D12.3 Approved list of prioritized topics for further guidance documents and selection process of one topic for the development of a pilot guide

Work Package 12

The project leading to this application has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 847593.

Document information

Project Acronym	**EURAD**
Project Title	**European Joint Programme on Radioactive Waste Management**
Project Type	**European Joint Programme (EJP)**
EC grant agreement No.	**847593**
Project starting / end date	**1st June 2019 – 30 May 2024**
Work Package No.	**12**
Work Package Title	**Guidance**
Work Package Acronym	**WP12**
Deliverable No.	**12.3**
Deliverable Title	**Approved list of prioritized topics for further guidance documents and selection of one topic for the development of a pilot guide**
Lead Beneficiary	**SURAO**
Contractual Delivery Date	**M22**
Actual Delivery Date	**22/11/2021**
Type	**Report**
Dissemination level	**PU**
Authors	**P. Carbol (JRC), J. Faltejsek (SÚRAO), B. Nős (PURAM), J. Mikšová (SÚRO), N. Železnik (EIMV), O. Tokarevsky, I. Yarmosh (SSTC NRS),**

To be cited as:

(2021): Approved list of prioritized topics for further guidance documents and selection of one topic for the development of a pilot guide D12.3 of the HORIZON 2020 project EURAD. EC Grant agreement no: 847593.

Disclaimer

Acknowledgement

This document is a deliverable of the European Joint Programme on Radioactive Waste Management (EURAD). EURAD has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 847593.

Status of deliverable		
	By	Date
Delivered (Lead Beneficiary)	SÚRAO	31/03/2021
Verified (WP Leader)	Jiří Faltejsek	31/03/2021
Reviewed (Reviewers)	PMO	18/05/2021
Finalized (WP leader)	Jiří Faltejsek	01/07/2021
Reviewed	PMO	25/10/2021
Finalized (WP leader)	Jiří Faltejsek	22/11/2021
Approved (PMO)	PMO	23/11/2021
Submitted to EC (Coordinator)	Coordinator	23/11/2021

Executive Summary

High priority is devoted to all types of Knowledge Management (KM) activities within EURAD. Recently, at the 4th General Assembly of EURAD the Knowledge Management & Networking Programme 2020-2024 document was approved, in which the vision of integration of KM activities within EURAD was expressed. In this process, the EURAD Roadmap plays an important role by providing a framework and basis for systematic evaluation of existing and needed knowledge.

Work Package 12 (Guidance WP) of EURAD has a role to develop guides for the end-users of EURAD and the RWM community. These guides have to be needs driven, meaning, that a wide range of end-users consider the newly developed guides useful for radioactive waste management (RWM) programme implementation. The guides are self-standing documents but integrated in the EURAD roadmap. To this end the Guidance WP has initiated a preliminary screening process to have a first list of prioritized topics for guidance documents. The aim was to select a first topic for a pilot guide, for which a simplified selection process was applied in comparison to the future selection process outlined in this deliverable. In the development of the pilot guide the earlier delivered quality management procedure (Deliverable 12.2) will be tested.

The pilot guide will cover the issue of "Funding and Financing Aspects of Radioactive Waste Disposal". The selection process and the proposed topic for the pilot guide was approved by the 4th General Assembly of EURAD. Later the title has been modified to "Cost Assessment and Financing Schemes of Radioactive Waste Management Programmes" in order to be in line with EU terminology (e.g. NAPRO Guide[1]), but the content of the pilot guide remained the same.

For future guides the simplified approach – implemented for selecting the topic of the pilot guide – will be complemented with the top-down approach based on the EURAD Roadmap gap analysis. Based on the result of this activity and the ongoing evaluation of end user needs and feedback, the approved list of prioritised topics will be regularly updated as a 'living document'.

[1] Guidelines for the establishment and notification of National Programmes under the Council Directive 2011/70/EURATOM of 19 July 2011 on the responsible and safe management of spent fuel and radioactive waste

Table of content

Glossary, abbreviations

AP	Advanced Programme: Radioactive waste management programmes that are close to implementation of disposal. This typically includes programmes that are licensing for construction, completing site-specific and detailed site characterisation, or programmes that have produced comprehensive safety cases (and their supporting evidence base) for detailed conceptual designs suitable for regulatory scrutiny and/or subject to international peer review.
ESP	Early Stage Programme: Radioactive waste management programmes that are at an early stage of development with respect to implementing disposal. This typically includes programmes in establishment or undertaking preliminary site evaluation and selection, or programmes yet to develop demonstrable competence for producing comprehensive safety cases (and their supporting evidence base) for detailed conceptual designs.
EURAD	European Joint Programme on Radioactive Waste Management
ILW	Intermediate Level Waste
KM	Knowledge Management
KM&NW	Knowledge Management & Networking
MS	Member State
RE	Research Entity
RWM	Radioactive Waste Management
RWMD	Radioactive Waste Management and Disposal
SIMS	Small Inventory Member States: Member States that have a small inventory typically containing medical waste, disused and sealed radioactive sources and possibly a small amount of spent nuclear fuel from research reactors. Such programmes typically consider the construction of a dedicated national geological repository unfeasible and work in pursuit of economical ways for disposing of small amounts of radioactive waste, either through the possibility of shared regional facilities, borehole disposal or through a focus on long-term storage.
TSO	Technical Support Organisation
WAC	Waste acceptance criteria
WP	Work package
WMO	Waste Management Organisation

1. Introduction

A common knowledge management strategy (Knowledge Management & Networking Programme 2020-2024) was developed within EURAD, aiming to support capturing of knowledge and its transfer between generations, Member States, and organisations. As part of the KM&NW programme the roadmap for implementing radioactive waste management, leading to geological disposal, provides an integrated and systemic framework for organising, structuring and sharing available RWM knowledge. The aim is to integrate the work performed in the knowledge management work packages of EURAD.

