European Partnership
on Radioactive Waste Management

Milestone 38: Workshop on building mutual understanding about RWM strategies for long-term storage exceeding the design lifetime

Work Package ASTRA

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Executive Summary

This report presents the results of Subtask 3.1 under the ASTRA WP, which addresses the challenges of managing radioactive waste storage facilities and packages that have exceeded or extended their design lifetime. The analysis draws on survey responses, workshop discussions, and contributions from a range of partners and end-users including WMOs, TSOs, REs, and CSOs.

The questionnaire, structured into six sections, covered both technical and organisational aspects of long-term radioactive waste storage, as well as future strategies, transparency and public participation, and opportunities for international cooperation.

- The first section collected general information about countries, organisations, and the overall number of storage facilities, including those already exceeding their design lifetime.
- The second section explored the current status of storage facilities in more detail, including facility characteristics, waste inventories, service life of packages, and the approaches used to preserve records and transfer knowledge across generations.
- The third section focused on challenges and risks, identifying the main reasons for exceeding design lifetimes, the technical and organisational difficulties encountered, and the measures implemented for ageing management. It also examined safety reassessments, hazard evaluations, and the ranking of risks and uncertainties.
- The fourth section turned to future strategies, including options for lifetime extension, repackaging, relocation, or closure of facilities. It also addressed cost estimates and funding sources, highlighting the economic dimension of decision-making.
- The fifth section dealt with transparency and public participation, reviewing how different countries ensure communication with stakeholders and maintain public trust in long-term storage.
- The final section explored opportunities for international cooperation, seeking ideas for knowledge exchange, joint projects, and collective problem-solving.

Data were collected from 22 organisations from 15 European countries, providing a comparative overview of current practices, gaps, and perspectives. Taken together, the questionnaire responses provide a comprehensive overview of how countries address long-term (exceeded or extended) operation of radioactive waste storage facilities and packages. They highlight both technical measures, such as monitoring, reconditioning, and safety reviews, and broader governance aspects, including data quality, knowledge preservation, stakeholder engagement, and cooperation across borders.

After data collection step, as part of Subtask 3.1, the first online workshop was organised to foster a shared understanding among partners and end-users on the challenges and strategies for managing radioactive waste storage facilities and packages with exceeded or extended design lifetimes. The event was structured to combine presentation of survey findings with interactive sessions, ensuring both knowledge exchange and collective reflection. A total of 33 participants from 17 countries, representing 23 organisations, took part in the workshop. During the small-group breakout sessions, participants analysed the main technical and organisational challenges, the risks and uncertainties associated with long-term storage, and the enabling conditions necessary to ensure safe and sustainable management. They also reflected on opportunities for international cooperation and outlined topics requiring further exploration in future phase of Task 3.

The information collected, along with insights from a dedicated workshop involving task partners and end-users, has contributed to a deeper understanding of the condition and long-term management needs of radioactive waste storage facilities across Europe. It has also helped to identify the key challenges associated with storage facilities and containers that have exceeded their intended design life, prioritise the most pressing gaps and issues faced by participating countries, and laid the foundation for the more detailed analysis to follow in Subtask 3.2. They also confirmed the relevance of continuing dialogue among a broad set of stakeholders to identify practical solutions and shared priorities for future collaboration.

Keywords
Alternative RWM strategies, SIMS, LIMS, storage facilities, design lifetime, ageing management, data quality, knowledge transfer, transparency & public participation, international cooperation, ASTRA WP, EURAD-2

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List of Acronyms

ASTRA WP:	Work Package “Alternative RWM strategies” in EURAD-2 partnership
CSO:	Civil Society Organisations
EIA:	Environmental Impact Assessment
EURAD-1:	European Joint Programme on Radioactive Waste Management
EURAD-2:	European Partnership on Radioactive Waste Management
LIMS:	Large Inventory Member States
PSR:	Periodic Safety Review
SIMS:	Small Inventory Member States
RD&D:	Research, development, and demonstration
RE:	Research Entity
RWM:	Radioactive Waste Management
TSO:	Technical Support Organisation
WMO:	Waste Management Organisation
WP:	Work Package

1. Introduction

Storage plays an important role in the safe management of radioactive waste, serving different purposes at different stages in the management of waste. It is necessary to store spent fuel and some other types of waste for a period to allow radioactive decay to reduce the levels of radiation and heat generation. For other types of waste, storage acts merely as a transitional step in the overall process of waste management, often lasting for a relatively short period before further treatment or disposal. In recent decades, however, mainly because of the unavailability of disposal facilities, storage facilities originally intended as temporary facilities have had their lifetimes extended and serious consideration has been given, in some countries, to the use of storage as a long-term management option [1]-[3]. This situation is the result of a complex interplay of political, technical, economic, institutional, and societal factors that have hindered the implementation of long-term radioactive waste management strategies. This strategy introduces new challenges for Waste Management Organisations (WMOs), other facility operators and national regulators, who shall ensure that these facilities remain safe and secure throughout their extended operational periods.

European Partnership on Radioactive Waste Management (EURAD-2) [4] creates a platform of collaborative effort among Member States and brings the opportunities to develop, maintain and consolidate the scientific and technical basis of radioactive waste management [5]. Work Package (WP) 3 ASTRA in EURAD-2 partnership is intended to analyse of readiness, feasibility and challenges of alternative radioactive waste management solutions needed by many countries due to new requests accruing in national programmes to safely manage and dispose of their waste [6]. Task 3 of the ASTRA WP was launched to explore radioactive waste management strategies for cases where storage extends well beyond the original design lifetimes of containers and facilities. The task brings together participants from both Small Inventory Member States (SIMS) and Large Inventory Member States (LIMS), united by a common interest in addressing this complex challenge.

It should be noted that the division into SIMS and LIMS has not yet been formally defined in official documents; however, for work within WP 3 ASTRA Subtask 3.1, the criteria developed in one of the EURAD-1 WP 9 ROUTES [7]:

1) LIMS include countries with nuclear power plants or large inventories of spent nuclear fuel and radioactive waste, including waste expected to be generated during decommissioning and dismantling of nuclear facilities. Management of such inventories requires a well-developed infrastructure, typically including geological repositories or other deep disposal facilities.

   Task 3 partners countries considered in LIMS group: Bulgaria, Czech Republic, Finland, France, Germany, Switzerland, Ukraine.

2) SIMS comprise countries that generate only relatively limited amounts of waste from medicine, industry, and research, including research reactors and/or nuclear power plants with limited energy production. In such cases, radioactive waste volumes range from a few hundred to several tens of thousands of cubic metres, mostly consisting of VLLW/LLW, with only small amounts of ILW/HLW. Despite the relatively small volumes, the safe management and disposal of these wastes remain a significant challenge.

   Task 3 partners countries are considered as SIMS: Austria, Denmark, Estonia, Greece, Netherlands, Poland, Portugal, Slovenia.

Task 3 of the ASTRA WP has been structured into two complementary subtasks. Subtask 3.1 focuses on gathering data and building a shared understanding of how long-term storage is managed when design lifetimes are exceeded. Subtask 3.2 moves a step further, aiming to examine alternative strategies that could be applied under such circumstances.

Considerable progress has already been made under Subtask 3.1. A dedicated survey was designed and distributed among the Task 3 participants, enabling the collection of detailed information on national practices and perspectives. The survey results analysis was followed by an in-depth analysis of the responses and a workshop that brought together different actors: WMO, Research Entities (RE), Technical Support Organisations (TSO), and Civil Society Organisations (CSO). The workshop provided a valuable platform for dialogue, allowing participants to compare approaches, highlight concerns, and identify areas of convergence in how long-term storage beyond design lifetimes might be addressed.

This document presents the main outcomes of Subtask 3.1, drawing both on the survey data submitted by participating countries and the rich discussions that took place during the first Task 3 workshop.

2. Data collection

2.1 Questionnaire

The questionnaire prepared within Subtask 3.1 was designed as a central tool for gathering detailed information on the long-term storage of radioactive waste in participating countries. Its main purpose was to collect and systematise knowledge about situations where the design lifetimes of waste packages or storage facilities have already been exceeded or are expected to be exceeded in the near future. By focusing on both technical and institutional aspects, the survey aimed to capture a comprehensive picture of current practices, challenges, and strategies, while also enabling the comparison of experiences across Member States. The ultimate objective was to provide a solid factual basis for further analysis (see Section 2.3) and discussions during the Subtask 3.1 workshop (see Section 3). The questionnaire was developed ensuring that it would reflect the variety of national circumstances while still being sufficiently structured to allow meaningful analysis. Attention was given to making the survey suitable for all types of organisations represented in Task 3, including WMO, TSO, RE and CSO.

The questionnaire was organised into six main sections (see Appendix A).

I. The first section was devoted to general information. Here, each respondent was asked to specify the country, the organisation they represent, its type, and their role in Task 3. This section also seeked to establish a basic overview of the national situation by asking for the total number of radioactive waste storage facilities and identifying how many of them are already operating beyond their intended design lifetimes.

II. The second section focused on the status of radioactive waste storages. It invited respondents to provide detailed information for each relevant facility, including its name, designed operational lifetime, expected end of operation, and the characteristics of the waste stored, including classification, volume, radiological and physicochemical properties, as well as the storage methods applied. Questions also addressed the service life of waste packages, the comprehensiveness of available data, and the approaches used for long-term preservation of records and for ensuring the transfer of knowledge across generations. This part of the questionnaire was intended to reveal both the technical features of facilities and the state of data management systems that support safe oversight.

III. The third section explored challenges and risk assessments. Respondents were asked to explain why facilities have exceeded their design lifetimes, whether due to technical limitations, insufficient funding, or lack of alternative options. The section then addressed the difficulties faced, such as package degradation or weakening of barriers, and the measures implemented to manage ageing infrastructure. Emphasis was placed on the safety reassessment of facilities, including resistance to natural or human-induced hazards, radiation impacts, and the methods used for analysis. Respondents were also asked to identify risks and uncertainties, rank their significance, and provide information on possible remediation measures, including the urgency of waste retrieval. This section was especially important in understanding how different countries approach risk management and prioritisation when design lifetimes are exceeded.

IV. The fourth section looked forward to future strategies and approaches. Here, organisations were invited to outline the plans they have developed or implemented for facilities with exceeded lifetimes, including lifetime extensions, retrieval and repackaging, relocation, or closure. The questionnaire asked for details about the steps envisaged, the timeframes involved, and the associated costs. It also inquiried about funding sources, whether from national budgets, the private sector, or international grants. This forward-looking part of the survey was meant to capture the variety of pathways being considered, as well as the economic factors that influence decision-making.

