system for the management and the control of its activities, in order to check and demonstrate the achievement of the objectives under its responsibility.

The management and supervision of collection activities (on the national territory), treatment, conditioning and medium-long term storage in temporary repositories of non-electronuclear radioactive waste deriving from medical, industrial and research activities, is a service established by the legislation entrusted to the ENEA. No particular milestones have been established, apart from the regulatory and authorization obligations of ENEA.

R&D activities will be carried out based on current needs, as well as the needs dictated by the geological disposal programme to be developed. Based on this research programme, the Italian Government will identify a subject who will coordinate the activities and will report annually to the Government on the implementation of the programme.

ARTEMIS observation

The ARTEMIS Review Team noted that Italian legislative framework forms the basis for monitoring of the progress of the radioactive waste and spent nuclear fuel management strategy. The approach used for monitoring of the progress of decommissioning and radioactive waste management activities is in line with the recommendations of IAEA safety standards.

The ARTEMIS Review Team, considering the relevance of established milestones and KPIs in of the draft National Programme (2023) to its objectives and considering that PTGvi is also submitted for the competent authorities for information, considers that the approach for monitoring of the progress of the National Programme is consistent with the recommendations of IAEA safety standards.

There were no findings identified for the topic of progress indicators.

3. INVENTORY OF SPENT FUEL AND RADIOACTIVE WASTE

Italian position

Italy provided detailed information on the topic of inventory in the ARM. Responsibility for compilation of the national inventory of spent fuel and radioactive waste rests with the regulatory body ISIN. ISIN updates and publishes the national inventory report on a periodic basis, and this report is used to inform planning, as well as for Italy to use in satisfying international obligations for inventory reporting.

ISIN presented detail on the purpose and function of the STRIMS tool. STRIMS is a software system developed for the regulatory body to track in real time all sources of ionizing radiation, as prescribed in law. The STRIMS tool therefore also tracks devices that emit ionizing radiation (e.g. x-ray machines) in addition to radioactive waste, radioactive materials and spent fuel. The STRIMS tool was put into operation in January 2022, and since inception has amassed many tens of thousands of records. All users, holders and transporters of sources of ionizing radiation must be registered to use STRIMS and must register in STRIMS all movements of radioactive materials.

Detailed radioactive waste data about waste packages in storage, or radioactive waste in any of the predisposal steps, is maintained on database systems under the control of the operators. SOGIN presented information on their system AIGOR. The other operators have their own systems that perform similar functions to AIGOR. STRIMS has been designed to integrate with the operators' data systems (such as AIGOR) such that the data needed by the regulatory body can flow from the operator data system to STRIMS, but there is no data flow in the opposite direction.

ARTEMIS observation

The ARTEMIS Review Team reviewed in detail all of the ARM on the topic of Inventory and prepared a list of questions for consideration by Italian counterparts to prepare for discussion during the review meeting. The questions were to assist the ARTEMIS Review Team to fully understand the Italian position, and questions spanned a broad range of aspects pertaining to the topic of inventory, including controlling and managing the process of compiling the inventory, quality of the inventory data, but also management of all the data pertaining to radioactive waste at any time during all of the pre-disposal steps to disposal.

The ARTEMIS Review Team observed that the STRIMS tool was primarily a tool for the regulatory body, and it did not contain all of the supporting data pertaining to each waste package that is needed for disposal. Nonetheless, it is viewed as an effective regulatory tool and should prove to be an efficient path to compiling the national radioactive waste inventory in an automated way. ISIN has put a lot of thought into quality management in the implementation of the tool, and many of the desired quality measures have already been implemented. It was observed during the discussion that there is one aspect of data, waste volume, that has not yet been fully standardized across the system. ISIN is fully aware of this and at present has the capability to make the needed manual corrections necessary when an inventory report is created from STRIMS. ISIN has plans to correct this in the system. The ARTEMIS Review Team considered this and has no concerns about ISIN being able to prepare future radioactive waste inventory reports. The ARTEMIS Review Team sees the STRIMS tool as an improvement that appears to have been well implemented and that ISIN has all the necessary expertise to develop radioactive waste inventory reports now and in the future.

In response to questions from the ARTEMIS Review Team, SOGIN presented extensive information on their system for tracking of radioactive waste data, AIGOR. It was clear that AIGOR has the full range of capability to manage data concerning individual waste packages, characterization, history, treatment and conditioning steps, and quality management controls at all steps. The system holds >950 fields for every record and preserves the entire history of data for any individual waste package. AIGOR has been set up to not only contain the data for any waste that has been generated and is in flow, but also to predict all future waste to be generated from any project, and to track waste that moves from the future predicted state to real waste packages that are managed in the system. SOGIN demonstrated a very high degree of maturity in understanding the use of radioactive waste data and quality management tracking of all levels of radioactive waste data. The degree of integration of the AIGOR system to the detailed work plans for decommissioning projects provides SOGIN a very mature method to predict the nature and quantities of radioactive wastes to be produced in future. The way SOGIN applies this tool to their planning process was very impressive.

The National Repository organization that currently resides within SOGIN has access to all of the information in AIGOR, which represents the majority of radioactive waste destined for the National Repository. The ARTEMIS Review Team questioned the National Repository organization concerning the degree of rigour they have applied to predicting the capacity necessary for the National Repository. This included challenging whether they had a sufficient understanding of radioactive waste volumes from sources other than SOGIN, including potentially large volumes of radioactive wastes that could come from projects such as environmental remediation. Following answers to all of the questions, the ARTEMIS Review Team concluded that the National Repository organization has a reasonable understanding and has applied a rigorous approach to scoping the capacity needed for the National Repository. The ARTEMIS Review Team also concluded that the National Repository organization has a strong understanding of what data from the waste generators will be needed to both support the design and performance assessment of the near surface disposal facility, and what data will be required and what quality underpinning will be needed when wastes are received in order to demonstrate compliance with the WAC. The ARTEMIS Review Team observed, however, that the National Repository organization currently are performing their work in this area utilizing SOGIN data via a node in the AIGOR system and haven't yet contemplated how detailed waste package information will flow from operators other than SOGIN to the repository operator during the waste acceptance process. Given the rather short timescales foreseen in the National Programme until operation of the National Repository, it is the view of the ARTEMIS Review Team that the National Repository organization should be mindful of the complexities introduced by multiple organizations and multiple independent data systems that will need to be integrated, and start exploring how this will be achieved in sufficient time. The fact that STRIMS was implemented successfully in a short time gives hope, but noting that STRIMS manages almost 2 orders of magnitude fewer data fields. The ARTEMIS Review Team would offer as advice for the National Repository organization to consider the importance of this aspect in the response to Suggestion S2 described in section 1.2.