Within Work Package 12 (Guidance) of EURAD, activities aim to develop a comprehensive suite of instructional guidance documents that can be used by Member-States with radioactive waste management programmes, regardless of their phase or level of advancement with implementation of geological disposal. These guidance documents have to assist “Transfer of knowledge towards Member-States with early-stage RWM programmes”, as well as “Transfer of knowledge between generations” objectives of EURAD in knowledge management to comply with the EURAD KM&NW Programme.

Based on the decision made by General Assembly 2 of EURAD the Guidance WP has to consider a widened scope to support the achievements of the objectives mentioned above. To this end, the activities of the Guidance WP have been restructured and the main priority is now to identify a list of the most requested topics of guidance documents from which a topic for a pilot guide has to be selected. This includes considering topics where there is access (within EURAD) to suitable experts from Advanced Programme Member States (AP) who could contribute to the related Guide development. This pilot guide will be compiled first to test the guidance development process (and the quality management procedure) in practice.

The aim of this document is to describe the guidance selection process in support to the decision made at EURAD´s General Assembly meeting N° 4 on the topic of the pilot guide.

2. Strategies for selection process

Selecting topics for guidance documents can be carried out by following two strategies, the bottom-up and/or the top-down approach. The bottom-up approach means, that experts involved in the selection based on their experience and knowledge accumulated in their respective fields of activities identify the gaps, where guidance is needed, but not available. While the top-down approach at EURAD level means that the selection process is carried out based on the Roadmap and the gaps are identified by the systematic evaluation of the themes, sub-themes and domains, using input from experts who has experience from the implementation process. Within the Guidance WP both strategies are implemented.

3. Selection criteria

The members of the Guidance WP have defined criteria to be applied when evaluating topic proposals for guidance development. These criteria are:

- End-users[2]: How wide (e.g.: WMO, TSO, RE, waste generators, ESP, SIMS, AP) is the range of end-users of a given topic?
- Relevance: It is evaluated how many domains of the Roadmap are covered by the topic. This more or less correlates with the aspect of how significant role a given topic has for radioactive waste disposal programme implementation.

[2] as end-users are defined in EURAD Knowledge Management & Networking Programme 2020-2024

- Urgency in terms of programme implementation phases: In what phase of RWM programme development the guidance should be implemented? When should guidance on a given topic be ready for the target end-users?
- Expertise: How much expertise is necessary for the development of the given topic outside the Guidance WP, or outside EURAD? Readiness and timely availability of experts (this is only a minor aspect and only considered when selecting the topic for the pilot guide)
- Length of development: Based on the preliminary assumptions, how lengthy could be the process of development of the guidance? (Suitability to be a pilot guide)
- Avoiding duplication: How large is the risk of overlaps of some parts of the given topic with existing guidance and planned guidance by other organisations?
- Interaction with EURAD WPs: Are there any outputs from EURAD already available to be used for guidance development? How and in what extend are they used?

4. Proposal for the topic of the pilot guide

It is important to make a distinction between the selection process of the topic for the development of the pilot guide and the process to be applied later for additional guidance documents. In the first phase, the objective was to select a topic for the pilot guide:

- which shall be needs driven (meaning, that wide range of end-users considers it useful for RWM programme implementation),
- which has low probability of controversy during review process,
- which has a low risk of duplicating existing guidance, and
- which can be developed in relatively short time (up to 6-8 months).

The Guidance WP team started the selection process using a bottom-up approach. First, some topics were raised by the team members and later a list of topics was provided by the EURAD Roadmap Advisory Committee (Tara Beattie, Bernd Grambow, Neil Chapman, Piet Zuidema, Johan Andersson). The rationale behind their proposal was to identify areas, where expert knowledge of programme history would provide useful strategic guidance to early stages programmes, where problems might be encountered in future, what are the really difficult issues to deal with in moving a programme forward and potential pitfall to avoid. The list of proposed topics (‘long list’) was:

- practical issues encountered while establishing a geological disposal facility (GDF) siting programme,
- factors encountered when waste management organisation (WMO) interface with government (and EU directives),
- managing interactions in multidisciplinary teams (engineers, sociologists, geologists, physicists, modellers and lawyers),
- means to ensure a constructive interaction between implementer (mostly WMO) and regulator, as well as other stakeholders, to ensure progress in the repository programme without jeopardising the roles and independence between them, when optimising the regulatory interface,
- managing organisational and mind set transition on the road from research to implementation, i.e. repository construction and operation without losing track of the uniqueness of nuclear waste repositories compared to other kind of nuclear facilities,
- ensuring success in communication,
- establishing and managing programme requirements and how these need to be linked to the findings of the research development and demonstration (RD&D) programme,

- optimising RD&D spending when budgets are limited,
- approaches to repository optimisation, when should it be done and on what should it focus,
- getting the most out of international collaboration and participation in international organisations.

Within the Guidance WP the criteria, mentioned in the previous chapter were first qualitatively applied based on expert judgement of the WP members.