V. The fifth section turned to the dimension of public involvement and transparency. It asked how countries ensure openness and communication with the public when extending the operation of facilities beyond their design lifetimes. Questions addressed decision-making processes, consultation mechanisms, and initiatives to maintain public trust through transparency, such as sharing safety reviews or involving civil society in licensing processes. This section highlighted the societal dimension of long-term storage, emphasising that technical solutions should be aligned with public confidence.

VI. Finally, the sixth section explored international cooperation and knowledge exchange. It seeked the views of respondents on how countries and organisations can collaborate more effectively to address common challenges, and what opportunities they see for joint efforts in this field. Respondents were also invited to share publications, reports, and other materials that could enrich the knowledge base of Task 3. At the end of the questionnaire, they were asked to estimate the time spent on completing the survey, the effort needed to gather the necessary information, and the number of people involved in the process.

Taken together, the six sections of the questionnaire created a comprehensive instrument that captures the technical, organisational, societal, and international aspects of managing radioactive waste in situations where design lifetimes are close to or exceeded. Its structure allowed both for detailed facility-level information and for broader reflections on strategy and cooperation. The results had to not only shed light on the current state of practice across Member States but also highlight the gaps and needs that must be addressed collectively, thereby forming a strong foundation for the analysis and discussions to follow in Task 3.

2.2 Survey

The process of collecting data for Subtask 3.1 began with the preparation of a draft version of the questionnaire, which was introduced and discussed during the Task 3 Kick-off meeting. At this stage, the proposed structure and content of the survey were described, and participants were invited to share their feedback on the formulation of questions and the scope of issues to be covered. Their comments and suggestions helped to refine the instrument and to ensure that it addressed not only technical and regulatory aspects, but also broader considerations relevant to the safe long-term storage of radioactive waste. Several participants raised additional questions that were considered important for inclusion, and these contributions were considered when finalising the questionnaire.

A series of focused discussions was also organised with representatives of CSO from ASTRA WP Task 6. These exchanges were aimed at ensuring that the perspectives and concerns of civil society would be meaningfully reflected in both the questionnaire and the subsequent planning of activities. The involvement of civil society actors was recognised as particularly valuable in broadening the scope of the analysis beyond the perspectives of technical and institutional stakeholders.

Following these rounds of consultation, the finalised version of the questionnaire was published on the EUSurvey platform [8] (according to recommendations of [9]). This platform was selected because it provides a secure and user-friendly environment for collecting responses, offering standardised formats for input, accessibility to participants from different countries, and transparency in the handling of data. The platform also enables participants to access the full questionnaire text, while ensuring that the collected data are stored in a centralised and protected EC system. The complete text of the questionnaire is provided as Appendix A to this report.

The link to the questionnaire [8] was distributed to Task 3 participants with an invitation to contribute actively to the data collection phase. Respondents were encouraged to provide detailed answers, but they were also given the option to indicate where information was unavailable. This approach aimed to ensure that the analysis could highlight both existing knowledge and important gaps where information is lacking.

Specific guidance was provided to representatives of CSO regarding the use of open and publicly available sources when filling in the questionnaire. They were asked not to approach national institutions taking part in the collection and management of the requested information, but rather to base their contributions on information that could be accessed independently.

By involving various organisations from the same country, the survey underscored how interpretations and priorities can vary significantly between different actors within a single national framework In particular, it highlighted the availability of open-access information about radioactive waste management for civil society.

22 organisations from 15 countries took part in the survey: Austria (NES, NTW), Bulgaria (TUS, NTW), Czech Republic (SURO), Denmark (DEKOM, NTW), Estonia (UTARTU), Finland (VTT), France (ASNR, NTW), Germany (DMT), Greece (NCSRD), Netherlands (NRG, COVRA), Poland (ICHTJ), Portugal (IST-ID), Slovenia (EIMV), Switzerland (PSI, ZWILAG), Ukraine (SSTC NRS, ENERGORISK).

Figure 1 Map with countries that took part in the survey

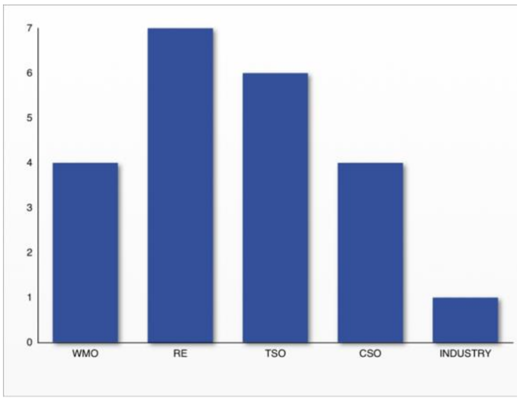

Figure 2 Distribution of organisations that took part in the survey by type

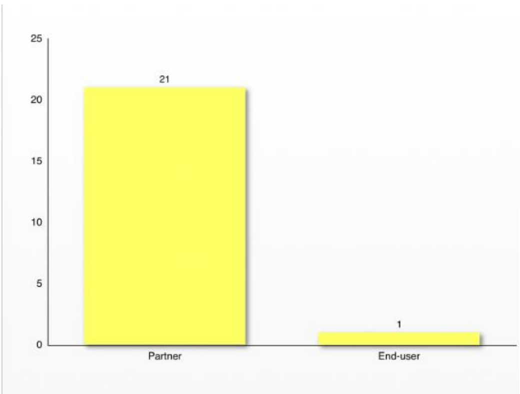

Figure 3 Distribution of organisations that took part in the survey by role in Task 3 of ASTRA WP

Table 1 List of organisations that took part in the survey

No	Country	Organisation	Type of organisation	Role in Task 3
1	Austria	Nuclear Engineering Seibersdorf (NES)	WMO	Partner
2		Nuclear Transparency Watch (NTW)	CSO	Partner
3	Bulgaria	Technical University of Sofia (TUS)	RE	Partner
4		Nuclear Transparency Watch (NTW)	CSO	Partner
5	Czech Republic	National Radiation Protection Institute (SURO)	TSO	Partner
6	Denmark	Danish Decommissioning (DEKOM)	WMO	Partner
7		Nuclear Transparency Watch (NTW)	CSO	Partner
8	Estonia	University of Tartu (UTARTU)	RE	Partner
9	Finland	Technical Research Centre of Finland (VTT)	TSO	Partner
10	France	French Authority for Nuclear Safety and Radiation Protection (ASNR)	TSO	Partner
11		Nuclear Transparency Watch (NTW)	CSO	Partner
12	Germany	DMT GROUP	Industry	Partner
13	Greece	National Centre For Scientific Research Demokritos (NCSRD)	TSO	Partner
14	Netherlands	NRG PALLAS	TSO	Partner
15		Central Organisation For Radioactive Waste (COVRA)	WMO	Partner
16	Poland	Institute of Nuclear Chemistry and Technology (IChTJ)	RE	Partner
17	Portugal	Associação do Instituto Superior Técnico para a Investigação e Desenvolvimento (IST-ID)	RE	Partner
18	Slovenia	Milan Vidmar Electric Power Research Institute (EIMV)	TSO	Partner
19	Switzerland	Paul Scherrer Institute (PSI)	RE	Associated Partner
20		Zwischenlager Würenlingen AG (ZWILAG)	WMO	End-user
21	Ukraine	State Scientific and Technical Center for Nuclear and Radiation Safety (SSTC NRS)	TSO	Partner
22		ENERGORISK, Ltd	RE	Partner

Data collection was conducted via the EUSurvey platform, with responses stored and made accessible to ASTRA WP partners on the EURAD-2 ProjectPlace. Once the survey was closed, the collected data were systematically organised and analysed based on thematic groups of questions and the respondents' countries of origin. This dual approach enabled the analysis to identify not only common trends across Europe, but also specific national circumstances. The main findings from this analysis are presented in Section 2.3 of the report.

2.3 Scope of Task reports 3: Milestone 38 and Milestone 60

The description and discussion of the results from the survey analysis are divided into two complementary parts, corresponding to Subtasks 3.1 and 3.2.

Within Subtask 3.1, this report (Milestone 38) presents the results and approaches related to: the general number of radioactive waste storage facilities in the participating countries, facilities operating beyond their design lifetimes, and the main reasons for exceeding those lifetimes. It also covers the key challenges faced, environmental hazards posed by such storage facilities, the measures implemented in ageing management programmes, and the assessment of how comprehensive radioactive waste data are across countries. Attention is also given to the gaps and challenges in data quality and accessibility, the steps being undertaken to improve data management, and the approaches for long-term preservation of records and knowledge transfer across generations. In addition, report provides information about practices of public involvement and transparency in extending storage facility lifetimes. Finally, this report explores opportunities for international cooperation and knowledge exchange. These questions were an integral part of the first workshop under Task 3, Subtask 3.1 (see Section 3 for details).

Within Subtask 3.2, the next report (Milestone 60) will provide, in particular, more detailed information on the radioactive waste storage facilities themselves, including the characteristics of the stored radioactive waste, applied storage methods, and expected service lives of radioactive waste packages. Moreover, it will present findings from the safety reassessment of facilities, highlight the main risks, uncertainties, and hazards, and provide information about urgency of radioactive waste retrieval from these facilities. Subtask 3.2 report will also address the future strategies, planned or implemented approaches for managing storage facilities with exceeded lifetimes, including planned timeframes, availability of cost estimations, and funding sources. These questions will be discussed further during the second workshop under Task 3, Subtask 3.2, and the results will be published in Milestone 60 as well.

Below, in Section 2.4, are the main results corresponding to the survey topics included in this report.

2.4 Main findings

2.4.1 Radioactive waste storage facilities across participated countries

The total number of radioactive waste storage facilities is presented in Fig. 4 and Table 2 and varies significantly across Member States. Data on the status of storage facilities in the countries represented in the study were provided by different participants (WMO, RE, TSO, CSO), which led to significant discrepancies in the level of detail and accessibility of information. This is especially noticeable in the responses received from representatives of Austria, Bulgaria, Denmark, France and Ukraine.

The number of radioactive waste storage facilities with an exceeded design lifetime across Member States is presented in Fig. 5 and Table 2. Several countries reported no facilities with exceeded design lifetimes (Bulgaria, Czech Republic, Finland, France, Germany, Greece and Switzerland). In many of these cases, facilities either have long design lifetimes linked to NPP operation, or lifetimes are not formally defined but are instead governed by periodic safety reviews, inspections and license renewals (Austria, Finland, France, Switzerland). Nevertheless, in some countries storage facilities might no longer align with current storage concepts, and are under clearing out and reconditioning of waste packages (e.g. Austria, France). At the same time, there are countries (Denmark, Estonia, Poland, Portugal, Slovenia, Ukraine) where storage facilities have already actually exceeded the design resource. In Ukraine, the situation is the most complex and large-scale in terms of the number of facilities.