Overall, the ARTEMIS Review Team were satisfied that Italy has robust arrangements in place regarding inventory of spent fuel and radioactive waste and that, in general, this is an area of strength. There were no findings identified for this topic.

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

Italian position

Concepts, plans, and technical solutions for spent fuel and radioactive waste present in Italy, from generation to disposal and the related complementary activities were presented.

Almost all of the fuel produced during the operation of the four Italian NPPs was sent abroad for reprocessing, with the expected return to Italy of the generated radioactive waste. All the spent fuel from Latina and part of that from Garigliano and Trino was sent to UK in the period until 2005 and the spent fuel from Caorso, and the remainder of that from Trino and Garigliano was sent to France in the period 2007-2015. Approximately 13 tons remain to be transferred to France. This arises from Garigliano and Trino and is currently stored at the pool of the Avogadro facility. In addition, there is a limited quantity of spent fuel for which reprocessing is not foreseen, notably consisting of 64 fuel elements stored at the ITREC plant in Rotondella, from the US Elk River research reactor. This fuel is currently stored at the facility's pool. It will subsequently be stored dry in 'dual purpose' TN24 ER casks in a special temporary storage facility, under construction on the site, that is expected to start operating by 2026.

About 115 kg of irradiated fuel are now stored in various containers at the OPEC-1 fuel storage plant of the Casaccia Research Centre. This will be repackaged in 'dual purpose' casks to be stored, on a long-term interim basis, at the CSA of the National Repository. Approximately 680 kg of spent fuel, are now stored in various locations on the JRC Ispra site.

Waste from nuclear power generation (‘energy radioactive waste’) mainly arises from decommissioning of the nuclear installations. The Italian Government has adopted the strategy of "accelerated decommissioning" of all nuclear installations. The process of decommissioning of nuclear installations is conducted with the final objective of releasing the site without any radiological constraints (so-called "green field"), which allows the site to be returned to the community for its reuse in other activities.

The goal of recycling/reusing most of the materials generated by the decommissioning process and therefore 'minimizing' radioactive waste (but also conventional waste) is pursued through procedures, methodologies and management tools that survey the individual components right from the initial stage of the process and follow its evolution and the various treatments up to the final destination (“*cradle to grave*”).

In the absence of the National Repository, the radioactive waste already produced in the nuclear installations during their past operation and waste that continues to be produced from activities for the safe conservation of the installations or from operations connected to their decommissioning (e.g. decontamination, dismantling of contaminated or activated structures, systems and components) are treated, conditioned and stored at the same sites.

Pending operation of the National Repository, it has become necessary to build additional temporary storage structures on the sites, or to refurbish the existing ones. These new storage structures are intended to improve the current waste storage conditions or to make it possible to continue the planned decommissioning operations by making available new storage space.

There are some particular streams of radioactive waste, mainly liquids or semi-liquids (sludge, etc.), from past operations, for which specific solutions are designed. The aqueous liquid radioactive waste from reprocessing at the EUREX plant in Saluggia represents the largest activity waste stream in Italy. Development of the CEMEX complex will provide a cementation facility for treatment of this waste stream. The completion of the cementation facility is the

most important challenge to be addressed for the waste predisposal management phase, however, contractor problems have been encountered resulting in delay to the project.

For spent ion exchange resins, a project was developed and approved in 2020 for the construction of an experimental treatment plant based on wet oxidation technology (WOT) and a mobile cementation plant called SiCoMoR for conditioning the product. Problems have led to termination of the contract and no decision has been taken how to treat the spent resins, but SOGIN has decided to start an alternative study for the direct solidification in a geopolymer concrete based binder of this waste stream.

Long-lived ILW produced in the operation of nuclear fuel cycle installations are being treated and conditioned and will be stored in existing or planned storage facilities at the nuclear installations where they have been produced.

Radioactive waste generated from non–energy uses is managed and temporarily stored in authorized facilities under the safety conditions established in the authorization, in compliance with the in force regulatory requirements by law and under the control of ISIN.

Most of the radioactive waste generated by medical, industrial and research applications is currently collected and managed by operators who choose to join the Integrated Service administered by Nucleco, and who deliver it to Nucleco for treatment, conditioning and temporary storage, pending transfer to the future National Repository.

It is currently expected that, following operation of the National Repository, starting in 2032, transfer operations for the radioactive waste temporarily stored in the SOGIN production sites to the near surface disposal facility of the National Repository will begin. Transfer operations will end in 2043 with the completion of the dismantling of the Latina plant. The transfer of all types of radioactive waste and spent fuel to the National Repository will also make it possible to release these sites without radiological constraints. The disposal of all radioactive waste as today registered in the national inventory is expected to be completed in 2055.

ARTEMIS observations

The ARTEMIS Review Team raised many questions on concepts, plans and technical solutions that were discussed with Italian counterparts.

Of particular note was the information relating to the application of methods and processes for reducing the volume of disposed wastes, specifically the VLLW and LLW. The ARTEMIS Review Team was satisfied that the assumptions on use of these methods were realistic and took full account of likely limitations to provide a robust estimate for waste volumes.

SOGIN was able to provide further information on the reasons for delay to the second phase of decommissioning of the Latina NPP, specifically the removal of the graphite. The concerns associated with dismantling of the graphite core were described along with the studies being undertaken, some in collaboration with Electricité de France (EDF), to develop approaches to physical and mechanical characterisation.

The situation with respect to periodic inspection of waste packages was clarified to the satisfaction of the ARTEMIS Review Team.

