Deliverable 10.10: UMAN - Analysis and description of groups of different actors

Work Package 10

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Authors	**Astrid Göbel (BGE), Marc Wengler (BGE), Agnieszka Strusińska-Correia (BGE), Nina Müller-Hoeppe (BGE), Jitka Mikšová (SURO), Hana Vojtechová (SURO).**

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Disclaimer

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Executive Summary

The deliverable D10.10 is an outcome from Subtask 4.1 of the EURAD UMAN WP. It presents the results of the analysis aimed at identifying the different categories of actors involved in each phase of a disposal programme as well as their roles and interests in respect to safety case-related activities. This deliverable is based on the 1st UMAN questionnaire and will serve as input to Subtasks 4.2 and 4.3 as well as Task 5 of the UMAN WP.

To collect information about the different actor categories and their involvement in a RWM programme, 1st UMAN questionnaire was distributed among the organisations participating in the UMAN and ROUTES WPs of EURAD. The questionnaire consisted of 5 parts, of which Part 2 ´*Identification, characteristics and roles of actors involved in radioactive waste management programmes*´ has been analysed in this deliverable. In total, 10 *WMOs*, 7 *TSOs*, 6 *REs* and 1 *TCC* from 17 countries at different phases of their disposal programmes, including Small Inventory Member States, responded to Part 2 of the questionnaire.

The actors´ categories introduced in this deliverable are based on the answers of the responding organisations and can be understood as a first effort towards a characterisation of the complex system of the stakeholders involved in RWM programmes with very different specialisations, roles and dependencies. Two main actor groups are distinguished: (i) the ´*contributing actors*´ (*Waste Management Organisations*, *Technical Support Organisations*, *Research Entities* and one *Technical Consulting Company)*, represented by the organisations involved in EURAD, which responded to the 1st UMAN questionnaire, (ii) the ´*other actors*´ identified by the ´*contributing actors*´ (*Waste Generators*, *Waste Owners*, *Regulators, Governments / Legislators*, *Ministries*, *Municipalities*, *State Authorities*, *Civil Society*, *Environmental Actors*, *NGOs*, *Geological Surveys*, *Technical Surveys*, *Operating Companies*, *Technical Consulting Companies* and *Miscellaneous Actors*).

A strict distinction of the responsibilities of these individual actors was in some cases challenging due to the fact that the roles are often intertwined in case of older RWM programmes and facilities or not clearly specified in case of RWM programmes at early stage of implementation. The functions played by the individual actors in a RWM programme, with the focus on safety case-related activities, are determined solely for the *contributing actors*, for which a self-assessment of their responsibilities and functions was available.

The results of the analysis clearly show that the types of the identified actors and their functions in different phases of a RWM programme depend strongly on the following factors: (i) the current phase of the national RWM programme, (ii) the applied approaches and strategies, (iii) the national legislative, regulatory and organisational framework ('national framework') for spent fuel and radioactive waste management, (iv) political and administrative systems and finally (v) the stage of adaptation of older RWM programmes to the obligatory international standards.

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CS	Civil Society
DGD	Deep geological disposal
EA	Environmental Actor
EBS	Engineered Barrier System
EJP	European Joint Programme
EURAD	European Joint Programme on Radioactive Waste Management
EU	European Union
EW	Exempt waste
FSC	Forum on Stakeholder Confidence of Nuclear Energy Agency (NEA)
GD	Geological disposal
GS	Geological Survey
Gov	Government
HLW	High-level waste
IAEA	International Atomic Energy Agency
IGD	Intermediate geological disposal
ILW	Intermediate level waste
ILW-LL	Intermediate level long-lived waste
Leg	Legislature
LILW-SL	Low and intermediate level short-lived waste
LLW	Low-level waste
LLW-LL	Low-level long-lived waste
LTP	Linked Third Party, embarked by the mandated actor (WMOs, TSOs and REs) to deliver work in the framework of EURAD Work Packages
MA	Miscellaneous Actor
Min	Ministry
Mun	Municipality
NEA	Nuclear Energy Agency
NGO	Non-governmental Organisation
NORM	Naturally occurring radioactive materials
NPP	Nuclear power plant
NSD	Near-surface disposal
OC	Operating Company
OECD/NEA	Nuclear Energy Agency of the OECD
PA / SA	Performance assessment / Safety Assessment

RD&D	Research, Development and Demonstration
RE	Research Entity
Reg	Regulator
ROUTES	EURAD Strategic Study WP ´Waste management routes in Europe from cradle to grave´
RW	Radioactive Waste
RWM	Radioactive Waste Management
SA	State Authority
Safety case	Here: a collection of arguments and evidence in support of the safety of a radioactive waste disposal concept
SIMS	Small Inventory Member States
SNF	Spent nuclear fuel
TCC	Technical Consulting Company
TS	Technical Survey
TSO	Technical Support Organisation
UMAN	EURAD Strategic Study WP ´Uncertainty Management multi-Actor Network´
VLLW	Very low-level waste
VSLW	Very short lived waste
WAC	Waste Acceptance Criteria
WG	Waste Generator
WMO	Waste Management Organisation
WO	Waste Owner
WP	Work Package

1. Introduction

1.1 Background information

The involvement of stakeholders is essential to the decision-making process in all phases of a radioactive waste management (RWM) programme. These phases are defined in the EURAD Roadmap, based on IAEA (2014), as follows (Fig. 1, Appendix A):

- Phase 0: Policy Framework and Programme Establishment,
- Phase 1: Site Evaluation and Selection,
- Phase 2: Site Characterisation,
- Phase 3: Facility Construction,
- Phase 4: Facility Operation and Closure,
- Phase 5: Post Closure.

Phase 0, not covered in IAEA (2014), was introduced in EURAD in order to address the needs of the Member States currently establishing national RWM programmes. Phase 5 of a RWM programme has been introduced recently due to the discussions about post closure monitoring. The post closure phase has to be dealt with by all Member States as a full-fledged component of the national RWM programme. In the past, an institutional control in this phase was considered as necessary particularly for near-surface facilities. At the present time, methodologies and monitoring related to the post closure control have been developed for deep geological repositories as well.

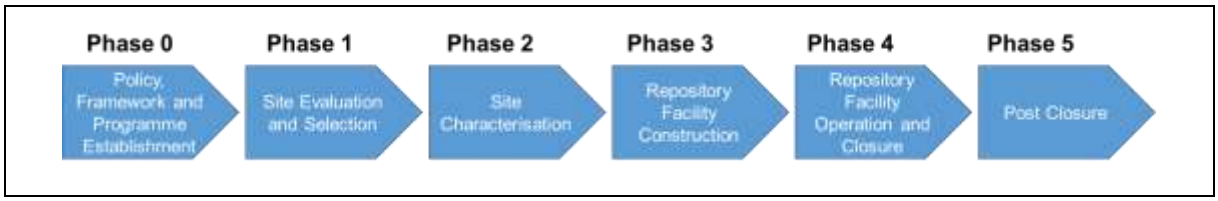

Figure 1 – Phases of a radioactive waste management programme (RWM) referring to the EURAD Roadmap

Decisions associated with each of these phases have to be made in the presence of both irreducible and reducible uncertainties. On the one hand, some of these uncertainties decrease as new information becomes available (e.g. “as-built” properties, monitoring data, RD&D results) and some of the uncertainties can increase in time (and phases). On the other hand, activities associated with the implementation of the RWM programme (e.g. process modelling, safety assessment) can lead to new perspectives and sometimes to new uncertainties. At the end of the implementation process, uncertainties will inevitably remain but it should be demonstrated that they do not undermine safety arguments. Hence, the management of uncertainties represents a key part of a successful programme planning and is central to the safety case of waste management facilities providing the arguments and evidence demonstrating their safety. Dealing with uncertainties associated with waste disposal facilities is particularly challenging due to the long timescales over which wastes will be generated and packaged, disposal facilities will be constructed and operated, and the very long timescales during which the radiotoxicity of the waste remains significant after the beginning of disposal.