It is important to note that in several countries, spent nuclear fuel is not classified as radioactive waste. This distinction influenced the way data were prepared for the survey and contributed to discrepancies observed in the results.

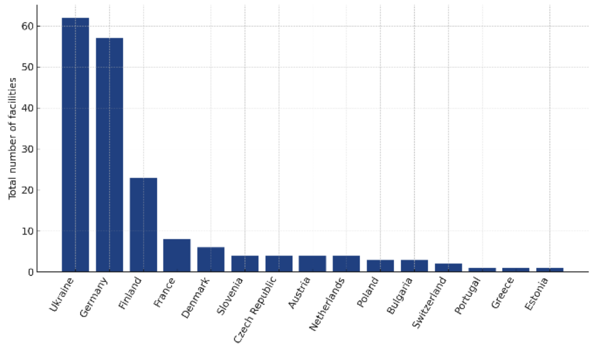

Figure 4 Total number of radioactive waste storage facilities reported by organisations per country

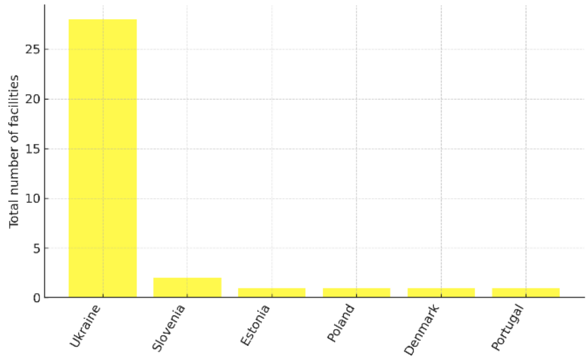

Figure 5 Number of facilities exceeding/nearing end of design lifetime reported by organisations per country

Table 2 Number of radioactive waste storage facilities per country (left column - total number of facilities, right column - number of facilities with an exceeded design lifetime)

Total number of facilities	Country	Number of facilities with an exceeded lifetime
1	Estonia	1
1	Greece	0
1	Portugal	1
1-2	Switzerland	0
3	Bulgaria	0
3	Poland	1
4	Netherlands	0
4	Austria	0
4	Czech Republic	0
4	Slovenia	2
6-1	Denmark	1
8+	France	0
23	Finland	0
57	Germany	0
49-62	Ukraine	28

2.4.2 Key reasons for exceeding the design lifetime of radioactive waste storage facilities and packages

Across most respondents, the key reasons for exceeding the design lifetime of radioactive waste storage facilities and/or radioactive waste packages fall into five recurring categories (for some countries, only the radioactive waste packages are stored longer than planned):

- Lack of alternative facilities for disposal - Austria, Bulgaria, Denmark, Estonia, France, Germany, Greece, Poland, Slovenia, Switzerland, Ukraine;
- Political or legal delays - Austria, Bulgaria, Denmark, Estonia, France, Portugal, Switzerland;
- Insufficient funding - Bulgaria, Estonia, Greece, Portugal, Ukraine;
- Technical limitations - Bulgaria, France, Portugal, Ukraine.

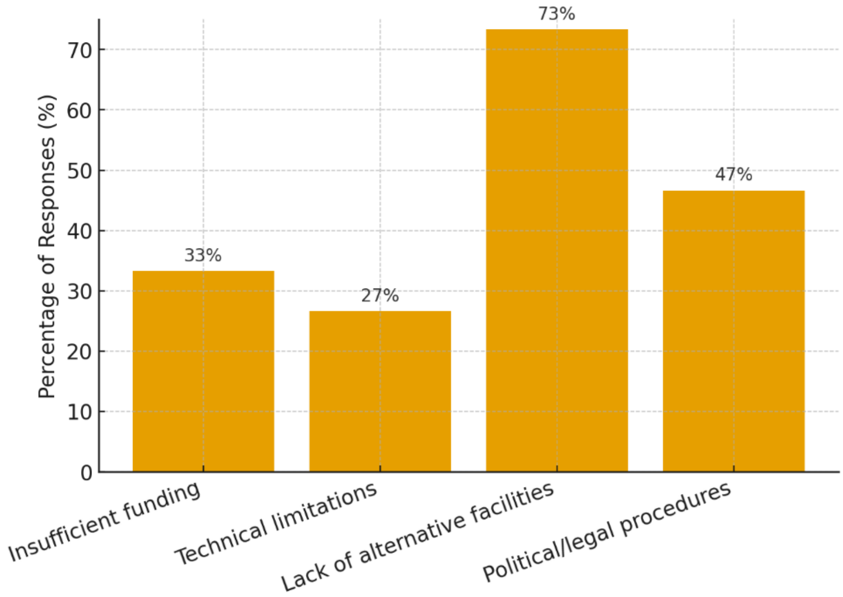

Figure 6 Key reasons for exceeding radioactive waste storage facilities and packages design lifetime (considering the number of answers for each option)

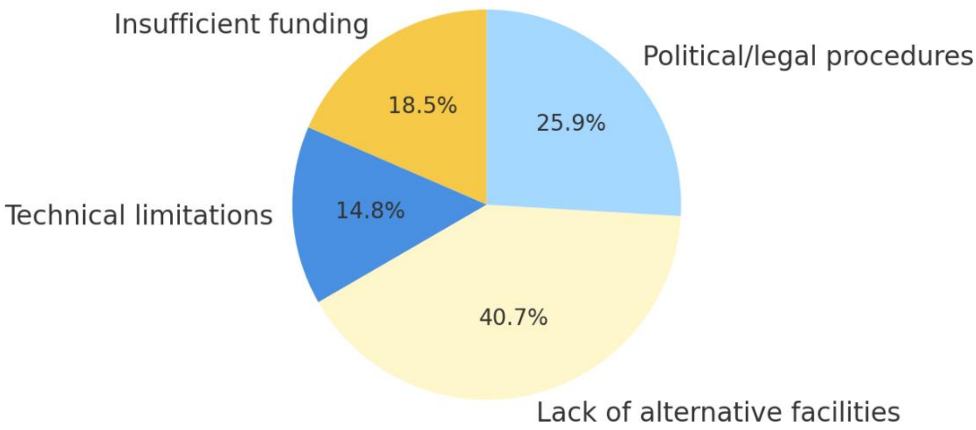

Figure 7 Key reasons for exceeding radioactive waste storage facilities and packages design lifetime (considering total distribution of answers between options)

The analysis reveals that the most widespread challenge across Member States is the lack of alternative disposal facilities, cited by eleven countries (Austria, Bulgaria, Denmark, Estonia, France, Germany, Greece, Poland, Slovenia, Switzerland and Ukraine). This factor underscores a common structural barrier: without operational final repositories, interim storage facilities inevitably remain in use beyond their intended design lifetimes.

The second most frequent factor is political or legal delays, identified by seven countries (Austria, Bulgaria, Denmark, Estonia, France, Portugal, and Switzerland). This factor highlights the impact of governance, regulatory, and decision-making processes in slowing progress toward long-term solutions

Insufficient funding is reported by five countries (Bulgaria, Estonia, Greece, Portugal, Ukraine), reflecting economic constraints that hinder investment in new infrastructure or upgrades to existing storage.

Technical limitations are cited by four countries as well (Bulgaria, France, Portugal, Ukraine), pointing to challenges such as ageing package integrity, engineering restrictions, or limited capacity to implement modern storage methods.

Some countries reported that technically no exceeding has yet occurred but acknowledged the risk of it happening in the future.

In summary, while the precise context differs, most respondents face a mix of financial, technical, and political barriers that delay the implementation of disposal facilities and forces prolonged reliance on interim storage.

2.4.3 Main challenges with radioactive waste storage facilities beyond design lifetime

The dominant challenges cited across countries are deterioration of waste packaging, degradation of packages (corrosion of metallic drums, drying of concrete, etc.) and reduced environmental resistance. Estonia, Ukraine, Bulgaria, and Greece all stressed the problem of package deterioration, which may lead to structural weaknesses or increased risks of release.

Some countries illustrated specific technical cases. The Netherlands described the degradation of PVC in certain packages, requiring reconditioning before long-term storage. Austria and France provided detailed accounts of corrosion in old drums and legacy waste conditioned to outdated standards, which have necessitated large-scale reconditioning projects. France highlighted that ageing management and safety reassessments are integral to regulatory reviews. Challenges here include not only material degradation but also the risks posed by legacy waste stored under outdated standards, where retrieval is often complex and safety-critical. In Austria, for example, interim storage halls without adequate climate control led to corrosion, prompting a long-term reconditioning programme.

Other challenges mentioned include insufficient exchanges of what problems could arise and how to solve them, and broader risks such as human intrusion and climate change impacts. Denmark noted risks from sea-level rise and corrosion.

Taken together, the answers show a wide recognition that physical degradation of packages is the most common and pressing challenge. However, institutional challenges - such as lack of transparency, incomplete documentation, and the management of legacy waste - are equally significant.

2.4.4 Main measures in aging management for radioactive waste storage facilities and packages

The survey responses show that aging management of radioactive waste storage facilities and packages is implemented in diverse ways across countries. Most countries emphasise regular inspections, monitoring of barriers and packages, regulatory oversight, and reconditioning or repackaging where necessary. Routine inspections and monitoring form the most widespread measure. Many respondents emphasised that containers and storage structures undergo regular visual checks, contamination and dose-rate measurements, and structural integrity assessments (specific checks for cracks, corrosion, or deformation). Inspection intervals vary widely (for example, 5 years in Austria, Estonia practices initial check after 3 years, then every 10 years) with corrective measures taken if defects are found. Repairs, reconditioning, and upgrades are another common strategy including reconditioning old drums, repairing or replacing defective packages, and upgrading storage halls. Countries with exceeded design lifetimes rely heavily on reconditioning and modernisation projects, while others emphasise preventive approaches.