Considering this long-list proposal and taking into account the guidance team's experience, the team members reduced the long list to a list of 3 plus 1 proposal with specified topics which are attached in the Annex A-C.

The development of the short list was based on the bottom-up approach, the preliminary evaluation of the link with themes, sub-themes and domains of the Roadmap was carried out and is prescribed in the specifications of the topics (see Annexes). The short list consists of the following topics:

- Funding and Financing Aspects of Radioactive Waste Disposal (Annex A)
- Optimization of Disposal of Radioactive Waste (Annex B)
- Derivation of Requirements for the Disposal System (Annex C)
- Waste Acceptance Criteria (reserve)

The last topic on waste acceptance criteria is kept as a reserve because there is a risk of overlapping with activities in EC H2020 PREDIS project. This topic might be re-evaluated in the future.

For selecting the topic for the Pilot Guide a simplified methodology was applied. The topics of the short list were evaluated against predefined selection criteria based on the expert judgement of the WP12 team in a qualitative and semi-quantitative way. Each team member could score the topic proposals and the results were discussed at the WP web-meeting on 11th December 2020.For any guidance document it shall be ensured, that it provides an added value to the target end-users (needs driven) in an area, which is not covered by existing guidance (avoid duplication). In the case of the Pilot Guide beyond these criteria, it was considered to be essential, to have a topic, which can be developed by the WP12 team within a reasonable time, with the assistance of some experts (having gone through the process themselves), who provide consultancy service to the team (simplified methodology). To represent these aspects in the topic selection process for the Pilot Guide higher weighting factor was devoted to three criteria (low risk of overlap with existing guidance, access to expertise and potential interactions within EURAD).

Based on the above-mentioned ranking exercise the Guidance WP agreed that the three proposals on the short list were very viable. The proposals on financing (Annex A) and requirements (Annex C) were very close to each other in the evaluation, but the team finally decided to propose 'Funding and Financing Aspects of Radioactive Waste Disposal' (Annex A) topic to be developed as a Pilot guide as the time period and readiness resources for its timely development was assessed reasonable. Later the title has been modified to "Cost Assessment and Financing Schemes of Radioactive Waste Management Programmes" in order to be in line with EU terminology (e.g. NAPRO Guide), but the content of the pilot guide remained the same.

A preliminary gap analyses of available documents on the Costing and Financing topic was completed. It demonstrated that international examples are abundant, but for countries that are about to start their activities in cost estimation and develop or update financing mechanisms of their RWM programmes, there is a challenge to get the proper information tailored to their national programme needs. The planned pilot guidance will aim to address this gap and orient the targeted countries on how properly plan their activities in this field.

5. Selecting topics for further guides

For future guidance selection, the bottom-up approach will be complemented with the top-down approach based on the EURAD Roadmap gap analysis (deliverable 12.7). It is also planned to ask inputs for topic proposals from a wide range of potential end-users (e.g. Colleges; RD&D, strategic and KM work packages), the way of doing this shall be developed. In the meantime, the selection criteria have to be reviewed and by using the approved set of criteria, the prioritization of these topics will be made. Based on these inputs, the list of the potential guide topics (deliverable 12.5) will be updated. Subsequent guides will be developed within EURAD by WP Guidance team and selected experts.

As a summary, the concept of guidance development within EURAD Guidance WP can be illustrated by the figure below.

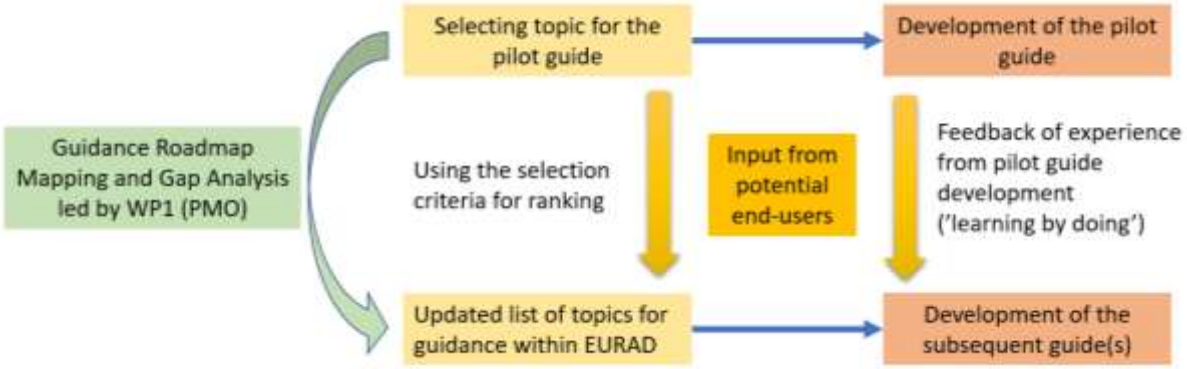


Figure 1: The concept of a guidance development applied by WP Guidance team.

Annex A: Funding and Financing Aspects of Radioactive Waste Disposal

1. Short description of the topic

A fundamental prerequisite for implementing a sustainable waste disposal programme is the provision of financial resources to cover the costs of the programme. It can be seen from international experiences that lack of financial resources can jeopardise and slow down the implementation of the disposal programme. Estimating the cost of a radioactive waste disposal programme and setting up a related funding mechanism is a challenging and complex task, especially for small inventory member states and early-stage programmes but this guide could also support large inventory member states or advanced member state programmes improvement targeted at their financial aspects. The financing aspects of the enlargement of interim storages or ILW disposals could also be interesting for APs.