With this background, a EURAD strategic study ´*Uncertainty Management multi-Actor Network* (UMAN)´ has been started with the aim of fostering a common understanding among various actors involved in the implementation of RWM programmes on the management of safety-relevant uncertainties (including management strategies, approaches and preferences). Subtask 4.1 ´*Identification and characterisation of the different actors across the entire RWM process*´ of UMAN Task 4 ´*Uncertainty management options and preferences of different actors across the various programme phases*´ aims to identify and characterise the different actors across all phases of a RWM programme in order to improve understanding of actors’ interests and preferences regarding the management of different types of uncertainties.

1.2 Methodology

To achieve a better overview of the actors involved in each phase of a RWM programme as well as their functions, impact and interest, an online questionnaire consisting of the five following parts was designed in the framework of the UMAN WP (i.e. 1st UMAN questionnaire), in which the generic phases of a RWM programme (Fig. 1) and the phase-related themes identified in the EURAD Roadmap were considered:

- Part 1: Background information,
- Part 2: **Identification, characteristics and roles of actors involved in radioactive waste management programmes** (template table integrated into the online questionnaire via a link),
- Part 3: Views on the types of uncertainties that need to be addressed in safety cases and their possible evolution throughout the programme phases,
- Part 4: Strategies for managing uncertainties,
- Part 5: Expectations of actors regarding stakeholder involvement.

Part 2 of the 1st UMAN questionnaire was dedicated to the identification and collection of comprehensive information about actors involved in each phase of a RMW programme. In order to facilitate answering the questionnaire and putting it into the EURAD context, the Part 2 template was based on phases and themes identified within the EURAD Roadmap, supplemented with further columns to give information on relevance, availability of information, functions and interests of the organisations and indication of further stakeholders. Taking into consideration different level of information and potential bias, self-assessment and identification of other actors were separated. The formulation of questions, structure and content of the table was done by expert judgement of the task partners and discussed and agreed with the UMAN WP board. Within the finalisation Part 2 was integrated into the common and harmonised 1st UMAN questionnaire.

Additionally to Part 2, Part 1 of the 1st UMAN questionnaire was analysed for additional information related to the current phase of national RWM programmes, considered types of radioactive waste and their disposal options.

Parts 1, 3, 4 and 5 of the 1st UMAN questionnaire were provided as a link to be opened via an internet browser and to be filled out online. Part 2 of the questionnaire was available as a separate file for downloading from the online platform. Microsoft Office software was used to develop all parts of the questionnaire.

All organisations participating in the strategic studies initiated in the first wave of EURAD1, i.e. ´*Waste management routes in Europe from cradle to grave* (ROUTES)' and ´*Uncertainty Management multi-Actor Network* (UMAN)´, were invited to respond to the 1st UMAN questionnaire and to provide information about the actors, their functions and impact / interest. These participating organisations are Waste Management Organisations (*WMOs*), Technical Support Organisations (*TSOs*), Research Entities (*REs*) and one Linked Third Party (*LTP*). The latter supports one of the above-mentioned beneficiaries in conducting the project work and categorised itself as a Technical Consulting Company (*TCC*). The responding organisations represent different European countries and radioactive waste management programmes in different implementation phases (Table 2). These countries include also Small Inventory Member States (SIMS), which can be defined as countries without nuclear energy, whose small inventory typically contains medical waste, disused and sealed radioactive sources and possibly a small amount of spent nuclear fuel from research reactors (IAEA, 2017). 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 a long-term storage. Very often, SIMS own insufficient resources (human, financial, etc.) and also infrastructure available. They do not have either sufficient expertise to plan, design, construct, operate and close disposal facilities. Most of them are in the early stage of their RWM programmes, without knowing efficient disposal options, including Waste Acceptance Criteria (WAC). Based on above discussed, as European SIMS

can be identified Malta, Austria, Denmark, Estonia, Poland, Latvia, Greece, Ireland, Portugal, Cyprus and Luxembourg. A special case presents Croatia that is a co-owner of the Krško nuclear power plant (NPP) located in Slovenia. The Krško NPP was built as a joint venture by Slovenia and Croatia, commissioned in 1983. Both two countries were a part of former Yugoslavia that time. Moreover, since 2025 Croatia has a contractual obligation to take responsibility for one half of all radioactive waste generated in the Krško NPP. For SNF, discussions are ongoing to prolong onsite storage for the extended lifetime, but later Croatia and Slovenia will share the responsibility. Croatia is currently addressing similar issues and challenges within its RWM programme as the other SIMS mentioned above, and therefore can be considered as SIMS, even though it does not fully comply with the SIMS definition.

The information provided by the responding organisations refers to all types of radioactive waste to be disposed of in near-surface facilities or in geological formations.

The analysis of the responds to the 1st UMAN questionnaire was performed using Microsoft Office software (Microsoft Excel and Microsoft Word), including compilation of tables and diagrams/figures. Due to special discrepancy (related mainly to the responsibilities/roles/interests of the actors involved in RWM programme) identified when comparing the responds with current superordinate regulations and history of radioactive waste disposal, it was decided in this case to present both, the pure data obtained via the questionnaire and an interpretation of the data to explain the discrepancy. The presentation of the data from the questionnaire has a qualitative character. The heterogeneity of the answers provided by the respondents (i.e. both generic answers – not phase-specific and phase-specific answers) did not allow to determine a complete picture of the actors for every programme phase. The data interpretive part is descriptive and thus qualitative in order to avoid data overinterpretation.

1.3 Objectives

The objective of this report is to identify and describe the actors, their roles, impact and interest in the different phases of a RMW programme, seen from the perspective of *WMOs*, *TSOs*, *REs* and one *LTP* (which was categorised as *TCC)*. The characterisation of the actors is based on the replies of *WMOs*, *TSOs*, *REs* and one *LTP* (which was categorised as *TCC)* to Part 1 and Part 2 of the 1st UMAN questionnaire.

The outcome of this work will serve as input to UMAN Subtasks 4.2 ´*Compilation and review of available information on possible uncertainty management options*´ and 4.3 ´*Preferences of the different actors on uncertainty management options*´ as well as Task 5 ´*Interactions between all categories of actors, including civil society*´.

1.4 Structure of the report

Chapter 1 describes the motivation behind this study as well as its methodology and objectives. The actors involved in a RWM programme and their roles, defined in the international standards, are discussed in Chapter 2. The structure of Part 2 of the 1st UMAN questionnaire is introduced in Chapter 3. The data gathered from the surveyed *WMOs*, *TSOs*, *REs* and one *TCC* are analysed and discussed in Chapters 4 and 5, respectively. Recommendations for future research activities in the framework of the EURAD programme are provided in Chapter 6. The key results of the performed analysis are presented in a tabular form in Chapter 7. Conclusions from the performed analysis are given in Chapter 8.