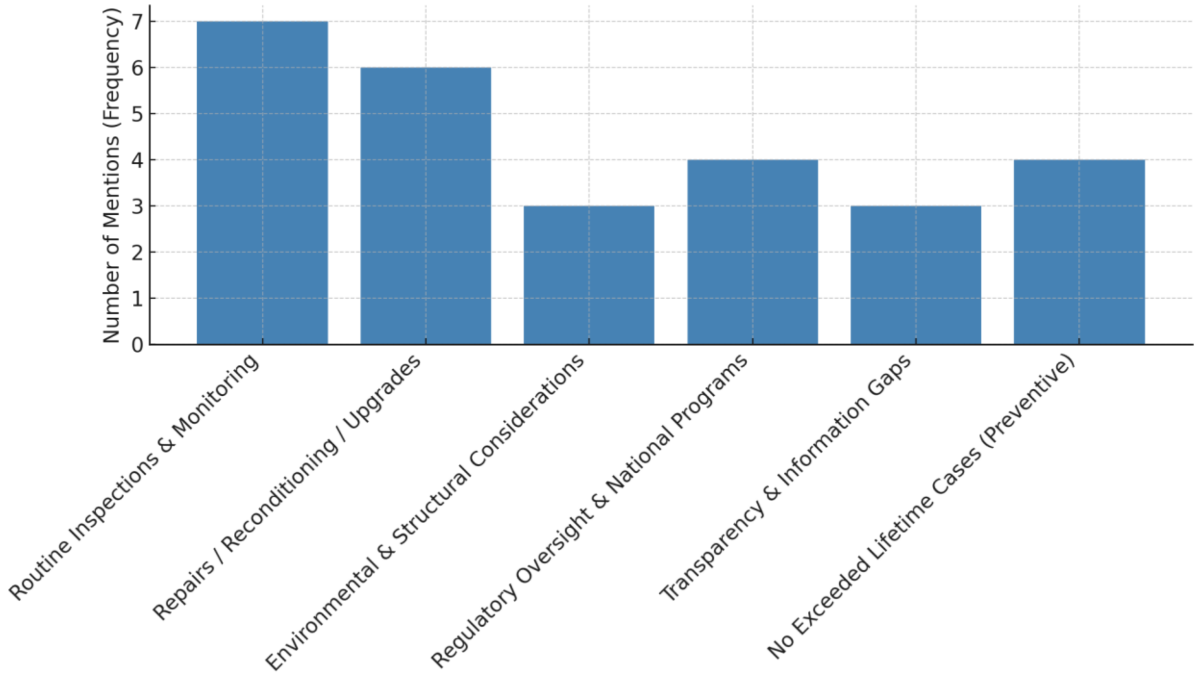

Figure 8 Main measures in aging management for radioactive waste storage facilities and packages applied across countries

2.4.5 Environmental hazards posed by storage facilities

A majority of respondents indicated that under normal operating conditions, environmental hazards from such storage facilities are minimal or negligible. Finland, Estonia, Greece, and Poland highlighted that hazards mainly arise in accident scenarios, such as aircraft crashes, fires, or container degradation. In Switzerland, the main concern was linked to the potential airborne spread of radioactive materials in the event of a severe accident.

Some countries pointed to specific natural hazards. Ukraine mentioned earthquakes and hurricanes, while Bulgaria and Denmark underlined the risks linked to climate change, including storms, landslides, and sea-level rise. The Danish case is notable, as rising water levels in Roskilde Fjord were identified as a major hazard, shaping the decision to locate a new storage facility at a higher elevation.

Other responses reflected institutional or societal perspectives. Civil society representatives in Bulgaria observed that environmental hazard information is not adequately presented to the public. For Austria, it was noted that no Environmental Impact Assessment (EIA) was conducted for early interim storage facilities because they predated relevant legislation. France provided a more nuanced view, emphasising that hazards are facility-specific, depending on proximity to rivers or populated areas.

Overall, the analysis shows a consensus that risks are low in normal operation but can increase significantly under accident or extreme event scenarios. Differences lie in the recognition of site-specific vulnerabilities, the role of climate change, and the degree of transparency in communicating risks to the public.

2.4.6 Data quality, availability, and knowledge preservation

The survey results show significant diversity across Member States in the comprehensiveness and quality of radioactive waste data and related storage facility information. The results highlight a spectrum of maturity in radioactive waste data management. While some Member States have developed robust systems with comprehensive databases and well-established preservation mechanisms, others still face major challenges due to incomplete legacy records, weak accessibility, or lack of structured approaches.

2.4.7 Data Completeness

Three levels of data completeness were identified. Six countries (Finland, Germany, Slovenia, Czech Republic, Switzerland, Denmark) reported comprehensive data systems, with regularly updated and accurate records that contain no significant gaps. The majority of participants (13 organisations across several Member States) indicated partially comprehensive data, where most information is available, but incomplete records and legacy data gaps remain an issue. Finally, two respondents (from Bulgaria and Denmark) reported limited data availability, with major deficiencies that pose challenges for safe radioactive waste management.

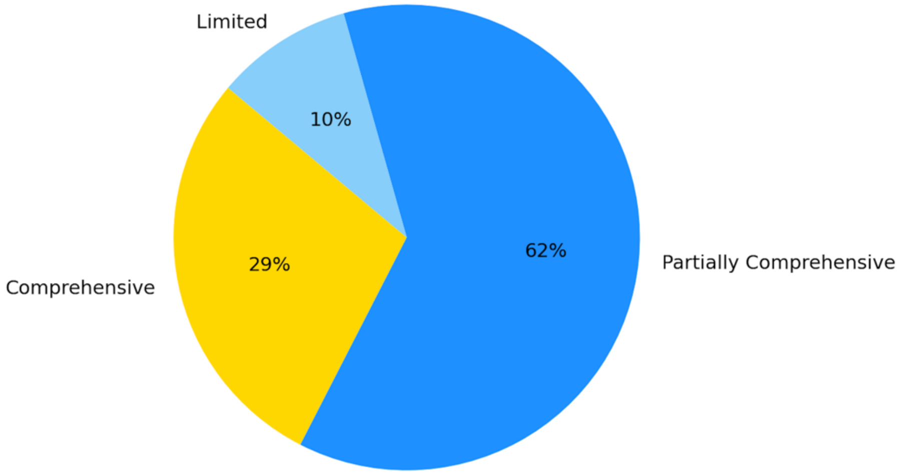

Figure 9 Radioactive waste data completeness

2.4.8 Gaps and challenges

The survey responses reveal a clear pattern of recurring difficulties across countries and organisations when it comes to the quality, completeness, and long-term preservation of radioactive waste data:

- Legacy / historical data issues - records from past decades are incomplete, poorly detailed, or exist in non-standardised formats. In several cases, data predating the introduction of centralised digital systems is particularly problematic, creating uncertainties about waste composition and storage histories.
- Incompleteness / data gaps - key parameters are missing from existing records, even in otherwise functional databases. These gaps are often linked to earlier periods of operation, but some also persist in current inventories due to insufficient measurement, reporting inconsistencies, or limitations in monitoring capabilities.
- Lack of standardisation / inconsistency - problems of incompatible data formats, varying terminology, and inconsistencies between facilities or time periods, which complicate integration into central databases and make international comparison or exchange of information more difficult.
- Verification / characterisation difficulty - difficulty of verifying old or incomplete records. In many cases, re-characterisation campaigns, such as gamma spectrometry of legacy waste, are required to establish accurate inventories, which represent both a technical and financial burden.
- Accessibility / retrieval problems - barriers to accessing records, whether due to older paper formats, obsolete digital storage media, or fragmented data spread across institutions. Stakeholder and public access was highlighted as particularly limited in some Member States.
- Data loss / risk of loss - concerns about physical degradation of old records, lack of backups in earlier periods, or risk of information loss due to external events, e.g. during institutional transitions.

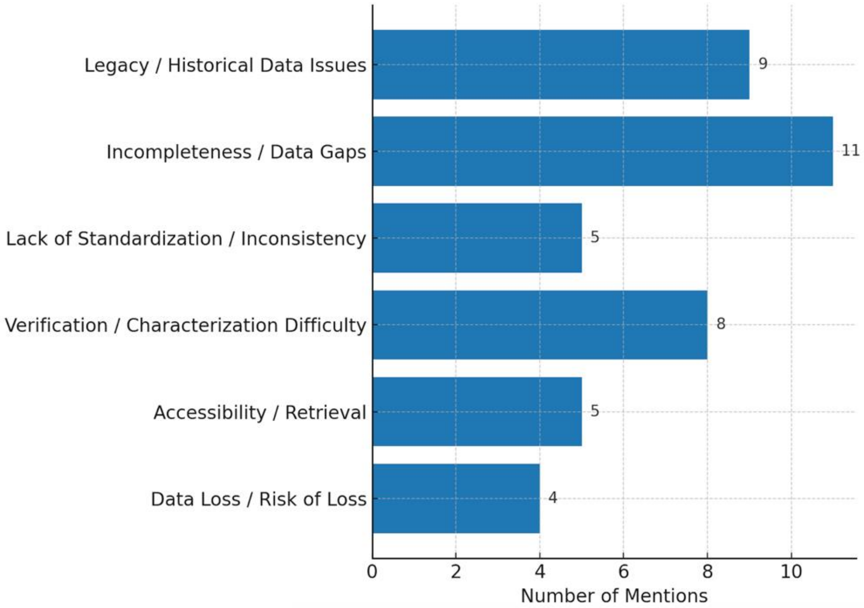

Figure 10 Key challenges in radioactive waste data quality and availability

2.4.9 Long-term preservation of data

The survey shows that data preservation in radioactive waste management is multi-layered and varies across countries, with a mix of digital, physical, and institutional approaches being employed. Common data preservation strategies include:

- Digital databases and systems – centralised inventories and electronic record management platforms are the backbone of long-term preservation efforts. These systems ensure accessibility, structured formats, and updates aligned with regulatory requirements.
- Quality assurance procedures - quality assurance checks are part of data workflows, ensuring consistency, accuracy, and traceability over time.
- Redundancy and backups - data is routinely duplicated across multiple formats and stored in different secure locations to reduce risks of accidental loss or degradation.
- Physical archiving - hard copies, microfilms, or secure physical archives are used to provide resilience against digital obsolescence.
- Digitalisation of paper records - addressing historical gaps, systematic scanning of older records to make them searchable and integrated into modern systems.
- Metadata use and format preservation - metadata enriches the context of records, ensuring usability by future generations, while proactive planning for data migration ensures that information remains readable as technologies evolve.
- National inventory programs - official state-led databases ensuring regulatory oversight, international reporting, and long-term institutional memory.