Until lately there was little attention given to the specific topic of funding and financial aspect of radioactive waste management and disposal (RWMD). Based on a preliminary screening of existing guidance, there have been generic documents published giving guidance on developing cost estimates of large projects (e.g. NASA, see chapter 5). Only lately more systematic approaches and investigations resulted in some technical documents (as provided in chapter 5) although some, which collect the latest knowledge are still not published, except of currently issued IAEA publication (NES NW-T-1.25, IAEA, 2020). However, none of the analysed documents provides guidance on; how to perform independent assessment of costs for the RWMD with practical examples, how to add the related uncertainties, how to extend or update the cost in time perspective and how to address the challenges of collection of appropriate funds. Such guidance would provide real impact to the different end users, like WMOs with clear direction on how to perform real estimations of costs for a RWMD programme, but also for research entities (REs) with prognoses for RD&D activities funds, and technical support organisations (TSOs) with information on activities planning.

The guidance should include the approach to estimate the disposal programme's cost taking into account the following steps:

1. a baseline document where the disposal programme is defined, the purpose of the cost estimate is explained and identifies the assumptions about the unknowns in the programme;
2. a work breakdown structure (WBS) of the programme is made dividing it into more specific components;
3. the present cost of these components is estimated, the way to be used to regular cost estimation update with respect to the programme phase, the issue of a validity of input data;
4. the cost impact of uncertainties and risks related to the disposal programme is assessed and taken into account; and
5. the present cost is converted into a discounted cost which will be used to determine the provision needed to finance the disposal programme.

The guidance should cover the summarized main aspects of radioactive waste management with special focus on radioactive waste disposal (RWD) financing, resources available, cost calculation tools/models, how to ensure financial sustainability etc. It should include also very practical approaches how to perform all calculations with examples. The main target audience would be early-stage programmes' members with lack of experiences in the area.

2. The rationale behind the proposal

The financial aspect of radioactive waste management including disposal forms a basic part of RWMD programme establishment. Although many publications on this topic are publicly accessible, the early stages programmes or SIMS specific needs could benefit from a summarized guidance on how to collect sufficient resources to ensure a successful and sustainable RWMD programme implementation on a national level.

Another issue is how to calculate and verify the right costs of the RWMD knowing that only a limited number of comparisons are available on national and international level. The main implementation

responsibility usually lays on the WMOs but in some programmes the responsibilities, functions and positions of all actors are not always clearly identified and established together with financial resources.

Another important challenge of RWMD cost management is how to deal with the situation in which the waste producer or owner is unknown or no longer exists or where there are only small waste producers active dealing with insufficient resources. A practical guidance of future funding of RWMD could be beneficial also with respect to the current situation in the world where some countries have reduced or even shut down their nuclear programmes or activities and the resources set aside to cover the further waste management, including decommissioning costs, are insufficient.

With development of guidance on funding and financial aspect of RWMD with practical examples on used methodologies and approaches, including the uncertainties treatments and discounting principles, the end users would have tools to assess the costs and to re-evaluate the finances regularly or when necessary. As this is an iterative process which needs to be performed whenever new elements (new waste management route, new waste producer, new category, new waste management facility or service etc.) or knowledge is achieved, such guidance would empower the end user.

3. Connection with EURAD Roadmap and/or other WPs

This proposal addresses the current Roadmap in:

1. a direct link to the Phase 0: Policy, framework and programme establishment but also other Phases1, 2, 3, 4 and 5, as the financial assessment of costs shall be iteratively re-assessed;
2. a direct link to Theme “Managing implementation and oversight of a radioactive waste management programme”, sub-theme “Programme resources”,
3. an indirect link to the rest of themes identified in the EURAD Roadmap.

Potential direct links to EURAD all Knowledge Management WPs is obvious. As there is a recommendation for mutual knowledge transfer from more advanced programmes this Guide could be used also as a learning material for training courses organised within WP13 Training and Mobility.

A direct link to the EURAD Knowledge Management and Networking Programme currently developed by EURAD is intended.

An intensive interaction with Strategic Studies WPs, mainly ROUTES is planned and will be beneficial as ROUTES is dealing not only with disposal but also with pre-disposal part of RWMD programmes in MSs.

The exchange with RD&D WPs could contribute to the cost assessment of the research activities which forms necessary component of every RWMD programme regardless of its scope, size and stage of its development. Interaction with new projects approved for 2nd phase of EURAD will be discovered. In case of MODATS[3], there is a direct link due to the necessity of monitoring programme assessment regardless of chosen disposal concepts. The cost calculation of monitoring programmes is of high importance during whole disposal facility life cycle, including post closure.

Additionally, information exchange with the team, who are responsible for the tasks planned within EC H2020 PREDIS (Pre-Disposal Management of Radioactive Waste) on evaluating the economic impacts of pre-disposal radioactive waste treatment activities could provide an added value for both programmes. The exact form of potential cooperation will be evaluated in the future.

4. Expected need of resources outside WP12

Expertise inside WP12 is sufficient to cover this topic.

Substantial involvement of external experts will be necessary for the development of the guide and also during the review processes.