2. Actors of RWM programmes and their roles in the context of international standards and available literature

The allocation of the different responsibilities/roles/interests to the actors involved in the different phases of national programmes for spent fuel and radioactive waste management (RWM) are ensured through the establishment of the national framework, comprising legislative, regulatory and organisational issues. International standards such as the Council Directive 2011/70/EURATOM and IAEA safety requirements (2011c) unify and regulate the process of the implementation of the national frameworks in different countries in order to ensure safe and responsible management of spent fuel and radioactive waste. This includes i.a. the identification of the key actors involved in RWM and the definition of their responsibilities.

In the context of RWM, an actor (termed also a ´stakeholder´) can be understood as any actor such as an institution, a group or an individual, with an interest or a role to play in a RWM programme (Forum on Stakeholder Confidence FSC of the Nuclear Energy Agency NEA: https://www.oecd-nea.org/rwm/fsc/oxford.html). However, IAEA (2011a) underlines that ´owing to the differing views on who has a genuine interest in a particular nuclear related activity, no authoritative definition of stakeholder has yet been offered, and no definition is likely to be accepted by all parties. However, stakeholders have typically included the following: the regulated industry or professionals; scientific bodies; governmental agencies (local, regional and national) whose responsibilities arguably cover, or 'overlap' nuclear energy; the media; the public (individuals, community groups and interest groups); and other States (especially neighbouring States that have entered into agreements providing for an exchange of information concerning possible trans-boundary impacts, or States involved in the export or import of certain technologies or material)´. A distinction between ´statutory´ and ´not-statutory´ stakeholders is suggested by IAEA (2011a) to be applied to the process of stakeholder identification. The first group represents the stakeholders required by law to participate in RWM such as regulatory authority. The second group includes the stakeholders that are directly or indirectly impacted by RWM, ´who feel in whatever way impacted or affected by an activity (thus some stakeholders in this category may be self-selected)´, such as local communities and non-governmental organisations (NGOs).

Aarhus Convention (1998), covering also environmental issues related to RWM, recognises and describes the rights and indirectly the interests/roles of the public representing the ´not-statutory´ stakeholders in IAEA (2011a). The stakeholder ´public´ is defined in Aarhus Convention (1998) as ´one or more natural or legal persons, and, in accordance with national legislation or practice, their associations, organizations or groups´, which is/are ´affected or likely to be affected by, or having an interest in, the environmental decision-making´. Thus, non-governmental organisations ´promoting environmental protection and meeting any requirements under national law´ fall into this stakeholder group, too. Public rights established by the Aarhus Convention (1998) include access to environmental information, participation in decision-making and access to justice in environmental matters as well as assistance required for exercising their rights. Through these rights, the public is given an opportunity to express public concerns with respect to the environmental issues related to RWM, which should be considered by public authorities. Thereby the public role can be understood as a voluntary accompaniment of the implementation of a RWM programme as well as active, voluntary participation in the related decision-making. However, it seems that the scope of the public involvement into a RWM programme has evolved and is understood now rather as public participation procedure that goes beyond the voluntary accompaniment. This in turn imposes certain responsibilities on the public such as active contribution to shaping of a site selection process (e.g. StandAG, 2017 and the corresponding arrangement of public participation by German regulator), particularly in the sense of a consent-based siting process (U.S. Department of Energy, 2016).

The actors recommended by IAEA (2011a) to be taken into consideration in the stakeholder analysis in respect to nuclear facilities include:

- local and national government leaders,
- news media,

- academic/ researchers,
- medical and health professionals,
- special and public interest groups, consumer groups and other non-governmental organisations,
- citizens,
- employees and suppliers,
- informal opinion makers such as local authorities, reputable persons, barbers, sportsmen, firemen, etc.

According to the Council Directive 2011/70/EURATOM, the following actors with their responsibilities are to be introduced by the Member States of the European Union when establishing their national framework:

- **a competent regulatory authority** (Articles 6 and 10) – an authority responsible for the regulation of spent fuel and radioactive waste management particularly in terms of the safety, which is ´functionally separate from any other body or organisation concerned with the promotion or utilisation of nuclear energy or radioactive material (…) or with the management of spent fuel and radioactive waste´. This includes regulatory control of the licence holders as well as providing information from the field of its competence to the public.´
- **licence holders** (Article 7) - actors under the regulatory control of the competent regulatory authority, responsible for the safety of spent fuel and radioactive waste management facilities and/ or activities. This includes regular, systematic and verifiable assessment, verification and continuous improvement of the safety of the spent fuel and radioactive waste management facility or activity.

The basic role of the government in the development of deep geological repositories is discussed in OECD (2020), based on the conclusions from the International Roundtable on the Final Disposal of High-Level Radioactive Waste and Spent Fuel, held on 14. October 2019 and 7. February 2020, in which representatives from 15 countries, the Nuclear Energy Agency (NEA) and the International Atomic Energy Agency (IAEA) took part. The identified governmental roles include:

- definition of national RWM policies which establish the necessary waste management institutions,
- promulgation of legislation to establish regulatory authority,
- ensurance of a clear allocation of the responsibilities of the actors involved in the RWM, particularly those of the government, regulatory authority and implementers,
- confirmation that the ´strategy for ensuring and demonstrating safety, providing the necessary financial provisions and allowing for programme development´ is defined in the national policies,
- confirmation that the arrangements required for the development of the necessary competencies in the organisations responsible for DGD are introduced,
- promotion of transparency of radioactive waste management in all stages,
- support of research, development and demonstration (RD&D) activities/ programmes aiming at the improvement of disposal safety,
- support in facilitating international cooperation through provision of necessary funding and human resources,
- promotion of the communication and interaction with stakeholders, in particular with the public and local communities,
- ensurance that a framework for active participation of the regulatory authority in the dialogue with the public and the local communities is established.

Public and local (host) communities, and in particular the young generation, are recognized in OECD (2020) to be relevant stakeholders in the decision-making process.

The safety requirements related to the planning for the radioactive waste disposal, elaborated by IAEA (2011c), describe the roles played by the responsible bodies in the governmental, legal and regulatory framework of RWM. These are:

- **responsibilities of government** (Requirement 1): establishment and maintenance of governmental, legal and regulatory framework for safety with a clear allocation of the legal, technical and financial responsibilities for organisations for radioactive waste disposal facilities during their entire life-cycle (siting, design, construction, operation and closure), in particular ´confirmation at national level of the need for disposal facilities of different types; specification of the steps in development and licensing of facilities of different types; (…) securing of financial and other resources, and provision of independent regulatory functions relating to a planned disposal facility´.
- **responsibilities of regulatory body** (Requirement 2): establishment of regulatory framework for development of radioactive waste disposal facilities of different types, establishment of procedures required to meet the requirements for the licensing of these facilities, establishment of ´conditions for the development, operation and closure of each individual disposal facility´, performance of necessary activities to ´ensure that the conditions are met´.
- **responsibilities of operator of a radioactive waste disposal facility** (Requirement 3): responsibility for the overall safety of the radioactive waste disposal facility, including safety assessment, development and maintenance of a safety case, performance of activities required for site selection, evaluation, design, construction, operation, closure and post-closure under consideration of the regulatory requirements and the national strategy. This also includes the conduction of RD&D activities and cooperation with the regulatory body.