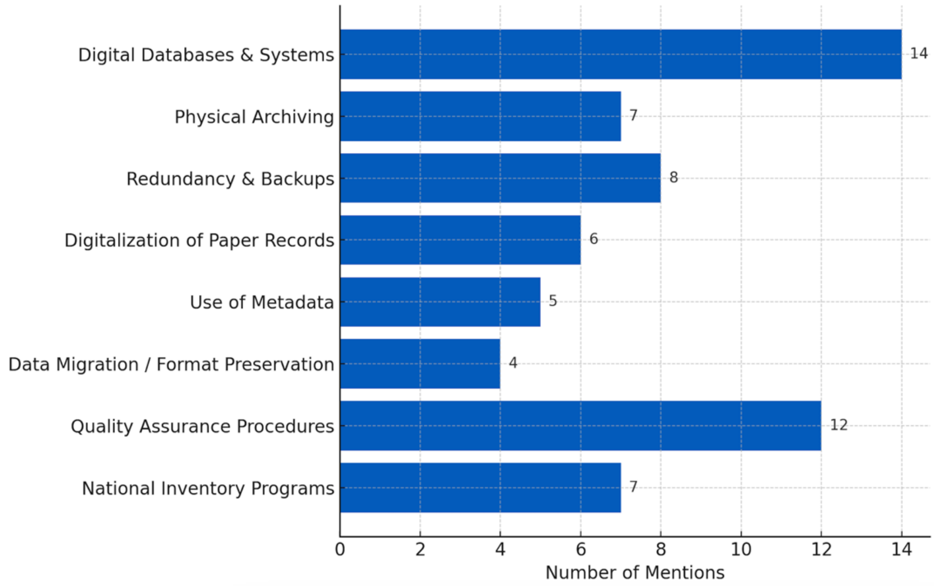

Figure 11 Common data preservation strategies

Overall, the strategies reflect a hybrid model of resilience: strong reliance on digital systems paired with physical archives and institutional safeguards. Countries with larger inventories (LIMS) tend to employ more structured, multi-level systems, while smaller inventory states (SIMS) rely on simpler but still robust solutions, often with international benchmarking support. The results also highlight that no single strategy is sufficient-rather, it is the integration of redundancy, quality assurance, digital and physical systems that ensures the preservation of knowledge for decades and across generations.

2.4.10 Knowledge transfer across generations

Knowledge preservation and transfer are widely acknowledged as critical. The survey highlights a strong emphasis on documentation and structured systems as the foundation of knowledge transfer.

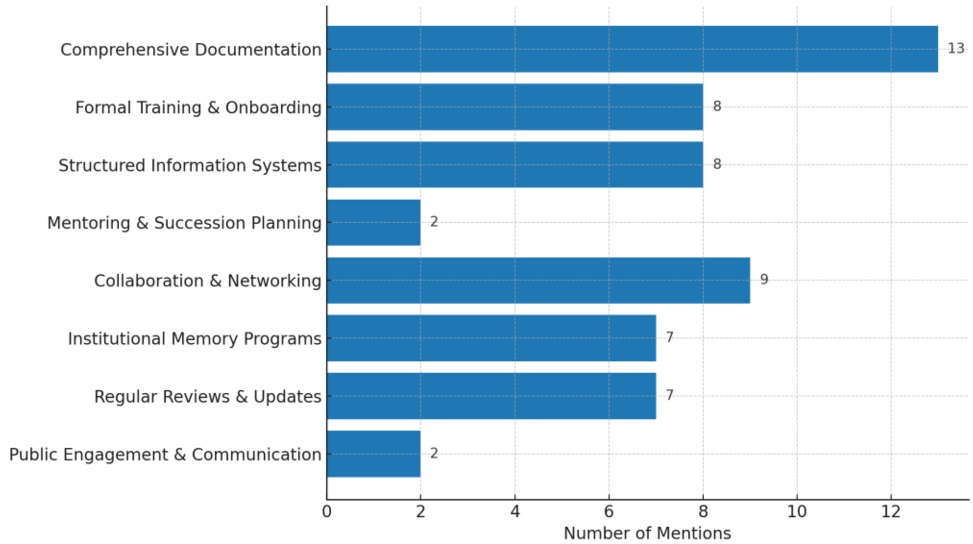

Figure 12 Common knowledge transfer approaches

Common knowledge transfer approaches include:

- Comprehensive documentation - creating detailed records that capture both technical data and contextual information.
- Formal training and onboarding and structured information systems - institutional learning and accessible databases for continuity.

- Collaboration and networking across national and international levels - knowledge transfer is not just an internal task but requires active external engagement.
- Institutional memory programmes and regular reviews and updates - maintaining long-term knowledge requires both systematic preservation and dynamic refreshment of records.
- Mentoring and succession planning - informal or personal knowledge handover.
- Public engagement and communication - was mentioned only occasionally, showing that while it is recognised, knowledge transfer is still mostly inward-looking rather than oriented towards the public.

Overall, the results reveal that while digital tools and systematic documentation are well developed in many Member States, there are still gaps in people-cantered approaches such as mentoring, as well as in broader outreach and engagement strategies.

2.4.11 Transparency and public involvement

Respondents were nearly unanimous in affirming that public trust is essential for extending the lifetime of radioactive waste storage facilities. Across respondents, transparency and public information in the context of operating storage facilities beyond their original design lifetime are generally embedded in existing nuclear licensing frameworks (periodic safety reviews, regulatory inspections, renewal of operating licences). In several programmes, licence renewal cycles of roughly 5 - 15 years and periodic safety reviews (PSR) provide the principal checkpoints at which safety cases are revisited; some jurisdictions link these reviews to opportunities for public questions or hearings. In other programmes, respondents noted there is no formally defined “design life” for particular storage buildings or casks; as a result, no dedicated lifetime-extension process is triggered and, consequently, no specific transparency measures are applied beyond the standing nuclear oversight regime. In a few cases, involvement of the host municipality or local committees was highlighted, but national and transboundary participation mechanisms were reported as less consistently specified or applied.

When asked how transparency is ensured specifically for long-term operation beyond design life, answers ranged from open information, hearings and publication of documentation, through local dialogue platforms and routine reporting, to statements that only general information is provided or that relevant procedures are not yet defined. Some programmes emphasised that information is accessible via regulator or operator websites; others stressed that continuation of operation had not been a public topic. Overall, the picture is heterogeneous: mechanisms exist almost everywhere in general terms, but their explicit applicability to lifetime extension of storages is not uniformly articulated.

On decision processes for operating beyond design life, many respondents pointed to the established sequence of operator safety assessment, regulatory review (often within the PSR framework), and licensing decisions; for some facilities or scales, an environmental impact assessment (EIA) with public consultation may apply, while for smaller facilities, EIA is not always required. Elsewhere, decisions were described as centred on inspections and approvals by authorities, with public involvement limited to information rather than consultation. A few respondents reported that processes are either not specified yet or not foreseen because exceedance of design life is not expected; in one case, contractual involvement of the host community was noted.

2.4.12 Opportunities and directions for international cooperation

The survey answers highlighted a strong consensus that international cooperation is not only beneficial but essential for addressing the challenges of managing radioactive waste storage facilities that operate beyond their intended design lifetimes. Respondents identified a broad spectrum of opportunities for collaboration, which can be grouped into several key areas.

First, knowledge exchange and experience sharing were seen as fundamental. Countries and organisations stressed the importance of learning from both successful and unsuccessful case studies, exchanging lessons on waste characterisation, reconditioning, safety case development, and facility operation.

Second, development of common methodologies and standards was frequently mentioned. This includes harmonised approaches to risk assessment, decision-making criteria for lifetime extensions, and standardisation of data and documentation practices to ensure comparability and reliability across different contexts.

Third, joint research and technical cooperation emerged as a major area of interest. Proposals included collaborative work on innovative monitoring methods, predictive tools for package degradation, digital solutions such as modelling and digital twins, and even the creation of shared or mobile facilities for waste characterisation and treatment.

Fourth, regulatory and strategic cooperation was considered necessary. Several contributions called for stronger European-level frameworks, new legislative initiatives, and closer bilateral or regional collaboration to align strategies, optimise resources, and ensure compliance with transparency conventions.

Fifth, societal and public engagement aspects were underlined as inseparable from technical solutions. Respondents emphasised cooperation on improving transparency, enhancing communication with stakeholders, and building public trust in decisions related to extended storage.

Finally, strengthening institutional capacities was also seen as a priority. This includes supporting smaller-inventory countries through partnerships, building stronger networks among WMOs, REs, TSOs, and CSOs in different countries, as well as ensuring that knowledge is preserved and transferred across generations.

Summary of proposed areas for cooperation

- Sharing lessons learned, case studies, and best practices.
- Developing common standards, methodologies, and decision criteria.
- Conducting joint R&D projects, including monitoring technologies, predictive tools, and digital solutions.
- Enhancing bilateral, regional, and European-level cooperation frameworks.
- Improving transparency, stakeholder engagement, and public trust.
- Strengthening institutional capacity, especially for smaller-inventory countries.
- Creating or supporting shared infrastructures and mobile facilities for waste characterisation and treatment.

3. Workshop

As an integral part of Subtask 3.1, a dedicated workshop was organised with the aim of fostering mutual understanding among different categories of actors (WMO, RE, TSO, CSO) and also the same category of actors but from different countries on existing strategies for the long-term storage of radioactive waste, particularly in situations where the design lifetime of facilities or packages has been exceeded.

The main objectives of the workshop was to build mutual understanding among participants on:

- Current situation of radioactive waste storage facilities and packages with an exceeded or extended design lifetime across participating countries based on the results of the pre-workshop survey and multi-stakeholder discussions.
- Main challenges, open questions and knowledge gaps related to extended radioactive waste storage.
- Role of transparency, public trust, and civil society participation.
- Priority areas for further study and cooperation.

3.1 Participants

The workshop brought together Task 3 partners and end-users online. A total of 33 participants from 17 countries, representing 23 organisations, took part in the workshop.