[3] EURAD 2nd wave proposal on Monitoring Equipment and Data Treatment for Safe Repository Operation and Staged Closure

5. Preliminary screening of existing guidance

As the most relevant literature seems to be:

- Costing methods and funding schemes for radioactive waste disposal programmes, NES, NW-T-1.25, IAEA, 2020.
- Cost Considerations and Financing Mechanisms for the Disposal of Low and Intermediate Level Radioactive. IAEA-TECDOC-1552, IAEA, 2007.
- Low-Level Radioactive Waste Repositories: An Analysis of Costs, NEA/OECD, 1999.

Other relevant:

- Communication from the Commission to the European Parliament and the Council on the use of financial resources earmarked for the decommissioning of nuclear installations, spent fuel and radioactive waste (COM(2013) 121 final)
- UK Funded Decommissioning Programme (https://www.gov.uk/government/publications/hinkley-point-c-funded-decommissioning-programme)
- Guidelines for comparing cost assessments for geological repository projects, EDRAM, 2012.
- Joint Top Down Review of Potential Benefits of transferring Swedish technology for geological disposal to the UK, SKB International Report 173, 2014.
- The cost of High level waste disposal in geological repositories, NEA, 1993.
- Geological Disposal, Review of Alternative Radioactive Waste Management Options, NDA Report no. NDA/RWM/146, 2017
- A PROPOSED STANDARDISED LIST of in the DECOMMISSIONING OF NUCLEAR INSTALLATIONS, NEA
- The cost of high level waste disposal in geological Repositories, Analysis of factors affecting cost estimation, AEN/NEA OECD, 1993

General for large projects:

- U.S. DEPARTMENT OF ENERGY, Cost estimating guide. DOE G 413.3-21A (2018).
- HM TREASURY, The Green Book: Appraisal and Evaluation in Central Government. Treasury Guidance. (2013)
- AACE INTERNATIONAL, Total Cost Management Framework. An Integrated Approach to Portfolio, Program and Project Management. (2015)
- NASA. NASA Cost Estimating Handbook Version 4.0. (2015)
- UNITED STATES GOVERNMENT ACCOUNTABILITY OFFICE, Cost Estimating and Assessment Guide. Best Practices for Developing and Managing Capital Programme Costs. GAO-09-3SP. (2009)
- The Methodology of Cost Estimation for Decommissioning Nuclear Facilities in the Russian Federation, International Expert Feedback on the Methodology Developed by ROSATOM, Final Report, NEA/OECD, 2018.

Annex B: Optimization of Disposal of Radioactive Waste

1. Short description of the topic

"Radioactive waste, including spent fuel considered as waste, requires containment and isolation from humans and the living environment over the long term. Its specific nature, namely that it contains radionuclides, requires arrangements to protect human health and the environment against dangers arising from ionising radiation, including disposal in appropriate facilities as the end location point.". (EC Directive 2011/70)

The Guide should cover the approaches to optimization of radioactive waste (RW) disposal with regard to selection of type(-s) of the disposal facility(-ies) (surface, near-surface, intermediate depth, geological, borehole) in specific country, optimization of waste streams to be sent to specific disposal facility.

It should cover the following aspects (according to the inputs from Roadmap Advisory Committee):

- "optimising RD&D spending when budgets are limited;
- approaches to repository optimisation, when should it be done and where should it focus;
- getting the most out of international organizations".

In general, optimization should cover 3 levels:

- Development of National Programme/Strategy/Policy on RW management
- Optimization of waste streams – Feasibility studies of the disposal facilities
- Final site selection and Designing of disposal facilities

Due to very wide scope of the optimization topic, this Guide will focus on first two levels. The Guide on level 3 could be developed later taking into account the results of development of this Guide and feedback obtained. Learning-by-doing approach will be applied as well.

The proposed approach would promote step-by-step development and implementation of national Programme/Strategy/Policy on RW management with regard to determination and optimization of disposal routes without compromising safety.

Iterative approach should be applied as far as possible not only when switching from higher level to lower level, but also within specific level as long as new knowledge/information is obtained. For example, at level 1, only rough assessment of RW streams with regard to disposal routes could be performed. At level 2, such assessment is performed more in detail, as more knowledge/information becomes available (in particular, as a result of RD&D performed). The results of such detailed assessment could lead to the necessity for revision of certain aspects of national Programme/Strategy/Policy.

Level 1- Development of National Programme/Strategy/Policy on RW management

According to EC Directive 2011/70, "Each Member State shall ensure the implementation of its national programme for the management of spent fuel and radioactive waste ('national programme'), covering all types of spent fuel and radioactive waste under its jurisdiction and all phases of spent fuel and radioactive waste management from generation to disposal. Each Member State shall regularly review and update its national programme, taking into account technical and scientific progress as appropriate as well as recommendations, lessons learned and good practices from peer reviews". (Article 11)

"The national programmes shall set out how the Member States intend to implement their national policies ... for the responsible and safe management of spent fuel and radioactive waste to secure the aims of this Directive, and shall include all of the following:

...(c) an inventory of all spent fuel and radioactive waste and estimates for future quantities, including those from decommissioning, clearly indicating the location and amount of the radioactive waste and spent fuel in accordance with appropriate classification of the radioactive waste;

...(e) the concepts or plans for the post-closure period of a disposal facility's lifetime, including the period during which appropriate controls are retained and the means to be employed to preserve knowledge of that facility in the longer term" (Article 12)

These issues could also be a subject of optimization.