Operator is defined in the IAEA safety standards as ´any organisation or person applying for authorisation or authorised and/ or responsible for nuclear, radiation, radioactive waste or transport safety when undertaking activities or in relation to any nuclear facilities or sources of ionizing radiation. This includes private individuals, governmental bodies, consignors or carriers, licensees, hospitals, self-employed persons´.

An analysis of key actors involved in national RWM programmes of 15 Member States of EU is presented in Martell and Ferraro (2014), based on a review of the documents, reports and webpages available in years 2013 and 2014. The identified actors are categorised as follows:

- **policy/ legislation actors**: ´organisations responsible for policy-making, legislation and other decisions that require involvement of government officials at national level´,
- **implementing organisations**: governmental, private or other organisations responsible for implementation of tasks related to RWM,
- **advisory and consultative bodies**: organisations responsible for advising the policy/ legislation actors, the implementing organisations or the advisory and consultative bodies-makers,
- **regulator and technical support organisations**: governmental agencies responsible for the regulation of RWM,
- **scientific research**: institutions or organisations (i.e. main national research centres) that provide scientific/ technical expertise services on nuclear and RWM topics to the other actors; these actors do not include universities,
- **non-governmental organisations (NGOs):** interest groups or civil society organisations, including professional societies and academies. NGOs in this context represent ´national umbrella organisations or confederations concerned with the protection of the environment and the impacts of nuclear energy and which are particularly involved in radioactive waste issues. Similarly, the professional societies considered are those which have a stake on nuclear energy issues.´
- **nuclear industry**: companies in the nuclear supply chain, involved in RWM,
- **local community**: local authorities at any level of lower than the federal or central government as well as local partnerships or local committees established for the interaction between the local politicians and officers and the local community.

3. Source of input data

The answers of the responding organisations (i.e. *WMOs*, *TSOs*, *REs* and one *TCC*) to Part 2 of the 1st UMAN questionnaire serve as a main source of input data and information for the analyses described in this report. Additionally, Part 1 of the 1st UMAN questionnaire, containing solely the replies from *WMOs*, *TSOs* and one *TCC* (i.e. no replies from *REs*), was analysed to define the current phases of national RWM programmes, the radioactive waste types and their considered disposal options. This was due to the fact that questions in Part 1 of the 1st UMAN questionnaire to be answered by *REs* were different from those to be answered by *WMOs*, T*SOs* and *TCC* and not focused on the current stage of national RWM programmes. The filled in questionnaires are available in the UMAN WP workspace on Projectplace: *https://service.projectplace.com/pp/pp.cgi/r19310518*. Part 1 and Part 2 of the 1st UMAN questionnaire are provided in Appendix B.

In Part 2 of the 1st UMAN questionnaire the responding organisations were asked to fill out a table, which consists of the 6 phases of a RWM programme (from phase 0 to phase 5), each of them containing 7 themes specified in EURAD Roadmap (Fig. 1, Tab. 1). Note that no specific themes were provided for phase 5.

Phases	Themes
Phase 0 = Policy, Framework and Programme Establishment	**Theme 1** = Managing implementation and oversight of a waste management programme
Phase 1 = Site Evaluation and Selection	**Theme 2** = Radioactive waste characterisation, treatment, packaging and storage and source term understanding for disposal
Phase 2 = Site Characterisation	**Theme 3** = Engineered barrier system properties, function and long-term performance
Phase 3 = Repository Facility Construction	**Theme 4** = Geoscience to understand rock properties, radionuclide transport and long-term geological evolution
Phase 4 = Repository Facility Operation and Closure	**Theme 5** = Geological disposal facility and the practicalities of construction, operation and closure
Phase 5 = Post Closure	**Theme 6** = Siting and licensing
	Theme 7 = Performance assessment, safety case development and safety analyses

Table 1 – Overview of the phases of a RWM programme and the specific themes according to EURAD Roadmap. Note that each phase, except for phase 5, contained the specific themes.

The structure of Part 2 of the 1st UMAN questionnaire is depicted in Figure 2. The different phases and the themes were provided in columns 1 and 2 of the table, respectively. In columns 3 to 5 the following specific information on the responding organisations was collected: phases and themes relevant for the responding organisation, the availability of relevant information as well as functions and roles played by the responding organisations, respectively. These functions were pre-defined in column 5 by the 1st UMAN questionnaire designers as follows:

- Initiation / Planning (function a),
- Execution / Implementation (function b),

- Funding (function c),
- Research (function d),
- Safety Assessment (function e),
- Civil Society (CS) Participation (function f),
- Regulatory Oversight (function g),
- Any other Involvement (function h).

In column 6, the responding organisations were asked to identify *other actors* (i.e. other stakeholders having an interest in or a potential impact on uncertainties and their management) in order to provide an overview of the diversity of the stakeholders involved in the implementation of a RWM programme. Bearing in mind the types of the mandated organisations (i.e. actors) involved in EURAD (i.e. *WMOs*, *TSOs*, *REs* and also the contracted Linked Third Parties *LTPs*), it is self-evident that the term ´other actors´ covers actors of categories different than *WMO*, *TSO*, *RE* (and *LTP*). Furthermore, in column 7 interests and potential impacts on safety and uncertainties of the actors identified in column 6 were to be specified. Apart from the three categories of actors *WMO*, *TSO* and *RE (and LTP)*, representing the responding EURAD beneficiaries, no other actor categories were pre-defined by the 1st UMAN questionnaire designers.

In case an assignment to phases 0 - 5 was not possible, a generic, phase-independent information could be provided in the first row "*Generic answers – not phase-specific*" of the table (Fig. 2).

COLUMN 1 Phase	COLUMN 2 Theme	COLUMN 3 Phase/theme relevant for your organisation? (Y/N/?)	COLUMN 4 Information available? (Y/N)	COLUMN 5 Functions/roles of your organisation: a) Initiation/Planning b) Execution/Implementation c) Funding d) Research e) Safety assessment f) CS participation g) Regulatory oversight h) Any other involvement	COLUMN 6 Other actors (optional, if identified): Name and roles	COLUMN 7 Interests and potential impact on safety and uncertainties of actors identified in columns 5 and 6
Generic answers (not phase-specific)						
Phase 0 Policy, Framework & Programme Establishment	Theme 1 …. Theme 7					
Phase 1 Site Evaluation & Selection	Theme 1 …. Theme 7					
Phase 2 Site Characterization	Theme 1 …. Theme 7					
Phase 3 Repository Facility Construction	Theme 1 …. Theme 7					
Phase 4 Repository Facility Operation & Closure	Theme 1 …. Theme 7					
Phase 5 Post-closure Phase						

Figure 2 – Structure of part 2 of 1st UMAN questionnaire (reduced representation). The specific themes are provided in Table 1.

4. Analysis of the input data from the 1st UMAN questionnaire

4.1 Contributions to the questionnaire

In total, representatives of 11 *WMOs*, 8 *TSOs*, 11 *REs* and one *LTP* (which was categorised as Technical Consulting Company *TCC)* from 19 countries responded to the 1st UMAN questionnaire as presented in Table 2. The responses specifically to Part 2 of the 1st UMAN questionnaire were provided by 10 *WMOs*, 7 *TSOs*, 6 *REs* and one *LTP* (which was categorised as *TCC)* from 17 countries at different phases of their national RWM programme, including SIMS. Please note that the actor group *TCC* is used in this report when referencing to the one *LTP* that replied to the 1st UMAN questionnaire.