SOGIN was able to provide the ARTEMIS Review Team with much more information on the basis for the near surface disposal facility concept, using existing facilities such as Centre de l'Aube and El Cabril as models, and the development of the module concept. This allowed us a better understanding of the basis for the waste categories.

The ARTEMIS Review Team notes also standardisation of treatment and waste conditioning methods across sites, including the use of the mobile conditioning plant (Sicomor) as well as the potential to move waste temporarily between sites in order to access treatment routes. All of these points indicate optimisation.

Regarding the geological disposal, the ARTEMIS Review Team acknowledge that Italy see their current priority is the siting and implementation of the National Repository. The ARTEMIS Review Team is concerned, however, that leaving all planning for geological disposal until after the National Repository is operational in 2032 will lead to the need for an accelerated, and possibly unachievable, programme for the GDF. From our experience, a siting and characterisation programme could easily take most of the period between 2032 and 2070, which is not long in terms of international experience. This is further discussed in section 2 and suggestion S5.

The ARTEMIS Review Team notes that delays due to the contractual challenges SOGIN has encountered in delivery of important waste treatment projects have consequences to safety. The ARTEMIS Review Team is concerned that similar contractual problems could continue to occur and could impact the implementation of the National Repository.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *Italy reported that several major projects are being impacted by contracting challenges, many of which are connected to procurement requirements imposed on public agencies in Italy, but may not be well suited to the nuclear decommissioning context. This is further challenged by availability of key competences within the Italian supply chain, which are difficult to secure internationally with current contracting constraints on public entities. Left unaddressed, this is anticipated to continue to delay execution of important projects including cementation of the high activity liquid wastes from reprocessing of spent fuel in Italy.*	
(1)	**BASIS: SSR- 5 Requirement 25, para.5.23 states that** *"The management system specifies the role of management and the organizational structure to be used for implementing processes for all safety related activities. It also specifies the responsibilities and authorities of the various personnel and organizations involved in managing and implementing the processes and assessing the quality of all work relating to safety."*
(2)	**BASIS: NW-G-1.1 para. 12.1 states that** *"The existing policy and strategy should be reviewed and analysed in relation to:* *— The experience obtained in their application: to identify any deficiencies that could be improved upon. This could include making improvements in national structures for radioactive waste management, clarifying or modifying the roles and responsibilities of national organizations and making improvements in the funding arrangements for long term radioactive waste management."*
S6	**Suggestion: The Government should consider review of SOGIN contracting performance along with legislated contracting constraints for state entities with the intention of exploring opportunities for SOGIN to achieve better project milestone delivery performance while also meeting the state contracting objectives.**

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

Italian position

According to the Italian legislation, all activities and facilities having relevance for the safe management of spent fuel and radioactive waste have to be authorized. The authorization is granted by the Licensing Authority (MASE) based upon the binding technical advice of the competent regulatory authority (ISIN). When applying for an authorization the applicant has to submit a safety demonstration which is reviewed and assessed by ISIN. For certain authorizations, the observations formulated by interested Ministries and the Region concerned are also considered.

ISIN, the independent safety authority, publishes Technical Guides to disseminate to the nuclear facilities operators with standards of good practice which define the implementation procedures, on a technical-operational level, of the legal provisions on nuclear safety and radiation protection, also establishing the criteria and methodologies with which it intends to carry out its control action. The Technical Guides presented in the ARM are n°29 to 33.

Installations under decommissioning and storage facilities

Most Italian nuclear installations are under decommissioning, for which operations are conducted according to a decommissioning license or are in safe conservation, conducting preliminary operations connected to decommissioning while waiting for the license to be granted. All installations include facilities for radioactive waste treatment/conditioning as well as for temporary storage. New radioactive waste storage facilities on the sites necessary to reach the brown field state will be realized either by the refurbishment of existing buildings or by the construction of new buildings.

All decommissioning operations are led by SOGIN. For Garigliano, Trino, Caorso and Latina NPPs and Bosco Marengo Fuel Fabrication Facility, SOGIN received decommissioning licenses several years ago.

The two dedicated spent fuel storage facilities located away from the nuclear installation sites, i.e. Avogadro and OPEC1, have been operating for many years and their safety demonstration was part of the application documents submitted for the operations authorization.

The Technical Guide n.30 requires that a periodic safety review of storage facilities has to be conducted every 10 years. For new facilities, constructed in the nuclear sites in the recent years, this date is also established as a condition in the approval issued by ISIN. For old facilities, for which a refurbishing has been planned or the stored waste or fuel is planned to be removed, a specific time after which to conduct a periodic safety review has not been established. However, if the plans for the new facility or for the removal of material are delayed, ISIN has requested extraordinary verification of the state of preservation of relevant structures and systems. An example is the case of the Deposito Avogadro spent fuel storage facility.

ISIN in 2022 has also performed inspections in the radioactive waste storage facilities in each installation, aimed at verifying both the compliance with the safety and radiation protection criteria set by the Technical Guide n. 30 (2020), the conditions of the relevant structures and components and the correct storage of the radioactive waste. Other inspections will be carried out in 2023.

Installations for Medical, Industrial RW management (treatment/conditioning and storage)

The Nucleco Installations located in the Casaccia Research Centre in Rome are the main installations devoted to the treatment and storage of medical and industrial radioactive waste. The safety demonstration is reported in the authorization application documents prepared according to the content now requested in Annex XIV of Lgs. Decree n.101/2020.

According to the technical specifications attached to the authorization, Nucleco is required to carry out a periodic safety review by submitting, every seven years, a technical report containing the update of the documentation previously sent for the purpose of issuing the authorization.

National Repository: Near Surface Disposal Facility and HLW and ILW long term storage facility

The Safety Case for the National Repository is currently under development. It will provide the documentation for: siting; concept of all the facilities (surface disposal of VLLW and LLW and long-term storage of ILW and HLW); inventory that will be transferred to these facilities. As the site is not yet selected, site specific safety analysis is yet to be completed. Generic safety analysis activities (such as human intrusion during post institutional period) and studies for the safety analysis for the biota are underway.