When considering optimization approach during development of the National Programme/Policy/Strategy, there shall be taken into account existing situation with already implemented solutions on RW management facilities (in particular, long-term storage and disposal), existing and planned RW inventory, legacy waste, etc. as well as experience accumulated worldwide (first of all, in countries with advanced programmes). Other peculiarities of the country, like existence of Chornobyl exclusion zone in Ukraine, should also be addressed.

Optimization of the National Programme/Policy/Strategy should be based on application of iterative approach. As new knowledge/information appears, as a result of RD&D and obtained experience, the National Programme/Policy/Strategy may be revised respectively to address new challenges.

This iterative approach will also be applied at the next levels (see below).

During development of the National Programme/Policy/Strategy, there should be established "the significant milestones and clear timeframes for the achievement of those milestones in light of the overarching objectives of the national programme" (EC Directive 2011/70).

At this stage, RD&D should be performed at more generic level, concentrating on making strategic decisions for support of such issues of development of national program/policy/strategy:

- Approaches to classification of RW with regard to disposal types
- Attributing of existing and planned RW inventory to specific RW classes
- Preliminary screening of the potential disposal sites for all types of the disposal facilities, including determination of their availability in principle

At this stage, issues that require optimization include in particular:

- What RW classes do exist in the country?
- What types of disposal facilities does the country need?
- Rough assessment of waste inventory (approximate amount of waste, radionuclides, range of activities, general information on properties and possible restrictions on disposal routes, etc.)

In addition, the optimization issues with regard to financing aspects and interaction with civil society will be considered in general.

The Guide will provide recommendations on development of optimized approaches to solving these and other issues.

Level 2 - Optimization of waste streams – Concepts of the disposal facilities

Optimization at this stage consists in achieving optimum distribution of RW by streams with regard to their disposal routes, as well as finding optimal conceptual design solutions for the disposal facilities. As a result, optimum solutions should be found on base of multifactor analysis.

At this stage, RD&D should be performed at more detailed level, concentrating on support of such issues of implementation of national program/policy/strategy:

- Development of conceptual design/feasibility studies for potential disposal facilities
- Development of generic safety cases for potential disposal facilities
- Development of generic WAC for potential disposal facilities
- Determination of optimal amount of waste to be disposed of in specified facilities

- Deep screening of the potential disposal sites for all types of the disposal facilities and preliminary selection of potential site(-s)

At this stage, issues that require optimization include in particular:

- How many disposal facilities does a country need?
- What are the preferable rock formations for the disposal facilities?
- What is the optimal amount of waste to be disposed of in specified facilities?
- Preliminary characterization of waste inventory
- Which sites could be recommended for specific disposal facilities (according to the results of deep screening)?
- What are the generic WAC for specific disposal facilities?
- Does the National programme/policy/strategy need revision taking into account experience obtained and results of RD&D?

The Guideline will provide recommendations on development of optimized approaches to solving these issues.

2. The rationale behind the proposal

This guide could be useful for the early-stage programmes and small inventory Member States, which have no experience on how to optimize the whole process of RW management. The beneficiaries of the Guide could also be advanced programs, as it addresses different stages of development and implementation of national programs/policies/strategies.

The Guide could be of interest for a wider audience, including civil society.

3. Connection with EURAD Roadmap and/or other WPs

What are the theme(s), sub-theme(s), domain(s) to which the proposed guide could be linked to? It should also be mentioned if the topic could be connected to some other WPs of EURAD.

The proposed Guide could be linked to the following Themes according EURAD GBS:

- Theme 1 – National Programme Management (e.g. Domains 1.1.4, 1.3.3)
- Theme 7 – Safety Case.

Also, the topic is connected to EURAD draft KM & Networking Programme.

It may be connected to ROUTES WP and UMAN WP, including their extensions.

4. Expected need of resources outside WP12

Expertise inside WP12 does not cover complete this topic. Some external help will be necessary for authoring this guide.

Substantial involvement of external experts will be necessary for review processes as at definition as for final product.

5. Preliminary screening of existing guidance

1. 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.

2. Optimization of Geological Disposal of Radioactive Waste. National and International Guidance and Questions for Further Discussion, OECD NEA, 2010.
3. The Optimization of Radioactive Waste Management in the Nuclear Installation Decommissioning Process, Matej Zahar, Vladimir Necas, Proceedings of the International Youth Nuclear Congress 2008, 9 p.
4. Geological Disposal of Radioactive Waste, Safety Requirements, No. WS-R-4, IAEA, 2006.
5. ICRP, 1998. Radiation protection recommendations as applied to the disposal of long-lived solid radioactive waste. ICRP Publication 81.

Annex C: Derivation of Requirements for the Disposal System

1. Description of the topic

Derivation, followed by iterative review and long-term management of requirements is a key process for implementing a successful radioactive waste disposal programme. The requirements are derived from different sources like legislation, regulatory expectations and guides, international standards and recommendations and also based on the safety case. The scope of this proposal is limited to those requirements, which can be derived based on the safety case, especially post-closure safety assessment.

Countries with advanced programmes for the implementation of their geological disposal facilities has elaborated systems for requirement management (see references for ANDRA, POSIVA and SKB). There are a lot of similarities between the applied approaches and most of the steps of requirement derivation is documented, but a comprehensive description of the whole process could provide added value to most of the Member States.