Out of 10 *WMOs* that provided replies to Part 2 of the 1st UMAN questionnaire, 8 *WMOs* identified the *other actors* as follows: 1 *WMO* provided *other actors* without assigning them to the phases of a RWM programme (i.e. as a generic answer), while 7 *WMOs* identified the phases of a RWM programme, in which the *other actors* play a role. Further, 10 *WMOs* provided phase-specific information on their own functions as actors of category *WMO*, while 2 *WMOs* provided phase-specific functions of the *other actors*. In both cases, there were no generic answers. Phase-specific information on the impact and interest of the identified *other actors* was provided by 8 *WMOs*.

Out of 7 *TSOs* that replied to Part 2 of the 1st UMAN questionnaire, 5 *TSOs* identified the phases of a RWM programme, in which *other actors* play a role. 7 *TSOs* defined their own phase-specific functions as actors of category *TSO*. In both cases, there were no generic answers. No *TSO* specified functions of the *other actors*. 6 *TSOs* provided information on the impact and interest of the *other actors*.

Out of 6 *REs* that responded to Part 2 of the 1st UMAN questionnaire, 5 *REs* identified the *other actors* in the following manner: 2 *REs* provided the *other actors* without assigning them to the phases of a RWM programme, while 3 *REs* identified the phases of a RWM programme, in which these *other actors* play a role. Regarding self-assessment in terms of the functions, 4 *REs* provided phase-specific information and 2 *REs* generic answers. 1 *RE* assessed phase-specific functions of the *other actors* and 2 *REs* provided generic replies. 2 *REs* provided phase-specific information on the impact and interest of the *other actors*, while 1 *RE* provided generic answers.

The *other actors* identified by the Technical Consulting Company (*TCC*) were provided as generic answers. The *TCC* defined its function for every phase of a RWM programme, while phase-nonspecific functions were provided for the *other actors*. No information about the impact and interest of the *other actors* was given by the TCC. Despite the fact that only one *TCC*, contracted in EURAD as a Linked Third Party, participated in the 1st UMAN questionnaire, it was decided to consider first these answers separately in the analysis (i.e. not to merge the answers of *TCC* with the answers of the other respondents such as *WMOs* or *TSOs*).

The phases of the national RMW programmes of the countries that the responding organisations represent, as well as the considered radioactive waste types and their disposal options are given in Table 3, based on the replies from 9 *WMOs*, 9 *TSOs* and one *TCC* to Part 1 of the 1st UMAN questionnaire. It should be noted that this information might not be complete. Classification of radioactive waste, given in Table 3, is based generally on IAEA (2009) and includes the following types of radioactive waste: very short lived waste (VSLW), very low level waste (VLLW), low level waste (LLW), intermediate level waste (ILW) and high level waste (HLW). A detailed description of the different waste types is provided in Appendix C. In a few cases, country-specific classifications of radioactive waste were used by the responding organisations, which includes the following categories of radioactive waste: very low level waste (VLLW), low- and intermediate level short-lived waste (LILW-SL), intermediate level long-lived waste (ILW-LL), high-level waste (HLW) and low-level long-lived waste (LLW-LL).

The types of radioactive waste managed by the countries that the responding organisations represent encompass predominantly low level waste (LLW), intermediate level waste (ILW), high level waste (HLW) and spent nuclear fuel (SNF). A few respondents addressed directly very low level waste (VLLW) in the 1st UMAN questionnaire, too. Depending on the type of radioactive waste, the disposal solutions

considered by these countries are generally geological disposal (GD) for HLW&SNF, ILW and sometimes LLW as well as near-surface disposal (NSD) for LLW.

Table 3 clearly indicates the diversity of the current stages of the national RWM programmes, varying in general from phase 0 to phase 4 for LLW and ILW and from phase 0 to phase 3 for HLW and SNF. A few countries indicated phase 5 for their RWM programmes, too. Based on the information shown in Table 3 it can be stated that the actors and their roles identified by the responding organisations correspond to all types of radioactive wastes with GD and NSD as disposal options.

Country	Small Inventory Member State (SIMS)	Name of responding organisation	Type of responding organisation (WMO, TSO, RE, TCC/LTP)
Belgium	No	ONDRAF-NIRAS	WMO
		Bel V	TSO
		SCK-CEN	RE
Czech Republic	No	SÚRAO	WMO
		SURO	TSO
Denmark	Yes	DEKOM	WMO
Finland	No	VTT	TSO
		EnviroCase	TCC (LTP to WMO)
France	No	Andra	WMO
		IRSN	TSO
		CNRS	RE
Germany	No	BGE	WMO
		GRS	RE
		HZDR	RE
		Technical University Clausthal	RE
Hungary	No	TS ENERCON	TSO
Lithuania	No	LEI	RE
Netherlands	No	COVRA	WMO
		NRG	TSO
Poland	Yes	ICHTJ	RE
Portugal	Yes	IST-ID	RE
Romania	No	RATEN ICN	RE
Slovakia	No	Slovak University of Technology	RE
Slovenia	No	ARAO	WMO
		EIMV	TSO
Spain	No	ENRESA	WMO
Sweden	No	SKB	WMO
Switzerland	No	NAGRA	WMO
		Paul Scherrer Institute	RE
United Kingdom	No	RWM (NDA)	WMO
Ukraine	No	SSTC NRS	TSO

Table 2 – Overview of the organisations that responded to the 1st UMAN questionnaire

Country	SIMS	Responding organisation	Disposal options considered in the 1st UMAN questionnaire	Current phases of the RWM programmes					
				Phase 0	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Belgium	No	ONDRAF-NIRAS (WMO)	NSD for LILW-SL; GD for HLW&SNF	HLW&SNF		LILW-SL			
	No	BeL V (TSO)	NSD for LLW; GD for HLW&SNF	ILW, HLW&SF		LLW			
Czech Republic	No	SÚRAO (WMO) SURO (TSO)	NSD for LLW and ILW; DGD of HLW&SF		HLW&SNF			LLW, ILW 3 facilities	LLW, ILW 1 facility
Denmark	Yes	DEKOM (WMO)	GD for LLW, ILW and irradiated RF	LLW, ILW, irradiated RF					
Finland	No	VTT (TSO)	NSD for VLLW, LLW and ILW; DGD for HLW	VLLW			HLW	LLW, ILW 2 facilities	
		EnviroCase (LTP categorised as TCC)	IGD – DGD for LLW and ILW; DGD for SNF	NORM, SNF		LLW, ILW	SNF	LLW, ILW	NORM
France	No	Andra (WMO) IRSN (TSO)	NSD for VLLW; NSD for LILW-SL; NSD for LLW-LL; GD for HLW and L/LW-LL	LLW-LL	LLW-LL	VLLW, L/ILW-LL, HLW		VLLW, LILW-SL	
Germany	No	BGE (WMO)	DGD for HLW; DGD for LLW and ILW; open repository for LLW and ILW	HLW	HLW		LLW, ILW 1 facility	LLW, ILW 2 facilities	
Hungary	No	TS ENERCON (TSO)	NSD for LILW-SL; GD for LILW-SL; GD for LLW-LL, HLW&SNF	LILW-SL	LLW-LL, HLW&SNF		LILW-SL	LILW-SL	
Lithuania *	No	LEI (RE)	NSD for VLLW and LILW-SL; DGD for LLW-LL, ILW-LL and SNF	LLW-LL, ILW-LL and SNF			VLLW and LILW-SL, 2 facilities		
Netherlands	No	COVRA (WMO) NRG (TSO)	DGD for LLW, ILW, HLW&SF	LLW, ILW, HLW&SF, depleted uranium					
Slovenia	No	ARAO (WMO) EIMV (TSO)	NSD for LILW-SL; GD for SNF (optionally regional/multinational repository for HLW&SNF)	SNF		LILW-SL			Uranium mine waste disposal
Spain	No	ENRESA (WMO)	NSD for LLW and ILW					LLW, ILW	
Sweden	No	SKB (WMO)	NSD for LILW-SL; GD for LILW-LL; GD for SNF		LILW-LL	SNF		LILW-SL	
Switzerland	No	NAGRA (WMO)	DGD for LLW and ILW; DGD for HLW&SNF		LLW, ILW, HLW&SNF				