In the article 27 of Lgs. Decree n. 31/2010 it was stated that within 6 months of the publication of the decree which will state the site, SOGIN has to submit an application for the authorization to construct and operate the National Repository (and all other related works included in the Technology Park), whose review and assessment has to be carried out by ISIN no later than 6 months from the submission of the application.

The Technical Guide n.32 also requires a Periodic Safety Review *"to be performed during the operational period, the closure and post-closure phases to confirm the assumptions and the requirements upon which the authorization is based. The review must be carried out at periodic intervals as defined in the authorization and in any case at least every ten years. A final review needs to be done to support the termination of the institutional control period"*.

For reviewing the safety assessment of the future National Repository, ISIN will need new and specific competencies, that are mainly planned to be acquired through recruitment and specific training programme, also taking advantage of international cooperation agreements. That does not exclude the possible needs for external support. In Italy, the technical competencies in the field of nuclear technology are limited since the decision to stop the production of nuclear energy was taken in 1987. So, to develop the project of National Repository, the operator SOGIN will concentrate the competencies available in this domain.

ARTEMIS observation

The ARTEMIS Review Team notes that the safety of facilities under decommissioning, including storage facilities, are regularly verified by ISIN based on periodic safety case reviews and safety inspections.

If ISIN has the objective to recruit people with the adequate competencies and to have exchanges with other regulators at the international level, the ARTEMIS Review Team considers that it is important that ISIN develops a process to ensure availability of experts who would have the adequate competencies to support their safety case review. The ARTEMIS Review Team observes that the external pool of specialist resources for safety assessment is small and is also the same pool supporting operators in preparing safety cases. The independence of these experts from the experts involved in the project with the operators is the key to guarantee the total independence of the regulator decision. The ARTEMIS Review Team

advises that if this is not considered early it may be difficult to find specialist resources that have not been working with the operators.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *ISIN provides independent and binding technical advice to the Ministers during the process of licenses by conducting the verification of license holder's safety case. It's noted that 60 people on the ISIN staff are technical experts but, for specific domains of expertise, ISIN can have access to external independent technical support. ISIN have indicated that they may need such access to verify the safety case for the National Repository. The expertise needed is from a small community that is also used by the operators.*	
(1)	**BASIS: GSR Part 1 (Rev. 1) Requirement 17 states that** *"The regulatory body shall perform its functions in a manner that does not compromise its effective independence."*
(2)	**BASIS: SSR-5 Requirement 2, para. 3.11 states that** *"The regulatory body also has to set out the procedures that it follows to assess compliance with the conditions throughout all stages of the development, operation and closure of the facility."*
(3)	**BASIS: SSR-5 Requirement 14 states that** *"The safety case and supporting safety assessment for a disposal facility shall be documented to a level of detail and quality sufficient to inform and support the decision to be made at each step and to allow for independent review of the safety case and supporting safety assessment."*
S7	**Suggestion: ISIN should consider developing a process to ensure availability of experts to support their safety case review who will be independent from the technical experts working with the operators.**

The ARTEMIS Review Team considers that the time afforded for preparation and review of the safety case documents for the application for the National Repository are too constrained and could compromise the level of quality. International experience demonstrates more time is required. Even if SOGIN's National Repository team are already working on the safety assessment, the characterization of the chosen site and the integration of the dedicated data in the safety case will take time, in particular in relation to the safety of the near surface disposal. The regulator needs sufficient time to perform a review which may include conducting confirmatory studies.

Concerning the CSA, the ARTEMIS Review Team notes that continued maturity of the conceptual design is necessary to make needed advances in the development of the safety case for the facility (e.g., refining specificity of the specific casks to be received, handled and stored). This can progress in advance of site selection.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES
Observation: *The law constrains both preparation and review of the repository safety case*

and safety assessment within strict timelines and the review team considers that the time frames are unreasonable. The driver for such work should be safety and the operator and regulator should be afforded the necessary time to thoroughly prepare and review these documents to the quality demanded in the Safety Standards. Strict enforcement of these unreasonable time constraints could result in an unintentional compromise in safety and erode public confidence.	
(1)	**BASIS: GSR Part 5 Requirement 15 states that** *"The safety case and its supporting safety assessment shall be documented at a level of detail and to a quality sufficient to demonstrate safety, to support the decision at each stage and to allow for the independent review and approval of the safety case and safety assessment."*
(2)	**BASIS: SSR-5 Requirement 14 states that** *"The safety case and supporting safety assessment for a disposal facility shall be documented to a level of detail and quality sufficient to inform and support the decision to be made at each step and to allow for independent review of the safety case and supporting safety assessment."*
R6	**Recommendation: The Government should take measures to ensure that the time constraints imposed on preparation and review of the safety case and safety assessment for the National Repository will not compromise safety.**

The ARTEMIS Review Team also notes that, according to the existing legislative provisions, the radiation protection objective for the near surface disposal facility in the post-closure period will be 10 μSv/year, and is lower than the ICRP guidance of 0.3mSv/y for a radioactive waste disposal. The ARTEMIS Review Team observes that the objective may unnecessarily constrain the activity of waste disposals to the repository, resulting in more waste being stored for longer before geological disposal.

The ARTEMIS Review Team observed overly conservative assumptions in the preliminary safety analysis that are not legislatively driven. SOGIN described the approach to the preliminary safety assessment of the near surface disposal facility in the period following cessation of institutional control and indicated that they will consider that the engineered structures no longer provide any barrier to contaminant release to the environment. This is a conservative approach that does not take credit for the benefit of the chemical barrier (e.g. limitation of solubility by the chemical environment, sorption capacity of cement-based materials such as the conditioning mortar).