Figure 13 Map with countries that took part in the workshop

Table 3 – Distribution of the workshop participants by countries and types or organisations

Country	SIMS/ LIMS	Organisation	Type of organisation	Role in Task 3	Number of participants
Austria	SIMS	Nuclear Engineering Seibersdorf (NES)	WMO	Partner	1
		Nuclear Transparency Watch (NTW)	CSO	Partner	1
Bulgaria	LIMS	Technical University of Sofia (TUS)	RE	Partner	1
		Nuclear Transparency Watch (NTW)	CSO	Partner	1
Croatia	SIMS	FOND NEK	WMO	End-user	1
Czech Republic	LIMS	National Radiation Protection Institute (SURO)	TSO	Partner	1
Denmark	SIMS	Nuclear Transparency Watch (NTW)	CSO	Partner	1
Finland	LIMS	Technical Research Centre of Finland (VTT)	TSO	Partner	1
France	LIMS	French Authority for Nuclear Safety and Radiation Protection (ASNR)	TSO	Partner	2
Germany	LIMS	DMT GROUP	Industry	Partner	1
Greece	SIMS	National Centre For Scientific Research Demokritos (NCSRD)	TSO	Partner	1
		Polyeco	WMO	End-user	1
Italy	LIMS	SOGIN	WMO	End-user	1
Netherlands	SIMS	NRG PALLAS	TSO	Partner	1

		Central Organisation For Radioactive Waste (COVRA)	WMO	Partner	1
Poland	SIMS	Institute of Nuclear Chemistry and Technology (IChTJ)	RE	Partner	2
Portugal	SIMS	Associação do Instituto Superior Técnico para a Investigação e Desenvolvimento (IST-ID)	RE	Partner	1
Slovenia	SIMS	Milan Vidmar Electric Power Research Institute (EIMV)	TSO	Partner	2
Switzerland	LIMS	Paul Scherrer Institute (PSI)	RE	Associate Partner	1
		Zwischenlager Würenlingen AG (ZWILAG)	WMO	End-user	2
UK	LIMS	Cavendish Nuclear	WMO	End-user	1
Ukraine	LIMS	State Scientific and Technical Center for Nuclear and Radiation Safety (SSTC NRS)	TSO	Partner	6
		ENERGORISK, Ltd	RE	Partner	2

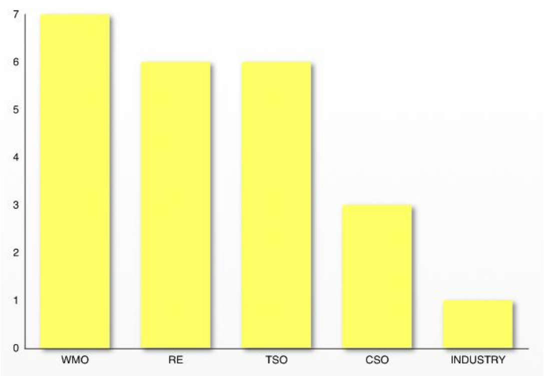

Figure 14 Distribution of organisations that took part in the workshop by type

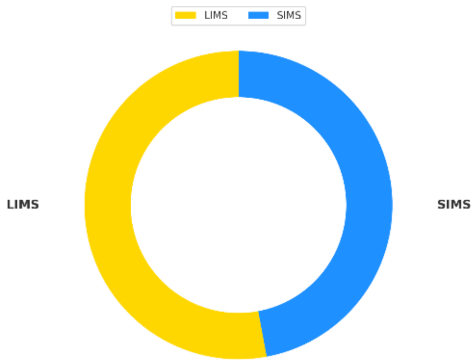

Figure 15 Distribution of organisations that took part in the wokshop by type

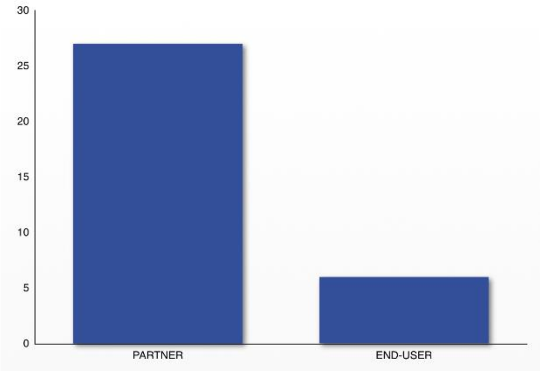

Figure 16 Distribution of organisations that took part in the workshop by role in Task 3 of ASTRA WP

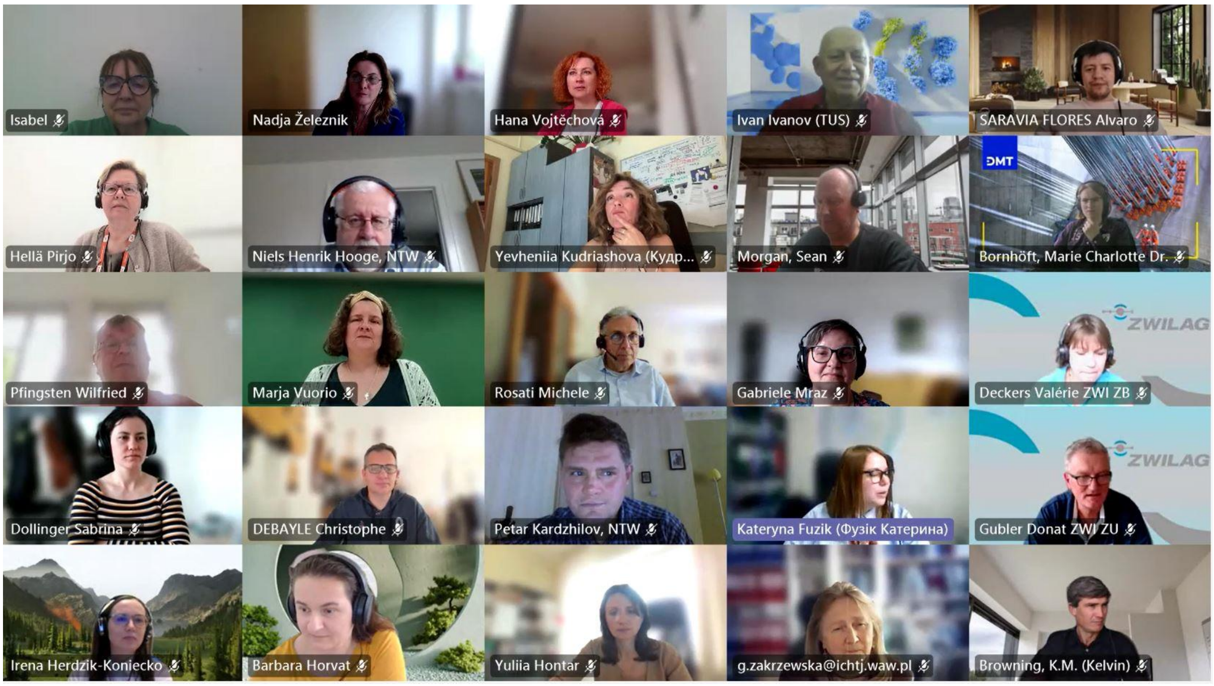

Figure 17 Photo of the Task 3 workshop participants

3.2 Agenda

The agenda of the event was structured to encourage both structured information-sharing and interactive dialogue. Following a welcome session and the presentation of objectives, participants engaged in an interactive "Blitz Poll" designed as ice-breaker to capture initial views and expectations. This part was followed by the presentation of key survey results, which provided a factual overview of national situations and highlighted common themes identified during the data collection stage. A dedicated presentation was also delivered on transparency and public participation in the context of long-term storage, emphasising the societal dimension of radioactive waste management. The second part of workshop was centred on interactive breakout session discussions in groups (5-6 persons per group) and joint plenary discussion aimed at mapping challenges, risks, uncertainties, existing solutions, enabling conditions for implementation, and ideas for future collaboration. The full agenda of the workshop is included in Appendix B.

3.3 Presentations

3.3.1 Task 3 data collection and analysis results

In the presentation on Task 3, the main results of the survey data collection and analysis included in Section 2 of this report were presented, in particular: (i) the current situation of radioactive waste storage facilities and packages with an exceeded or extended design lifetime across participating countries, based on the results of the pre-workshop survey and multi-stakeholder discussions, and (ii) the main challenges, open questions, and knowledge gaps related to extended radioactive waste storage.

3.3.2 Transparency and public participation in long-term storage

In the presentation on public perspective, the expectations of CSOs regarding greater clarity and legal definition of lifetime extension processes, the need for public access to safety documentation, and stronger integration of public participation in decision-making processes related to long-term radioactive waste management were emphasised. Particular attention was given to the role of Environmental Impact Assessments, the Periodic Safety Review process, and the importance of intergenerational responsibility. Recommendations included improving public access to information, enhancing dialogue between civil society and technical actors, and ensuring long-term transparency through sustainable governance, monitoring, and knowledge preservation mechanisms. The presentation served to highlight the current gaps in participation practices and outlined concrete expectations from civil society for more inclusive and transparent approaches in the governance of ageing radioactive waste storage infrastructure.

3.4 Interactive breakout session discussions

An important component of the workshop was the small-group discussions. To support these, participants had received in advance a short list of guiding questions in order to prepare their reflections and contributions. Each discussion group had moderator for facilitation of discussions and began with a brief round of introductions of participants, their institutional affiliation, and situation in the country with storage facilities or packages with exceeded or extended design lifetimes exist in their country, origin of the waste or spent nuclear fuel stored in them as well as the main reasons behind storage extensions.

Building on this introduction, the group discussions turned to substantive issues and following discussion topics.

3.4.1 Main challenges

Proposed question: What are the main common challenges are faced (or expected to be faced) when it comes to operating radioactive waste storage facilities or packages with an exceeded or extended design lifetime?

Across all groups, the most frequently ranked or highlighted issue was degradation and deterioration of waste packages and barriers (corrosion, cracks, weakening of concrete, gas generation, etc.), requiring repackaging. Other major points included:

- Aging of infrastructure and facilities.
- Licensing limits on radioactive waste packages and storage facilities.
- Legacy waste and decommissioning challenges.
- Non-compliance of old packages with current waste acceptance criteria and technical standards.
- Lack of national strategies and clear responsibilities.
- Climate change and external hazards.
- Limited financial and human resources.

3.4.2 Risks and uncertainties

Proposed question: What are the main risks or uncertainties you can identify related to the long-term storage of radioactive waste, especially when facilities or packages are used beyond their originally planned design lifetime?

Participants identified a broad range of risks, with several recurring themes:

- Loss or incompleteness of records, knowledge gaps, and poor documentation.
- Regulatory, political, and financial uncertainties.
- Facility degradation leading to leaks and contamination.
- Climate change impacts – rising sea levels, flooding, extreme events.
- Public trust and acceptance issues.
- Operational risks such as lack of spare parts, inability to maintain older facilities, or human intrusion.

Overall, loss of data and increasing vulnerability of infrastructure, combined with uncertainties in regulation and financing, were seen as the most critical risks.

3.4.3 Enabling conditions

Proposed question: What enabling conditions are necessary to develop and implement strategies/solutions for managing radioactive waste storages and packages with an extended design lifetime?