Country	SIMS	Responding organisation	Disposal options considered in the 1st UMAN questionnaire	Current phases of the RWM programmes					
				Phase 0	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
United Kingdom	No	RWM (NDA) (WMO)	GD for ILW, some LLW, HLW&SNF		ILW, some LLW, HLW&SNF				
Ukraine	No	SSTC NRS (TSO)	NSD for VLLW and LLW; GD for ILW-LL and HLW		ILW-LL and HLW			VLLW and LLW	

*Table 3 – Overview of the phases of the national RWM programmes with considered disposal option(s) and radioactive waste types, according to replies from WMOs, TSOs and one TCC to Part 1 of 1st UMAN questionnaire. VLLW = very low-level waste, LILW-SL = low- and intermediate-level short-lived waste, LLW = low-level waste, ILW = intermediate-level waste, ILW-LL = intermediate-level long-lived waste, HLW = high-level waste, SNF = spent nuclear fuel, NORM = naturally occurring radioactive materials, DGD = deep geological disposal, GD = geological disposal, IGD = intermediate geological disposal, NSD = near-surface disposal, SIMS = small inventory member state, * subsequently provided data by Lithuanian RE, not considered in the analysis of the responds to the 1st UMAN questionnaire*

4.2 Identified actors

4.2.1 Actors classification and definition

The actors identified by the responding organisations (i.e. *WMOs*, *TSOs*, *REs* and one *LTP* classified as *TCC*) are categorised according to their functions and responsibilities in the RWM programmes. Despite the fact that several replying organisations identified very specific actors due to specificities of the national framework, political and administrative systems of the country they represent, an effort was made to provide a generic, non-country specific classification of the actors in the context of the Council Directive 2011/70/EURATOM. Identified actors, whose roles in the RWM programmes are very country-specific and/or have a low number of indications, are grouped into the category ´*Miscellaneous Actor*´.

Descriptions of *WMO*, *TSO* and *RE* are the original definitions provided by EURAD. Definitions of the other identified actors are based on the replies of the responding organisations to Part 2 of the 1st UMAN questionnaire (Columns 6 and 7 in Fig. 2) as well as on the available literature (IAEA, 2011a; Martell and Ferraro, 2014; OECD, 2020) and knowledge / experience of the authors of this report.

Based on the analysis of the replies to Part 2 of the 1st UMAN questionnaire (Columns 5, 6 and 7 in Fig. 2) it was recognised that some of the identified actors might play additional, sometimes even contradictory roles to those foreseen by the international standards (see also Chapter 5). This is a result of operation of facilities licensed under other political and administrative systems as explained in the following. The sea dumping of high level radioactive waste was prohibited in 1975 (London Convention) and of all kind of radioactive waste in 1994. In the meantime, many countries established their individual solutions to dispose of their radioactive waste according to their political and administrative systems. Whereas for high level waste no disposal facility exists presently, several facilities for low and intermediate radioactive waste are in the operational or closure phase. They were commissioned some decades ago in agreement with regulatory conditions at that time, which deviate significantly from the ones currently in force (e.g. repository Morsleben and Konrad in Germany, near-surface disposal in Czech Republic, repository Baita Bihor in Romania). Nevertheless, these facilities are operated further on the basis of the issued licenses. As a consequence, there might be an overlap of responsibilities of some actors when considering the fact that implementation of the EU directives is a long-time process.

The actors, identified on a basis of the replies to Part 2 of the 1st UMAN questionnaire (Columns 5, 6 and 7 in Fig. 2*Figure 2*), are classified into the following categories:

- **Waste Management Organisation (WMO)** – ´has the ultimate responsibility for the implementation of RW disposal (which includes the management and partial funding of a supporting RD&D programme), and for some other topics of RWM (e.g. waste characterisation, treatment and packaging, interim storage, etc.).´

- **Technical Support Organisation (TSO)** – ´carries out activities aimed at providing the technical and scientific basis for supporting the work and decisions made by a national regulatory body. As safety cases for waste processing, storage and disposal develop, so too do the safety case reviews and independent scrutiny responsibility by regulatory organisations in the framework of the decision-making process. This requires specific skills (such as safety case review methodology) from the regulatory expertise function undertaken by safety authorities, regulators, and their *TSOs*.´

- **Research Entity (RE)** – ´works to different degrees on the challenges of RWM including disposal (and sometime in direct support to implementers or *WMOs* or *TSOs*), under the responsibility of Member States. This includes national research centres, some research organisations and some universities that could also be funded by other sources. Research Entity provides scientific excellence and leading-edge research on basic components and generic processes in relation to the management of radioactive waste.´

- **Waste Generator (WG)** – is an entity, whose activities generate different types of radioactive waste. This includes waste from nuclear power plants, medicine, nuclear research organisations,

industry and military. At the early stages of a RWM programme, Waste Generator is often the Waste Owner, based on national legislative requirements. In this context packaging, conditioning and storage are among its responsibilities.

• **Waste Owner (WO)** – owning or responsible for the radioactive waste management based on national legislative requirements. This includes the responsibility for a proper handling and disposal with its financial obligations. Ownership might change along a waste management programme.

• **Regulator (Reg)** – (or regulatory authority, regulatory body) is an authority with the legal responsibility for regulatory control of nuclear safety and radiation protection as well as supervision of the implementer of a RWM programme, including inspection and appeals. Depending on the national framework, Regulator is also responsible for participation of the civil society in the RWM programme, for the safety case review and for making regulations for the implementation of the programme (NEA/RWM/RF, 2004).

• **Government / Legislature (Gov / Leg)** – is responsible for framing of the national RWM policy, decision making and funding.

• **Ministry (Min)** – represents RWM programme owner and any other ministry „whose portfolios cover one or more aspects affected or influenced by management of radioactive waste (NEA/RWM/RF, 2004)“. Ministry can provide also funding for RD&D activities.

• **Municipality (Mun)** – represents the most local level of administration below national and prefectural / regional bodies. Municipality is a stakeholder strongly involved in the facility construction permission, the subsequent facility planning and facility licensing as it hosts a RWM facility / repository. Municipality can also represent all municipalities affected to some degree by / considered in a site selection procedure.

• **State Authority (SA)** – is a supervising and licensing authority and a stakeholder in the decision making process in a RWM programme. Further, it can be responsible for the transport of radioactive wastes, facility safety and execution of the mining law.

• **Civil Society (CS)** – represents both individuals and organised civil society groups with or without in-depth knowledge on radioactive waste management/disposal that manifest the interest and concerns of citizens with respect to RWM programme implementation. Civil Society enforces a public-oriented implementation of the disposal programme and participates to some extent in the site selection procedure. In this context, media is an important player as they inform the Civil Society.