The combined consequence of overconservatism makes it difficult to compare the performance of different sites or different designs for the disposal facility. This may result in potential sites or designs being screened out early in the assessment process. For the purpose of optimisation, the assessment needs be based on assumptions that are as realistic as possible to highlight differences in performance between sites.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES
Observation: *The repository organization is applying overly conservative assumptions in the preliminary safety assessment that may cause unintended consequences to safety by ruling out options that could otherwise prove optimal.*

(1)	**BASIS: SSR - 5 Requirement 2, para. 2.15 states that** *"The safety objective and criteria for the protection of people and the environment after closure of a disposal facility are as follows:* ***Safety objective*** *The safety objective is to site, design, construct, operate and close a disposal facility so that protection after its closure is optimized, social and economic factors being taken into account. A reasonable assurance also has to be provided that doses and risks to members of the public in the long term will not exceed the dose constraints or risk constraints that were used as design criteria."*
(2)	**BASIS: SSR - 5 Requirement 4, para.3.17, states that** *"Disposal facilities for radioactive waste may be developed and operated over a period of several years or several decades. Key decisions, such as decisions on site selection and evaluation, and on the design, construction, operation and closure of the disposal facility, are expected to be made as the project develops. In this process, decisions are made on the basis of the information available at the time, which may be either quantitative or qualitative, and the confidence that can be placed in that information."*
(3)	**BASIS: SSG-29 Para 4.8 states that** *"The development, operation and closure of a near surface disposal facility involves an iterative process of site characterization and design and evolution of the safety case and supporting safety assessment to provide an optimized level of operational and post-closure safety […].In this process, optimization of the disposal facility and its safety performance through the evaluation and comparison of options should generally progress from more strategic considerations to detailed choices for design and operation. Optimization of the long term safety of a near surface disposal facility should mainly be achieved by means of decisions on the site and the design of the facility, and by a cautious approach followed in safety assessment to set adequate limitations on the inventory.[…] However, optimization of the design of the facility should take due account of all the favourable and unfavourable site characteristics and should be based on best practices."*
S8	**Suggestion: The repository operator should consider avoiding unrealistic overly conservative assumptions in the development of the safety assessment of the near surface disposal facility.**

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

Italian position

The responsibility for financing of radioactive waste and spent fuel management in Italy is divided by the operators generating the waste and Italian Government. If the waste producer is unable to bear the costs, the Government is responsible. Consistent with international practice and the articles of the Joint Convention on the Safety of Radioactive Waste Management and on the Safety of Spent Fuel Management, the Government has ultimate financial responsibility.

The costs associated with the implementation of the National Programme are generally divided in:

- the decommissioning of nuclear power plants;
- the disposal of radioactive waste, (siting, planning, construction, operation, closure, decommissioning) of the low and intermediate (short lived) waste disposal facility, storage facility for intermediate and high level waste and deep geological disposal facility;
- the research and development activities.

Decommissioning of nuclear power plants:

The costs relating to the decommissioning activities have been estimated by operators of the facilities (latest estimate 2020). Italy used cost estimation methodologies based on international good practice. Because of different stage of decommissioning programmes (some nuclear facilities are under decommissioning, others have not started) they identified uncertainties that need to be addressed. For this reason Italy classifieds the costs in three levels of accuracy (rough estimation, budgetary estimation and final estimation).

Until 2023 the costs for decommissioning were covered by specific component of electricity rate and managed in dedicated fund, operated by Cassa per i servizi energetici e ambientali (treasury for energy and environmental services). From 2023 the resources were transferred to the state budget, which is now responsible for financing the activities. Operators of decommissioning activities provide three year budget forecast to the Government. A part of these resources are to be used for the incentives to local communities that host nuclear facilities.

Disposal of radioactive waste

SOGIN prepare the cost estimation for the National Repository, including:

- activities to start with the operation, and
- operation activities.

This cost estimation was prepared based on preliminary SOGIN experiences and cost for the first three years are presented in SOGIN “Whole life plan”.

Article 24, paragraph 5 of law decree 1/2012 establishes that the producers and holders of radioactive waste that will be disposed of in the National Repository must pay a contribution. It was presented that Italy has pricelist, that includes the costs for:

- certified containers for the transport of radioactive waste and sources,
- treatment and conditioning,
- transfer of ownership titleship,
- cost for storage and cost for disposal.

In Lgs. Decree No. 45/2014 it is stated that the radwaste producers have primary responsibility for safe management of radioactive waste in the absence of the owner the State is subsidiarily responsible.

The cost estimation for deep geological repository is made on the base of the cost estimation for National Repository. Italy takes the same value for both projects.

Research and development activities

Italy presented that for the moment the cost estimation for the R&D activities connected with decommissioning of the facilities are more detailed, when for the other R&D cost they just made a rough estimation.

ARTEMIS observation

The ARTEMIS Review Team notes that Italy places importance on ensuring there is financial provision for the safe management of its radioactive waste and spent fuel.

The ARTEMIS Review Team noted that cost estimation for the National Repository was prepared on the basis of assumptions around siting and preliminary design that need to be updated after site selection, and notes that costs can change when the site is selected. The cost assessment should also include the foreseeable risks and delays.

It was observed that the cost estimate for geological disposal facility is not based on a design and plan, but assumes that it will be the same as the cost for the National Repository. Italy should prepare a more detailed cost estimation for geological disposal facility directly relevant to the scope and activities for the geological facility that will also include consequences of inflation and potential risks.

The cost of the decommissioning and closure of the nuclear fuel cycle is funded by the Government budget, while costs for non-electronuclear waste are provided by the waste producers. The funding Law, that yearly allocates the funds needed, does not explicitly include geological disposal. Italy doesn't have specific dedicated funds for financing the planned actions of radioactive waste management foreseen in the National Programme. Thus, the ARTEMIS Review Team observes that, considering the long term, the budget needed for certain activities may not be sufficient when required. The ARTEMIS Review Team observes that a funding mechanism to ensure adequate funds are available when needed would be beneficial.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *There are different levels of cost estimate maturity within the life cycle estimate of the National Programme. Higher certainty in cost is needed for execution of near term activities in the programme. SOGIN has invested considerable effort in refinement of cost estimates for decommissioning, however there is still uncertainty for the cost of the National Repository due to the status of the siting and design and this project is scheduled for completion in advance of many decommissioning projects. Furthermore, the review team sees additional cost not accounted for including those from extraordinary inflation from pandemic; from delays that will happen as current schedule is too optimistic; and, ongoing contracting challenges.*	
(1)	**BASIS: GSR Part 1 (Rev. 1) Requirement 10, para. 2.33 states that** *"Appropriate financial provision shall be made for:*