The enabling factors were strongly aligned across groups:

- Stable and sufficient funding.
- Clear and adaptive regulatory frameworks, ideally with civil society involvement.
- Development of long-term radioactive waste strategies including next-step facilities.
- Continuous monitoring, periodic safety assessments, and updated documentation.
- Human resources and expertise - training, education, and knowledge transfer.
- Access to state-of-the-art technologies for conditioning, repackaging, and monitoring.

Consensus shows that financial sustainability, strong regulation, and modernisation of infrastructure are indispensable conditions for safe long-term storage.

3.4.4 International cooperation

Proposed question: What types of international cooperation or experience exchange, and on what topics, would be most beneficial in managing radioactive waste storages and packages with an extended design lifetime, or in supporting safe long-term storage?

Suggestions for cooperation were wide-ranging but converged on the need for knowledge exchange and shared practices:

- Working groups, training, and exchanges between operators.
- Sharing of case studies, lessons learned, and roadmaps.
- Joint projects and EU-funded cooperation (EURAD, IAEA, SIMS - LIMS exchanges, bilateral projects).
- Collaboration on monitoring, ageing management, and reconditioning practices.
- International cooperation on public engagement strategies.

Overall, there was strong support for structured cooperation through existing European and international frameworks, as well as direct exchanges between institutions.

3.4.5 Future topics for exploration

Proposed question: Which topics related to the management of long-term radioactive waste storage or extended design lifetime operation would you like to explore, study or discuss more deeply in the next steps of ASTRA WP Task 3?

Groups suggested a mix of technical, societal, and strategic topics for future focus:

- Risk assessment methodologies and cost–benefit analysis of lifetime extensions.
- Common EU legislation and harmonised standards.
- Characterisation of waste packages and safety issue identification.
- Development of predictive tools for waste package alteration.
- Deeper focus on ageing management and reconditioning approaches.
- Climate change impacts and collaboration with relevant expert groups.
- Public engagement and acceptance strategies.
- Exploration of joint disposal solutions.

3.5 Summary of the workshop

The discussions confirm that technical reliability, safety assessment tools, and societal trust are key areas needing further study.

The workshop served as a platform for bringing together partners, end-users, and stakeholders of Task 3 to establish a shared understanding of the current situation with radioactive waste storage facilities and packages operated beyond or close to their design lifetimes. Participants discussed challenges, risks, enabling conditions, and international cooperation needs, based on survey results and group discussions.

The agenda combined presentations with interactive elements, including breakout group sessions that encouraged exchange between organisations of different profiles (WMO, RE, TSO, CSO). This format allowed both national experiences and stakeholder perspectives to be reflected. The discussions confirmed the diversity of situations across countries but also revealed many common issues.

The discussions highlighted that the most pressing issue across countries is the degradation of waste packages and storage infrastructure, which often necessitates repackaging or upgrading. Alongside technical deterioration, participants underlined the challenges of ageing facilities, incomplete documentation, and the mismatch of legacy waste with today's standards. These problems are further aggravated by limited financial and human resources and, in some cases, by the absence of clear national strategies and responsibilities.

Uncertainties also remain high, particularly due to gaps in historical records, difficulties in data verification, and delays in repository development, which prolong reliance on interim storage. External pressures such as climate change impacts, political factors, and public acceptance were identified as additional sources of risk.

At the same time, participants stressed that successful management depends on certain enabling conditions: stable funding, strong regulatory frameworks, availability of disposal routes, and continuous public and stakeholder engagement. International exchange was viewed as essential for sharing lessons learned, developing common approaches, and supporting both SIMS and LIMS countries in addressing extended storage challenges.

The workshop confirmed that while national contexts differ, many challenges in extended storage of radioactive waste are common across Europe.

A clear message from the workshop was the importance of international exchange and cooperation: sharing both problems and solutions, developing common approaches, and building capacities jointly. The results provide a solid basis for shaping the next steps of Task 3, particularly in Subtask 3.2, which will explore strategies and risks of long-term management in greater depth.

4. Summary and outcomes

Task 3 of the ASTRA WP was initiated to study alternative radioactive waste management strategies in situations where radioactive waste is stored for periods exceeding the design lifetime of storage containers and/or storage facilities and to map the range of strategies under consideration across Member States with very different inventories and institutional settings. To support these efforts, Task 3 is divided into two subtasks. Subtask 3.1 focused on collecting data and developing a shared understanding of long-term storage when design lifetimes are exceeded or extended, while Subtask 3.2 will explore alternative strategies for such situations.

Under Subtask 3.1, a survey gathered information from 22 organisations from 15 countries. It covered the current status of radioactive waste storages and its barriers, options for extending the lifetime of storage facilities and containers, quality and accessibility of radioactive waste related data, main challenges, risk assessment approaches, potential future radioactive waste management strategies, funding principles and their availability, and current practices for public communication, trust-building, and stakeholder involvement in relevant decision-making processes.

Subtask 3.1 work combined a structured questionnaire, followed by analysis and a multi-stakeholder workshop, engaging 33 participants from 17 countries, representing 23 organisations (WMOs, REs, TSOs and CSO). The workshop enabled open dialogue between WMOs, REs, TSOs, and CSO, helping to identify challenges, compare approaches, and highlight areas for cooperation in addressing extended storage needs.

Across survey respondents, the total number of storage installations and their status vary widely, not least because definitions differ on whether temporary, legacy or inactive installations are counted. Several programmes report no facilities currently beyond design life; others indicate exceedance where legacy storages no longer fit the current storage concept and are being cleared and radioactive waste packages reconditioned. In a number of programmes, formal design lifetimes are not specified for storage buildings; instead, continued operation is governed by periodic safety reviews, inspections and license renewals.

The principal reasons cited for extended storage coalesce around four recurring themes: lack of alternative facilities or disposal routes (most frequently mentioned), insufficient funding and political/legal processes (both commonly mentioned), and technical limitations (regularly mentioned, though less frequently than the other drivers). A further “other” category captures country-specific circumstances, notably delays in final disposal development and programme-level decisions to align storage lifetimes with evolving national strategies.

Technical challenges identified by respondents through the survey and ranked at the workshop are consistent and concrete. Degradation of waste packages and specific barriers (e.g., corrosion of metallic drums and lifting hardware, drying of concrete) and ageing of infrastructure feature prominently, alongside reduced resistance to external events, climate-related hazards such as flooding, and documentation gaps in historical inventories. Several programmes highlighted non-compliance of older packages with current waste acceptance criteria, which in turn drives reconditioning campaigns. Underpinning many of these issues is the challenge of historical inventories that are not completely identified, which directly impacts a facility's safety case and licensing. Capacity constraints, access limitations in densely packed stores, and uncertainties about internal package processes over extended periods were also noted.

In response, ageing-management measures reported include routine surveillance of structures, systems and components; periodic inspection of packages with defined frequencies; targeted repairs, upgrades or replacements; and, where needed, systematic reconditioning of legacy waste. Programmes describe modernisation of storage conditions (e.g., temperature/humidity control, seismic upgrades), research on critical components (e.g., long-term behaviour of gasket systems), and regulatory oversight through periodic safety reviews. Practical constraints, including limited space to move or inspect packages, can hamper implementation and require phased solutions.

Environmental hazard assessments converge on low impacts in normal operation, with risk profiles shaped by credible accident scenarios. The most frequently cited hazards include flooding and sea-level rise, severe weather, seismic events, aircraft crash scenarios and contamination pathways via leaks. While many programmes emphasise the effectiveness of existing barriers and monitoring, they also recognise the need to account explicitly for climate-related extremes and to ensure that legacy stores attain a level of robustness commensurate with contemporary expectations.

Data maturity is a clear differentiator across programmes. A minority reported comprehensive, accurate and regularly updated datasets; a larger group reported generally robust data with specific gaps - most often in legacy records; a small number reported significant gaps that complicate management. The most common issues were incomplete or inaccessible historical records, lack of standardisation across time and facilities, difficulties verifying older data, and challenges with stakeholder accessibility. Mitigation approaches were widely shared: centralised digital inventories, digitisation of paper archives, use of metadata, redundancy and backups, ongoing quality assurance, participation in national inventory schemes, and investment in staff training and institutional memory. Knowledge-transfer practices mirror these trends, combining comprehensive documentation with formal training, mentoring, structured information systems and participation in national/international networks.

On governance, the consolidated findings on transparency, participation and decision-making showed that general transparency frameworks exist in many programmes, and local stakeholder structures are often in place, but procedures specific to lifetime extension of storage facilities are not always clearly defined. Where periodic licensing or safety reviews occured, opportunities for public information and, in some cases, participation are available, yet the visibility of storage-specific questions can be limited. Across the survey and workshop, participants consistently underscored that public trust and social acceptance are critical enablers of extended operation.

A strong appetite for international cooperation runs through the evidence. Respondents and workshop groups pointed to concrete areas where joint work would add value: shared methodologies and tools for ageing assessment and decision criteria; exchange of case studies on reconditioning and lifetime extension; mobile or shared characterisation capabilities; harmonised data standards; Communities of Practice to address common technical topics; and continued SIMS - LIMS exchange on proportionate, resource-efficient solutions. These proposals reflect a pragmatic focus on actionable knowledge that can reduce uncertainty, accelerate safe remediation of legacy inventories and support sound decision-making.

This report describes Subtask 3.1 results of data collection and analysis, and following first Task 3 workshop discussions. Subtask 3.1 results are focused on the number of radioactive waste storage facilities, those operating beyond their design lifetimes and reasons for it, the main challenges and hazards, measures for ageing management, the state and gaps of available data, steps to improve data quality, approaches for preserving records and knowledge transfer, as well as practices of public involvement, transparency, and opportunities for international cooperation.

Subtask 3.1 has provided a solid starting point, offering valuable insights into the state and long-term management requirements of Europe's radioactive waste storage facilities. It highlighted the main challenges linked to facilities and packages operating beyond their original design lifetime, outlined priority gaps in data and practice, and set the stage for the more detailed technical and strategic examination to follow in Subtask 3.2. Importantly, it also reinforced the importance of maintaining inclusive dialogue among diverse stakeholders, ensuring that practical solutions, shared priorities, and future opportunities for cooperation can be developed in a collaborative manner.

The following activities on analysis of data and following second Task 3 workshop discussions will be performed in Subtask 3.2 and reported in the next report (Milestone 60). Subtask 3.2 results will present detailed information on such radioactive waste storage facilities, including the characteristics of the stored waste, applied storage methods, as well as findings from safety reassessments, identified risks, uncertainties and hazards, urgency of retrieval, and future strategies and approaches for facilities with exceeded lifetimes, covering timeframes, cost estimations, and funding sources. This combination of efforts will support the consideration of both existing and alternative strategies for managing radioactive waste within the scope of the topic.