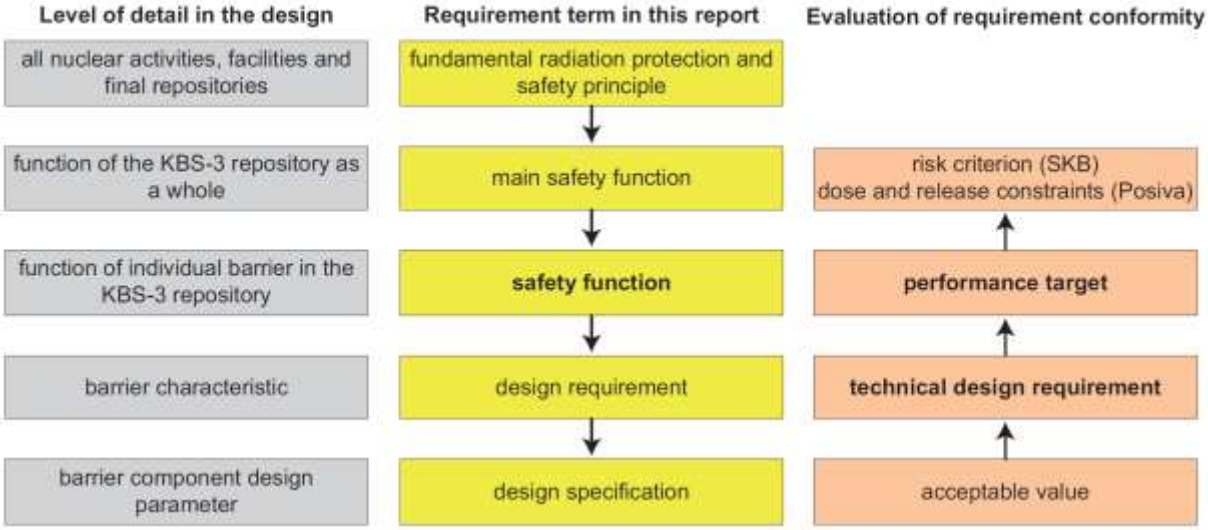
The starting point of defining the requirements for disposal system elements on the basis of post-closure safety assessment is the dose or risk constraint, as a high-level safety goal. It is common, that containment and isolation are the two basic post-closure safety functions, which have to be fulfilled. These safety functions can be broken up to sub-functions in a hierarchical system. The natural and engineered barriers of the disposal system and other safety relevant systems and components can be linked to the safety functions, clearly indicating which system element has to fulfil each given function. It should also be described, that the fulfilment of a given function is required for what time period in the post-closure phase.

The challenges came into the picture, when taking into account the complexity of a disposal system, quantitative requirements need to be defined e.g. for a given barrier. The high-level safety goals and the need of defining exact measurable requirements have to be bridged with a defendable, transparent process, which is agreed between the waste management organization (licensee) and the safety authority (and the technical support organization). Some examples can be found in the literature from the experiences of Sweden, Finland and France having the most advanced programmes in geological disposal implementation (briefly referenced below).

- In the Swedish system *safety indicators* and *safety function indicator criteria* are used in order to determine whether a safety function is maintained. *Design premises* (requirements) need to be defined for the initial state with sufficient margin to allow deterioration of the system components over the assessment period so that safety is still fulfilled, i.e. so that, ideally, all the safety function indicator criteria are fulfilled also at the end of the assessment period e.g. 1 million years). [SKB, 2011]
- In the Finnish case the safety functions are implemented in the proposed design through a set of technical *design requirements*, based on *performance objectives* that are defined for each barrier of the repository system. The performance objectives are expressed as *performance targets* (engineered barriers) and *target properties* (natural barriers) that the system should meet in the long-term to provide the safety level needed. The technical design requirements of the repository system are expressions of these performance targets and target properties in a form that can be tested or otherwise proven at the stage of implementation through observations and measurements. The definition of the performance targets and target properties requires the identification of the different loads and interactions that may act on the repository system at the time of canister emplacement and in the long-term. The loads and interactions are identified through a comprehensive analysis of the features, events and processes that are likely to affect the system in the design basis scenarios. The performance targets and target properties, together with the derived technical design requirements and the underlying design basis scenarios, form the *design basis* of the repository. [POSIVA, 2012]
- In the French case Andra has established a process for incorporating the *post-closure safety requirements* from the design phase and for checking that these requirements are met using an iterative process as part of the gradual development of the waste disposal facility. The global approach to post-closure safety assessment is based on practical expression of the *safety functions* and *associated requirements*, analysis of *component performance* and analysis of the

> uncertainties related to the scientific and technological knowledge underpinning the design. Understanding the evolution of the disposal system in the long term and its impact on the safety functions relies on a robust *phenomenological understanding* of the processes associated with this evolution. More generally, the design of Cigeo, from the selection of the main options to the detailed technical solutions, has been guided by research into the *best available techniques* for fulfilling the safety functions, taking account of technical and financial constraints. [ANDRA, 2016]

A really useful publication has been produced by POSIVA and SKB [POSIVA and SKB, 2017], in which a common terminology and structure is used (illustrated in the figure below).



The general methodology is described in the report as follows.

Within the safety assessment, scenarios of the post-closure development including interactions between barriers, potentially occurring conditions, loads and stresses during which the safety functions shall be maintained are compiled and assessed. As part of the assessment the performance targets are assessed and developed.

The barrier specific safety functions together with the conditions and stresses identified in the scenarios form the basis for the development of technical design requirements and a design with characteristics that are potentially capable of maintaining the safety functions in a long-term perspective.