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
	(a) Decommissioning of facilities; *(b) Management of radioactive waste, including its storage and disposal;* *(c) Management of disused radioactive sources and radiation generators;* *(d) Management of spent fuel."*
(2)	**BASIS: SSR – 5 Requirement 1, para. 3.7 states that** *"The government is required to establish and maintain an appropriate governmental, legal and regulatory framework for safety within which responsibilities shall be clearly allocated for disposal facilities for radioactive waste to be sited, designed, constructed, operated and closed.* *Matters that have to be considered include: […]* *(c)Ensuring the adequacy and security of financial provisions for each disposal facility; […]"*
R7	**Recommendation: The Government should ensure the improvement of cost estimate associated with all activities in the National Programme with consideration that:** • **activities scheduled in the near term have a cost estimate of high enough confidence to support execution;** • **the cost estimate for the National Programme includes all foreseeable costs, including those that may result from foreseeable risks and delays;** • **a robust cost estimate for the geological repository implementation is developed as the programme for the implementation is better defined.**
S9	**Suggestion: The Government should consider funding mechanism to ensure adequate funds are available when needed to execute all activities of the National Programme.**

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

Italian position

The requirements for the training of SOGIN personnel are described in the internal document (Training program catalogue). The personnel training process is based on IAEA SAT (systematic approach for training) model. To provide the training SOGIN founded the Radwaste Management School (briefly RaMS) in 2008, to ensure a high-level of professional and technical training. It promotes managerial and technological innovation based on the Company's experience and specialized know-how in decommissioning and radioactive waste management. The school is also open to professionals coming from external institutions and companies, representing a reference point for safety management in industrial processes. In discussions with the ARTEMIS Review Team, Italy also noted that courses were provided by RaMS in other countries to provide a wider access to the training.

RaMS is part of the strategic assets for achieving the mission of SOGIN and Nucleco. The goal is to transfer skills, know-how and competencies to the future generation and satisfy the increasing knowledge demand in the nuclear sector both at international and at national level.

The training needs are collected every year into the annual training program. The framework is formed by training requirements that are function-specific or related to special roles or permits, which are supplemented by training proposals received from various stakeholders. RaMS training courses are carried out by its own resources on topics such as ways of working, safety culture, technology of the nuclear facility, etc.; and subcontractors specialized in some special features.

The ENEA Agency has highly qualified personnel, advanced laboratories, experimental facilities for both implementation of projects and research and provision of training.

ENEA collaborates with the major national and international institutions, universities and research bodies. It plays active part of agreements signed with key international nuclear organizations (International Atomic Energy Agency, Nuclear Energy Agency, EURATOM), and participates in the main EU research programmes (SNETP, EERA, ESNII, etc.). It also collaborates and exchanges researchers with the two major French nuclear research bodies (Commissariat à l'Énergie Atomique and Institut de Radioprotection et de Sûreté Nucléaire) as well as with US-DOE laboratories. ENEA also participates in the OECD/NEA Nuclear Education, Skills and Technology framework (NEST), supporting the training of younger generations through the transfer of practical experience.

Regarding education and training, several possible courses of undergraduate study are currently available in Italy. Since 1994, however, a consortium of universities have offered MSc and PhD courses in Nuclear Energy and Engineering or on nuclear engineering topics. CIRTEN (Inter-University Consortium for Nuclear Technology Research) groups Politecnico di Milano, Politecnico di Torino and the Universities of Bologna, Padova, Pisa, Rome "La Sapienza" and Palermo. Some of those universities have been operating in the nuclear education and research fields since the early 1950s. No new MSc / PhD university programmes are planned, since the number of applications to the current nuclear related programmes is increasing.

Training of nuclear plant technicians, operators and managers, for the TRIGA RC1 and RSV TAPIRO research reactors, CALLIOPE Gamma Facility facilities and Nucleco Installations, is carried out in collaboration with the principal Italian universities through CIRTEN, the ministries and major sector industries and training companies.

The ENEA Integrated Service performs information and training on management of orphan sources, non-electronuclear waste and high activity sources to local health authorities, prefectures and industrial realities that request it.

ARTEMIS observation

The Self-Assessment questionnaire provided a summary of key activities for the training of resources to meet the expected needs of SOGIN, Nucleco and ENEA. Upon questioning, however, the ARTEMIS Review Team became aware of a much wider and richer collaborative culture supporting the education, training and development of young people in the nuclear and radioactive waste management fields. Especially notable is that the consortium of Italian universities providing MSc and PhD opportunities that result in 100-130 nuclear engineering postgraduates each year. This should be a source of national pride after several decades without nuclear power generation.

SOGIN also noted that it supports post-graduate opportunities, in collaboration with universities, that are targeted at potential siting areas for the National Repository, thus establishing links with those areas as well as potential trained resources. ISIN for its part is funding the access for Italian universities to modelling codes for accident simulation by agreement with the US NRC, in order that they can be used for research in universities. Information on the research will be fed back to ISIN and the US NRC under this agreement.

The National Programme on Sustainable Nuclear Technology is a further initiative under the coordination of MASE aimed at involving early career professionals in the development of new nuclear technologies.

The ARTEMIS Review Team was very impressed by the range of coordinated and collaborative training and development opportunities across all technical areas required to support decommissioning and waste management, as well as new nuclear technologies.

The ARTEMIS Review Team noted that the SOGIN's PTGvi provided a thorough analysis of resources for their current and future activities based on requirements for mandated and 'commensurate' staff for decommissioning. In discussions, it was further stated by SOGIN that they had used an assumption that the National Repository would be implemented approximately to schedule so that experienced staff released by the attainment of brown field status at decommissioned sites could be retained by SOGIN for deployment to the National Repository programme. Delay of the National Repository, leaving a period when these resources might be lost to SOGIN, was recognised as a risk to the programme to implement and operate the National Repository, as well as moving sites to greenfield status.

However, the required human resources of other actors are not similary defined in the National Programme or underpinning documents. The ARTEMIS Review Team noted that ISIN staff numbers are dictated by legislation, and ISIN has not carried out an exercise to determine their future resource needs to support the National Programme. This analysis is needed to determine whether ISIN will have the resources necessary to fulfil their responsibilities under the National Programme and measures to ensure availability as needed.