Appendix A. Subtask 3.1 Questionnaire

As part of the EURAD-2 partnership, the Work Package 3 ASTRA Task 3 is dedicated to the long term storage of radioactive waste (RW), especially to study RW management strategies for situations in which RW is stored for periods that exceed the design lifetime of the container and/or storage facilities.

The questionnaire below serves as a data collection from task partners on situations and possible ways of management of RW packages and about storage facilities for which the design lifetime has been exceeded. Obtained results will be synthesised and analysed (in March/April 2025) and based on the results of data collection, a workshop will be focused on building of mutual understanding about the views of different actors (WMO, RE, TSO, CSO) on existing and alternative RWM strategies for storage facilities exceeding the design lifetime (in May 2025). Analysis and workshop results will be used as input to the Green paper and Task 3 reporting document Milestone MS38.

The questionnaire is structured in 6 main sections.

Section 1. General information

Section 2. Status of RW storage facilities

Section 3. Challenges and risk assessments

Section 4. Future strategies and approaches

Section 5. Public Involvement and Transparency

Section 6. International Cooperation and Knowledge Exchange

Note: Detailed answers are asked for, however, if information is not available to repliers, please indicate this also. It may help to assess the accessibility of such data in different countries for different actors.

Section 1 General Information

1.1 Country

1.2 Organisation name

1.3 Organisation type (WMO, RE, TSO, CSO, other).

- WMO: Waste Management Organisation
- RE: Research Entity
- TSO: Technical Support Organisation
- CSO: Civil Society Organisation
- Other (specify)

1.4 What is your role in Task 3 of ASTRA WP?

- Partner
- End-user
- Stakeholder

- Other (specify)

1.5 What is the total number of RW storage facilities in the country?

1.6 What is the number of RW storage facilities in the country with an exceeded design lifetime?

Section 2 Status of RW Storages

Provide the information about RW storage facilities in your country with exceeded or expected-to-exceed design lifetime (for each individual facility, information is filled in separately).

What is the total number of such facilities (to open fields for filling in information below)? (from 1 to 9) (Example below is provided for 1 facility)

2.1.1.1 Name of the RW storage facility №1

2.1.1.2 Design lifetime of the storage facility, years

2.1.1.3 End of the facility's operational period, year (designed/expected)

2.1.1.4 Characteristics of RW for the facility №1

	RW class	Criteria for RW class (according to your country specific system if differ from IAEA)	Volume	Main radiological characteristics	Main physicochemical characteristics
1					
2					
3					
4					
5					

2.1.1.5 What methods are used for RW storage?

- Bulk Storage
- Primary Packages
- Containerised Storage
- Liquid Waste Storage
- Wells for Spent Radioactive Sources
- Other (specify)

2.1.1.6 What is the service life of the RW packages, and when is it expected to end?

2.2 How comprehensive is the available data on RW (e.g., level of detail, data quality, challenges)?

- Comprehensive (RW data are complete, accurate, and regularly updated. No significant gaps or challenges)
- Partially Comprehensive (most RW data are available, but some gaps exist (e.g., incomplete records)
- Limited (significant data gaps or inconsistencies exist, posing challenges for RW management)

2.3 What gaps or challenges are faced in RW and storage facility(s) data quality and availability?

- Incomplete records
- Loss or inaccessibility of historical data
- Lack of standardisation

- Difficulties in data verification
- Data loss due to external events
- Limited accessibility for stakeholders
- Other (specify)

2.4 Could you please explain the situation with data quality and availability in more detail?

2.5 If applicable, could you please describe the steps being taken to improve data quality and accessibility?

2.6 What approaches are used to ensure the long-term preservation of RW storage and inventory data?

2.7 What approaches are used to ensure knowledge transfer across generations?

- Creating comprehensive records
- Implementing centralised databases and platforms
- Using digital archiving systems
- Employing standardised formats and metadata
- Integrating lessons learned and historical data into knowledge repositories
- Utilising artificial intelligence for data analysis
- Storing hard copies and backups in multiple, secure locations
- Education and training programmes (specialised training courses, collaborating with academic institutions)
- Institutional memory preservation
- Community and public engagement
- International collaboration and benchmarking
- Long-term knowledge preservation initiatives
- Other (specify)

Section 3 Challenges and Risk Assessments

3.1 What are the key reasons for exceeding the design lifetime of RW storage facilities and RW packages in your country?

- Insufficient funding
- Technical limitations
- Lack of alternative facilities for further RW management
- Political/legal procedures
- Other (specify)

3.2 What are the main challenges faced with RW storage facilities with exceeded design lifetime? (e.g., deterioration of RW packaging, degradation of specific barriers, reduced resistance to environmental impacts)

3.3 What are the main measures implemented in aging management programmes for RW storage facilities with exceeded design lifetime, their systems, equipment, and packages? Frequency of control? (e.g., monitoring the condition of structures, barriers, and packages; conducting repairs or upgrades; or replacing damaged components)

3.4 Please provide brief Information on the safety reassessment of RW storages after exceeding their design lifetime (for each individual facility mentioned in 2.1, information is filled in separately).

(Example below is provided for 1 facility)

3.4.1.1 Name of the RW storage facility №1

3.4.1.2 Main results of assessment of storage facility resistance to natural and man-made impacts

3.4.1.3 Main results of assessment of radiation impacts

3.4.1.4 Methods and software used for the safety reassessment of storage facility

3.4.1.5 Main identified risks, uncertainties and hazards

3.4.1.6 Risk and hazard ranking

- High
- Medium
- Low

Please provide the explanation of criteria used for ranking

3.4.1.7 Urgency of RW retrieval:

- within 5 years
- 5 to 15 years
- more than 15 years

3.4.1.8 Approaches and measures for the remediation of the storage site being considered

3.5 What are the environmental hazards posed by the storage facilities to the region?

3.6 How important is public perception and trust in RWM for extension of lifetime of storage facilities?

Section 4 Future Strategies and Approaches

4.1 What approaches have you planned or implemented for RW storages with exceeded design lifetimes?

Indicate all applicable strategies for each facility mentioned in 3.4, information is filled in separately

(Example below is provided for 1 facility)

4.1.1 Approaches for RW storage facility №1

Approach	Approach realisaton steps	Timescale
Lifetime extension		
RW retrieval and repackaging		
Recycling/reprocessing		
Relocation to new storages		
Deep geological disposal		
Storage closure		
Other (specify)		

4.2 Have the costs of implementing each planned approach been estimated? Have the preferences for specific approaches been determined based on their cost levels? (Specify)

4.3 What funding sources are used for these activities (indicate all applicable funding sources)?

- Government budget
- Private and industry sector
- International grants
- Other (specify)

Section 5 Public Involvement and Transparency

5.1 How are transparency and public information ensured when considering the continued operation of a storage beyond its design life?

5.2 What is the decision process when it becomes necessary to operate RW storage beyond its design lifetime? (e.g. public consultations, transparency initiatives (e.g., sharing safety reviews), public involvement in the licensing process for RW storages / extension of licenses and decision-making)

Section 6 International Cooperation and Knowledge Exchange

6.1 Which opportunities do you see for international cooperation in this area?

6.2 On your opinion, how can countries or organisations work and exchange together to address shared challenges and needs?

References and Feedback

We would greatly appreciate it if you could share links to open publications, reports, and documents related to the topic of Task 3 that may be useful for further survey within this task

Your efforts	Answer
How much time (h) did you use to fill out this questionnaire?	
How much time (h) did it take to find related information?	
How many people were involved?	

Appendix B. Agenda of the Task 3 Workshop #1

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European Partnership
on Radioactive Waste Management

WP3 ASTRA
TASK 3 WORKSHOP 1
AGENDA

Teams meeting 28th May 2025 13:00-17:00 CET

Link to the meeting: [Join teams meeting here]

Start time	Topic	Speakers
13:00-13:10	Welcome and objectives	Kateryna Fuzik & Wilfried Pfingsten
13:10-13:20	Interactive Blitz Poll	Yevheniia Kudriashova & All
13:20-14:00	Presentation of key survey results	Kateryna Fuzik
14:00-14:20	Transparency and public participation in long-term storage	Gabriele Mraz
14:20-14:30	Q&A Session: Open floor for questions and clarifications	Wilfried Pfingsten & All
	Photo of participants	All
14:30-14:40	Coffee Break	
14:30-15:20	Interactive breakout sessions Each group addresses common topics with input from each participant (guide in e-mail).	Moderators & All (5 groups)
15:20-16:05	Joint mapping of challenges, risks & uncertainties, existing solutions, implementation conditions	Moderators & All
16:05-16:15	Coffee Break	

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KM WP Kick-off Meeting Agenda

Start time	Topic	Speakers
16:15-16:35	Ideas for future collaboration: opportunities, needs	Moderators & All
16:35-17:00	Conclusions of workshop, next steps & closing remarks	Kateryna Fuzik & Wilfried Pfingsten

2

References

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, The Long Term Storage of Radioactive Waste: Safety and Sustainability, Non-serial Publications, IAEA, Vienna (2003) https://www.iaea.org/publications/6858/the-long-term-storage-of-radioactive-waste-safety-and-sustainability

[2] NEA (2006), The Roles of Storage in the Management of Long-lived Radioactive Waste, OECD Publishing, Paris https://www.oecd-nea.org/jcms/pl_14068/the-roles-of-storage-in-the-management-of-long-lived-radioactive-waste?details=true

[3] EURAD ROUTES WP https://ejp-eurad.eu/implementation/waste-management-routes-europe-cradle-grave-routes

[4] EURAD project website https://www.ejp-eurad.eu/

[5] EURAD Roadmap - A generic framework to organise typical scientific and technical domains in a logical manner against different phrases of a RWM programme. https://www.ejp-eurad.eu/roadmap

[6] EURAD-2 ASTRA WP https://www.ejp-eurad.eu/implementation/alternatives-rwm-strategies-astra

[7] EURAD-1 Deliverable 9.10 – Collection and Analysis of Actual Existing Knowledge about Disposal Options for SIMS https://www.ejp-eurad.eu/publications/eurad-d910-collection-and-analysis-actual-existing-knowledge-about-disposal-options

[8] EURAD-2 WP03 Task 3.1 Survey https://ec.europa.eu/eusurvey/runner/EURAD2ASTRASurveyTask3

[9] EURAD-2 D1.3 Data Management Plan https://www.ejp-eurad.eu/publications/eurad-2-d13-data-management-plan