• **Environmental Actor (EA)** – represents individuals and non-governmental environmental organisations addressing environmental aspects related to the implementation of a RWM programme.

• **NGO (NGO)** – is a non-governmental and strongly internationally linked interest group representing common views on certain aspects related to the radioactive waste management (e.g. environmental issues, health issues, social-economical aspects, safety case review, etc.).

• **Geological Survey (GS)** – is a national / federal scientific agency performing research in the field of geology, hydrology, geography, etc. as well as field investigations. Geological Survey may offer consultancy service to *WMOs* and *Regulators*, too.

• **Technical Survey (TS)** – is a technical expert organisation, which plays an important role in the whole permission procedure (e.g. technical approval of the repository components and the facilities).

• **Operating Company (OC)** – is actively involved in construction, operation, sealing and/or post-closure maintenance of a radioactive waste disposal facility. This may be a third party that

operates actively a radioactive waste facility on behalf of a *WMO* or a contractor of the *WMO*, e.g. mining companies, construction companies, etc.

• **Technical Consulting Company (TCC)** – is an engineering, technical and scientific company providing consultancy (including planning and design of a repository facility) services to different actors, also to *Regs*. In the latter case, there is an overlap of functions fulfilled by *TSOs* and *TCCs*, despite different responsibilities. The functions of *TCC* can also include research activities. A *TCC* is not responsible for the safety of a disposal facility.

• **Miscellaneous Actor (MA)** – usually a country-specific actor whose function cannot be clearly defined, based on the responses to the 1st UMAN questionnaire. This actor may have a large influence on a RMW programme.

4.2.2 Actors identified by all responding organisations

The following analysis discusses the number of indications (from highest to lowest) of the different actors involved in all phases of RWM programmes. The number of indications relies on the views and information given by the responding organisations (*WMOs*, *TSOs*, *REs* and one *TCC*) to Part 2 of the 1st UMAN questionnaire (Column 6 in Fig. 2). The abbreviations of the identified actors' categories are used in the analysis in plural form according to Section 4.2.1 (e.g. *Regulators* = *Regs*, *Waste Generators* = *WGs*).

An overview of all identified actors and their number of indications is given in Figure 3 and Table 4, including both phase-specific and generic answers of *WMOs*, *TSOs*, *REs* and one *TCC*. The number of indications for each actor category, depicted on the vertical axis of the diagram, represents the sum of all indications made by each *WMO*, *TSO*, *RE* and one *TCC* for the considered actor categories across all themes in all phases (Tab. 4). If more than one actor of the same category was identified by one responding organisation, it was counted as one indication. For example, two different ministries, such as Ministry of Health and Ministry of Environment, were identified in phase 1 and theme 1, they are considered as one indication and categorised as ´Ministry´. In case two categories were assigned to one identified actor, they are counted correspondingly as two indications. In general, a majority of actors were indicated with a phase reference (phase-specific answers), whereas the option ´*Generic answers*´ (not phase-specific) was used sparsely (Fig. 3, Tab. 4).

The phase-specific answers of the responding *WMOs*, *TSOs*, *REs* and one *TCC* and the number of indications for each actor category are shown in Fig. 4 and Tab. 4. With a total of 136 indications, including 132 phase-specific and 4 generic indications, the *Regs* show the highest number of indications among all identified actors across all phases. The *Regs* are predominantly indicated in phase 0 (39 indications) and phase 1 (37 indications) (Fig. 4, Tab. 4). Their number of indications decreases to a total of 12 indications in phase 2, 22 indications in phase 3, 17 indications in phase 4 and 2 indications in phase 5 (Fig. 4, Tab. 4). The *WMOs* reveal the second highest number of indications among all actors and across all phases with a total number of 91 indications (87 phase-specific and 4 generic indications). The *WMOs* are indicated in all 5 phases (phase 0 = 24 indications, phase 1 = 26 indications, phase 2 = 19 indications, phase 3 = 9 indications, phase 4 = 8 indications, phase 5 = 1 indication) (Fig. 4, Tab. 4). With 63 total indications (59 phase-specific and 4 generic indications) the *Min* are indicated in all 5 phases. However, the indications show a clear dominance in phase 0 (13 indications), phase 3 (12 indications) and phase 4 (19 indications) (Fig. 4, Tab. 4). The *REs* show 52 phase-specific and 3 generic indications. Their indications predominantly focus on phase 0 (24 indications) and phase 1 (17 indications), they are not indicated in phase 5 (Fig. 4, Tab. 4). Similarly, the *TCCs* reveal a total of 43 indications (42 phase-specific and 1 generic indication) and are mainly indicated in phase 0 (15 indications) and phase 1 (16 indications) (Fig. 4, Tab. 4). *TCCs* are not indicated in phase 5. The number of indications considering the *GSs* amounts to 29 (28 phase-specific and 1 generic indication). The number of indications is slightly higher in phase 0 (7 indications) and phase 1 (9 indications) and reveals a constant number of indications in phase 2 (4 indications), phase 3 (4 indications) and phase 4 (4 indications). They were not indicated in phase 5 (Fig. 4, Tab. 4). The *WGs* (total indications = 30,

26 phase-specific and 4 generic indications) also show a slight preference in phase 0 (9 indications), phase 1 (4 indications) and phase 4 (9 indications) and a decline of indications in phase 2 (2 indications) and phase 3 (2 indications). They are not indicated in phase 5 (Fig. 4, Tab. 4). The *TSOs* show a total of 26 indications across the phases 1 to 4 (25 phase specific and 1 generic indication). They are exclusively indicated in phase 0 (6 indications), phase 1 (5 indications) and phase 4 (14 indications) (Fig. 4, Tab. 4). The *Muns* show a total number of 18 phase-specific indications, that are almost equally distributed across the phases 0 to 4 (phase 0 = 3 indications, phase 1 = 4 indications, phase 2 = 1 indication, phase 3 = 6 indications, phase 4 = 4 indications) (Fig. 4, Tab. 4). The *OCs* are indicated 15 times, split into 14 phase-specific indications and 1 generic indication. Their indications focus on phase 0 (4 indications) and phase 1 (8 indications), while phase 3 and phase 4 reveal only 1 indication each (Fig. 4, Tab. 4). The *Govs / Legs* show a total of 10 phase-specific indications equally distributed across the phases 0 to 4 (Fig. 4, Tab. 4). The *SAs*, *CSs* and *EAs* show the lowest number of indications across the phases 0 to 4. Their total indications range from 8 (*SAs*), 7 (*CSs*) and 6 (*EAs*) (Fig. 4, Tab. 4). The *MAs* show 22 total indications (18 phase specific and 4 generic indications) with a major focus of phase 0 (13 indications). The indications of phase 1 to phase 4 range only from 1 to 2 indications (Fig. 4, Tab. 4). The *WOs* and *NGOs* are exclusively indicated by using the option ´*Generic answers*´ (not phase-specific) (Fig. 4, Tab. 4).