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *In spite of not having an operational nuclear power programme, Italy is having a high degree of success in attracting students to a creative integrated development programme that is supported through collaboration of all the major actors in Italy. Overall, this range of coordinated and collaborative training and development opportunities across all technical areas required to support decommissioning and waste management, as well as new nuclear technologies, indicates a significant investment in the future and is to be commended.*	
(1)	**BASIS: GSR Part 1 (Rev. 1) Requirement 11 states that** *"The government shall make provision for building and maintaining the competence of all parties having responsibilities in relation to the safety of facilities and activities."*
GP1	**Good Practice: The broad-based, collaborative training and development programme for nuclear professionals established in Italy between many entities is an exemplary achievement.**

RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES	
Observation: *The issue of human resources capacity and competency development is not explicitly addressed in the National Programme. Furthermore, the regulator has not showed a resource profile matched to the scope of the National Programme.*	
(1)	**BASIS: GSR Part 1 (Rev. 1) Requirement 1, para. 2.3. states that** *"National policy and strategy for safety shall express a long term commitment to safety. […]. The strategy shall set out the mechanisms for implementing the national policy. In the national policy and strategy, account shall be taken of the following:* *(d) The need and provision for human and financial resources; […]"*
(2)	**BASIS: NW-G-1.1 para 10.4.2. states that** *"A properly trained and competent workforce is needed to operate the waste management facilities. Similarly, the facilities must be properly regulated and the regulatory body must, therefore, be staffed with effective and knowledgeable staff. These are important aspects to be considered in developing or updating a national strategy. An assessment should be made of the number of staff needed and the levels of competence needed for the implementation of the technical options decided upon. Based on such an assessment, the adequacy of the existing staff for this purpose should be determined. […]".*
(3)	**BASIS: GSR Part 5 Requirement 1 states that** *"The government shall provide for an appropriate national legal and regulatory framework within which radioactive waste management activities can be planned and safely carried out. This shall include the clear and unequivocal allocation of responsibilities, the securing of financial and other resources, and the provision of independent regulatory functions. Protection shall also be provided beyond national borders as appropriate and necessary for neighbouring States that may be affected."*
R8	**Recommendation: ISIN should fully identify the regulatory resources needed according to the scope of National Programme and plan for acquiring those resources.**
R9	**Recommendation: The Government should ensure that ISIN has the necessary resources to execute its duties according to the National Programme.**
S10	**Suggestion: The Government should consider including within the National Programme an analysis of the resources and competencies required across all entities/actors.**

APPENDIX A: TERMS OF REFERENCE

Terms of Reference

1. Introduction

On 5 August 2020, Permanent Mission of Italy to the United Nations, requested the International Atomic Energy Agency (IAEA) to organize and carry out, in 2023, an Integrated Review Service for Radioactive Waste and Spent Fuel, Decommissioning and Remediation (ARTEMIS) review. Italy 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).

The review will be organized by the Department of Nuclear Safety and Security and the Department of Nuclear Energy of IAEA. It will be performed by an independent, international peer review team selected by the IAEA.

2. Objective

The ARTEMIS review will provide an independent, international evaluation of Italian governmental, legal and regulatory framework, national programme and its implementation for safe management of spent fuel and radioactive waste.

The review will be performed by an international peer review team selected by the IAEA.

3. Scope

The ARTEMIS review will address the Italian governmental, legal and regulatory framework, national programme and its implementation for safe management of spent fuel and radioactive waste.
It was agreed to exclude the radioactive waste generated by activities of Defence administration from the scope of the review.
Results from the IAEA Integrated Regulatory Review Service (IRRS) mission to Italy conducted in November 2016 will be taken into account, if relevant and appropriate.

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.

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 Ministry of the Environment and Energy Security. The National Counterpart Liaison Officer for the review is Mr Mario Dionisi from the National Inspectorate for Nuclear Safety and Radiation Protection (ISIN).
The ARTEMIS review mission will be conducted from **1 to 10 October 2023** in **Rome**, Italy. 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 Italy as of **16 April 2021**
- Preparatory Meeting: **14 March 2023** (WebEx meeting)
- Notification by IAEA to the Counterparts on the review team composition: by **14 March 2023**
- Submission of reference material: by **1 August 2023** (including the completed self-assessment)
- Submission of questions from the review team to the Counterpart based on preliminary review of the reference material: by **13 September 2023**

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:

- Six 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 Stefan Mayer from the Waste Technology 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 Paul McClelland from AECL, Canada. 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, being the National Inspectorate for Nuclear Safety and Radiation Protection (ISIN).

9. Funding of the ARTEMIS review

The peer review will be funded by Italy. 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 review were paid to the IAEA as voluntary contribution before the start of the mission. Italy is aware that the review cost includes 7% programme support costs.

If the actual cost of the ARTEMIS review exceeds the estimated voluntary contribution, Italy 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 Italy through the Counterpart.

These Terms of Reference were agreed on 31 May 2023 between the IAEA and the National Inspectorate for Nuclear Safety and Radiation Protection (ISIN) during the preparatory meeting held on-line.

Annex 1: List of reference material

- Responses to the ARTEMIS Self-Assessment Questionnaire
- Laws, regulations and regulatory guidelines (including waste classification, concept of clearance, radiation sources categorization)
- Italy third National Report on Implementation of Council Directive 2011/70/Euratom, (2021)
- 6th Joint Convention National Report (2020)
- 9th CNS National Report (2022)
- The IRRS Review Report from 2016 and information on the progresses of the implementation of the findings
- National programme (version from 2019 and draft of update, if ready)
- ISIN relevant Technical Guidances
- Commission Implementing Decision on the financing of the Joint Research Centre (JRC) Decommissioning and Waste Management Programme - C(2022) 9247 final
- COUNCIL REGULATION (Euratom) 2021/100 - Establishing a dedicated financial programme for the decommissioning of nuclear facilities and the management of radioactive waste, and repealing Regulation (Euratom) No 1368/2013
- Decommissioning Plan SOGIN