Based on the integrated analysis of the long-term evolution of the barrier system the performance targets as well as the technical design requirements for each barrier are developed. The technical design requirements may also be derived from the as-built state of the repository and the interactions between its different parts. Such technical design requirements are determined so as to ensure that each part of the repository is only exposed to conditions that are acceptable with respect to the maintenance of its safety functions. [POSIVA and SKB, 2017]

Another important publication was published by OECD NEA, which considered requirement and information management [OECD NEA, 2018]. This document identified the challenge, what has been motivated this proposal for producing further guidance: “A particular challenge in assembling systems of requirements is to **trace the requirements or rationale that motivated design decisions**, when in practice these may date back several decades, and might not have been fully documented at the time.”

The guidance document should be to answer at least the following questions:

- How the requirements are defined in different phases of RW disposal programmes?
- What is the role of the safety functions and the safety case in the process? How the performance assessment and/or the sensitivity analyses is applied in practice? (the real added value would be to show practical examples, how the requirements are derived)
- How the RD&D programme is linked to requirement derivation process and governed to fill the gaps and reduce the uncertainties?

2. The rationale behind the proposal

Derivation of requirements in different phases of radioactive waste disposal programmes plays an important role also from licensing and also from industrial implementation point of view. The evaluation, whether all the defined requirements are met is a key point in the decision-making process.

The Site Evaluation & Selection phase is specific for a given disposal option. The aim is to define site selection criteria from two aspects. There can be exclusion criteria, which excludes the implementation of a facility and requirements (favourable properties of a site), on the basis of which different potentially suitable sites can be compared. In this phase the main focus is on the site properties and the safety functions, which has a role to fulfil the post-closure safety goals.

In the Site Characterisation phase for a geological disposal facility it is a strategical decision, whether the underground research facility (URF) is designed and excavated so that it will be a part of the future repository or not. In case the repository will be extended from the URF all the safety requirements for the future repository shall be applied to the URF as well. In case the URF is a separate research facility it has to be proved that all the information gathered in the URF is valid for the future repository site as well. The pros and cons of the two concepts could be elaborated for this phase. In the second part of this phase the detailed design and the design basis of the repository has to be defined.

In the facility Construction and Operation phase on the basis of the predefined and regularly updated requirements the performance targets of the system elements can be defined and the system optimization could take place.

This is an overarching topic, covering all the phases of the implementation of a disposal facility. This provides the opportunity to define subtopics for the interest of Member States in different stages of programme implementation. For countries with early stage programmes, the main interest could be site selection and characterization, while countries with advanced stage programmes can find interest in system optimization.

3. Connection with EURAD Roadmap and/or other WPs

The requirement derivation process and consequently the current guide can have potentially connection to the following subthemes or domains of the Roadmap. The most relevant items are highlighted with bold red letters.

- 3.2 Identify appropriate container materials and designs for each waste form and their properties with respect to storage and disposal conditions (Waste packages, for disposal)
- 3.3 Identify appropriate buffer, backfill and seal/plug materials and designs, and confirm their properties, behaviour and evolution for the selected repository concept (Buffers, backfills, plugs and seals)
- 4.1.1 Develop a model of the host rock and surrounding geological environment, including distributions of rock types, geometry and properties of structural features, geotechnical properties and the hydrogeological and hydrochemical environment (Site descriptive model)
- 4.1.2 Describe bedrock transport properties, including retention material properties (diffusion and sorption) of different geological materials as well as flow related properties (Aqueous transport and retention)
- 4.2.1 Assess the expected geological and tectonic evolution and the potential for natural disruptive events and their impacts on the stability of the natural barrier (Geological and tectonic evolution)
- 5.1 Design and develop a disposal system for the national radioactive waste inventory (Design)
- 6.1.2 Identify areas that may contain suitable sites by using the developed screening guidelines (site evaluation)
- 7.1.1 Establish the requirements that must be met to ensure the protection of people and the environment, both now and in the future (Safety requirements)
- 7.1.2 Establish safety indicators to complement dose and risk, defined relative to overall safety requirements (Performance indicators)

The development of the proposed guidance can have interrelation with WP10 - Uncertainty Management multi-Actor Network (UMAN) more specifically with subtask 2.3– Methodological approaches to

uncertainty and sensitivity analysis. This was only a preliminary judgement, it shall be checked with the given task leader.

4. Expected need of resources outside WP12

WP12 members has only partial experience with suggested topic. Experience of experts from advanced programs (e.g. ANDRA, POSIVA, SKB) is essential for authoring this guide.

5. Preliminary screening of existing guidance

ANDRA, 2016	Safety Options Report - Post-Closure Part (DOS-AF)
OECD NEA, 2018	Managing Information and Requirements in Geological Disposal Programmes
POSIVA, 2012	Safety Case for the Disposal of Spent Nuclear Fuel at Olkiluoto - Design Basis 2012
POSIVA, SKB 2017	Safety functions, performance targets and technical design requirements for a KBS-3V repository - Conclusions and recommendations from a joint SKB and Posiva working group
SKB, 2011	Long-term safety for the final repository for spent nuclear fuel at Forsmark - Main report of the SR-Site project
IAEA, 2020, NW-T-1.27	Design Principles and Approaches for Radioactive Waste Repositories (chapter 3.1.1). - doc available since Dec. 2020