APPENDIX B: MISSION PROGRAMME

Time	Sunday 1st October	Mon 2 Oct	Tue 3 Oct	Wed 4 Oct	Thurs 5 Oct	Fri 6 Oct	Sat 7 Oct	Sun 8 Oct	Mon 9 Oct	Tue 10 Oct
9.00-10.00	Arrival of Team Members	9.00 Opening General presentation	Inventory	Safety case and safety assessment Capacity building	Session reserved for further discussions if required/ drafting of the report	Presentation and discussions of Recommendations and Suggestions with the Counterparts	Draft report to be sent to the Counterparts for fact checking	Counterparts review the draft report	Discussions with the Counterparts on the draft report	Delivery of final draft report EXIT MEETING
10.00-12.30		National Policy and Framework								
12.30 – 13.30		**Lunch**	**Lunch**	**Lunch**	**Lunch**	**Lunch**	Lunch	**Lunch**	**Lunch**	Departure of Team members
13.30 – 16.30	Artemis team meeting	National Strategy	Concepts, Plans and technical solutions	Cost estimates and financing	Finalization of Recommendations and Suggestions	Drafting of the report	Sightseeing (Team Members) Counterparts review the draft report	Internal reflection of comments	Finalising draft report	
17.00 – 18.00		Team meeting	Team meeting	Team meeting						
18.00 – 22.00		Drafting of the findings	Drafting of the findings	Drafting of the findings					Official dinner	

APPENDIX C: RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES

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 Government should approve without undue delays the 2023 National Programme, that includes geological disposal as a final destination for spent fuel and high-level radioactive waste.
		R2	The Government should ensure that the process for authorization of closure of the near surface disposal facility requires update of the safety report as part of the application.
		S1	ISIN should consider completing the development and issuance of guidance without undue delay, detailing procedures for release of installations, sites and materials from regulatory control.
		S2	The Government should consider ensuring a formal waste certification programme between waste generators and repository operator is developed.
		S3	The Government should consider reviewing existing legislative constraints around what locations can be considered for siting of the National Repository with the potential to relax where they do not impact safety.

Area		R:Recommendations S: Suggestions G: Good Practices	Recommendations, Suggestions or Good Practices
2.	NATIONAL STRATEGY FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT	R3	The Government should compile and publish an R&D programme that is clearly linked to the activities defined in the National Programme.
		R4	ISIN should implement its own R&D programme to build its expertise to review safety cases for the activities in the National Programme.
		S4	The Government should consider developing a comprehensive strategy for proactive involvement of all interested parties, including the public, that encompasses the full scope of the National Programme, in order to reduce implementation risk for both the National Repository and the geological disposal.
		R5	The Government should review and revise if needed the schedule for the implementation of the National Programme and confirm that it is realistically achievable.
		S5	The Government should consider commencing the preliminary studies of the feasibility of a national geologic repository without undue delay.
4.	CONCEPTS, PLANS AND TECHNICAL SOLUTIONS FOR SPENT FUEL AND RADIOACTIVE WASTE MANAGEMENT	S6	The Government should consider review of SOGIN contracting performance along with legislated contracting constraints for state entities with the intention of exploring opportunities for SOGIN to achieve better project milestone delivery performance while also meeting the state contracting objectives.

Area		R:Recommendations S: Suggestions G: Good Practices	Recommendations, Suggestions or Good Practices
5.	SAFETY CASE AND SAFETY ASSESSMENT OF RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT ACTIVITIES AND FACILITIES	S7	ISIN should consider developing a process to ensure availability of experts to support their safety case review who will be independent from the technical experts working with the operators.
		R6	The Government should take measures to ensure that the time constraints imposed on preparation and review of the safety case and safety assessment for the National Repository will not compromise safety.
		S8	The repository operator should consider avoiding unrealistic overly conservative assumptions in the development of the safety assessment of the near surface disposal facility.
6.	COST ESTIMATES AND FINANCING OF RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT	R7	The Government should ensure the improvement of cost estimate associated with all activities in the National Programme with consideration that: • activities scheduled in the near term have a cost estimate of high enough confidence to support execution; • the cost estimate for the National Programme includes all foreseeable costs, including those that may result from foreseeable risks and delays; • a robust cost estimate for the geological repository implementation is developed as the programme for the implementation is better defined.
		S9	The Government should consider funding mechanism to ensure adequate funds are available when needed to execute all activities of the National Programme.

Area		R:Recommendations S: Suggestions G: Good Practices	Recommendations, Suggestions or Good Practices
7.	CAPACITY BUILDING FOR RADIOACTIVE WASTE AND SPENT FUEL MANAGEMENT – EXPERTISE, TRAINING AND SKILLS	GP1	The broad-based, collaborative training and development programme for nuclear professionals established in Italy between many entities is an exemplary achievement.
		R8	ISIN should fully identify the regulatory resources needed according to the scope of National Programme and plan for acquiring those resources.
		R9	The Government should ensure that ISIN has the necessary resources to execute its duties according to the National Programme.
		S10	The Government should consider including within the National Programme an analysis of the resources and competencies required across all entities/actors.

APPENDIX D: LIST OF ACRONYMS USED IN THE TEXT

ARM	Advance Reference Material
CSA	High Activity Storage Complex
ENEA	the Italian National Agency for New Technologies, Energy and Sustainable Economic Development
HLW	High Level Waste
IAEA	International Atomic Energy Agency
ILW	Intermediate Level Waste
IRRS	Integrated Regulatory Review Service
ISIN	the National Inspectorate for Nuclear Safety and Radiation Protection
KPIs	Key Performance Indicators
Lgs. Decree	Legislative Decree
LLW	Low Level Waste
MASE	Ministry of the Environment and Energy Security
PTGvi	Whole Life Plan
VLLW	Very Low Level Waste

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. SSR-4, IAEA, Vienna (2017).

[10] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Energy Basic Principles, Nuclear Energy Series, NE-BP, Vienna (2021).

[11] INTERNATIONAL ATOMIC ENERGY AGENCY, Radioactive Waste Management 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, INFCIRC/546, IAEA, Vienna (1997).

[17] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Safety and Security Glossary, IAEA, Vienna (2022 interim edition).

[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).