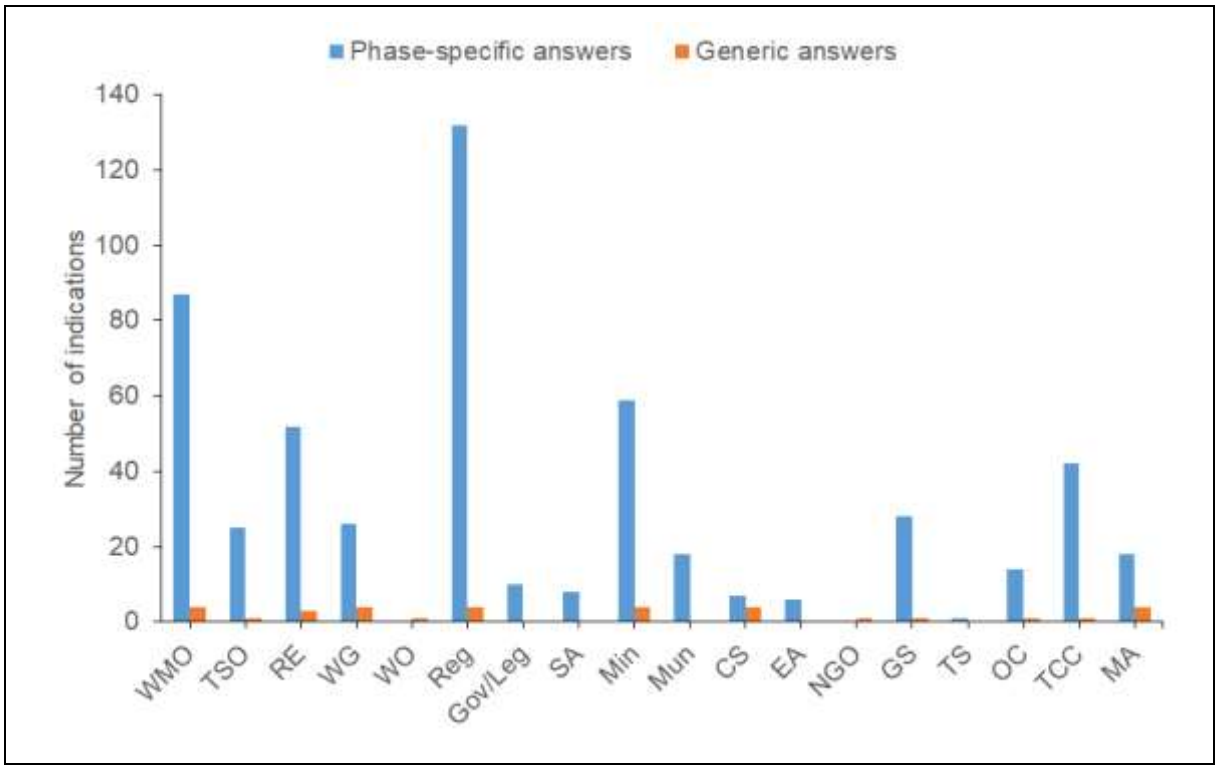

Figure 3 – Overview of the actors identified by all responding organisations (WMOs, TSOs, REs and one TCC), based on phase-specific and generic answers. The number of indications represents the sum of all indications made by each WMO, TSO, RE and TCC across all themes in all phases (see columns ´phase-specific´ and ´generic answers´ in Tab. 4). The actor category abbreviations refer to the definitions of the actor categories in Section 4.2.1.

Actor	Phase 0	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase-specific answers	Generic answers
WMO	24	26	19	9	8	1	87	4
TSO	6	5	0	0	14	0	25	1
RE	24	17	7	2	2	0	52	3
WG	9	4	2	2	9	0	26	4
WO	0	0	0	0	0	0	0	1
Reg	39	37	15	22	17	2	132	4
Gov/Leg	3	4	1	1	1	0	10	0
SA	0	0	0	1	7	0	8	0
Min	13	9	5	12	19	1	59	4
Mun	3	4	1	6	4	0	18	0
CS	3	3	1	0	0	0	7	4
EA	2	2	0	1	1	0	6	0
NGO	0	0	0	0	0	0	0	1
GS	7	9	4	4	4	0	28	1
TS	0	1	0	0	0	0	1	0
OC	4	8	0	1	1	0	14	1
TCC	15	16	3	4	4	0	42	1
MA	13	1	2	1	1	0	18	4

Table 4 – Number of indications for the actors identified by all responding organisations (WMOs, TSOs, REs and one TCC). The column ´phase-specific answers´ sums up all indications that were given with phase reference. The column ´generic answers´ sums up the number of all indications without phase reference.

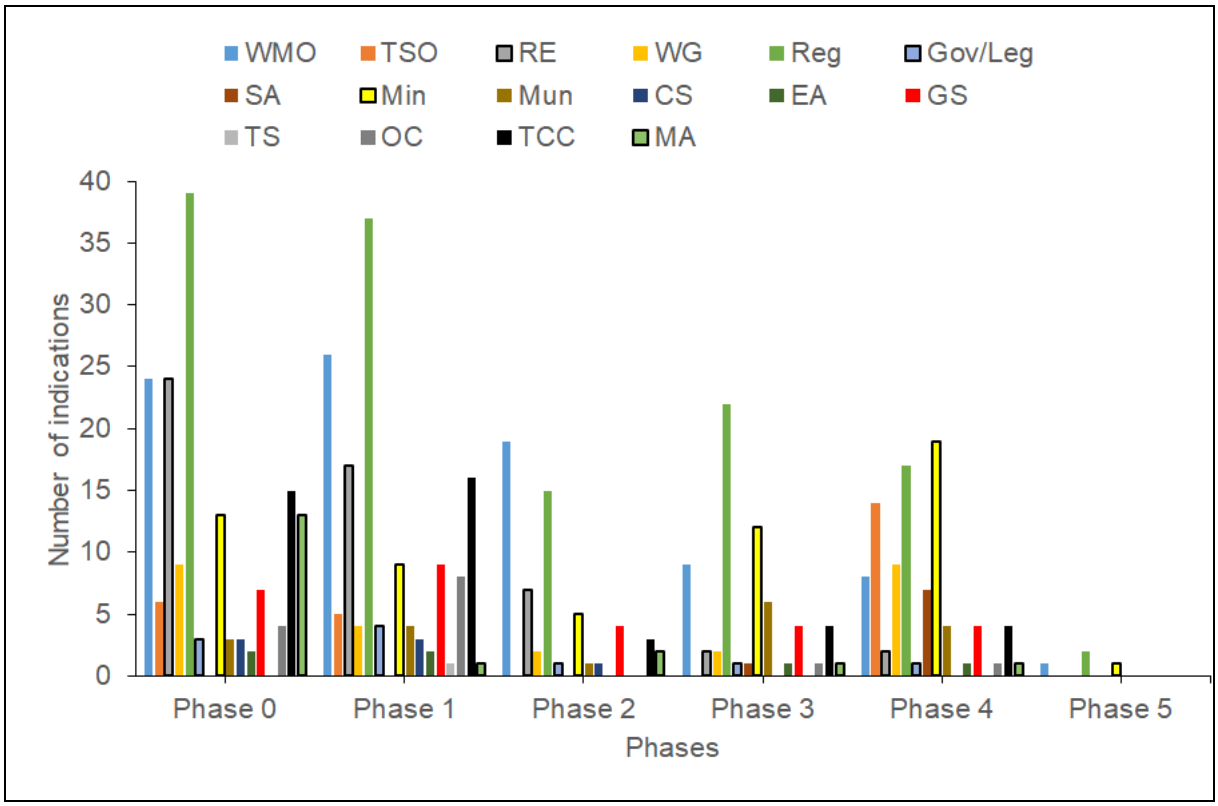

Figure 4 - Phase-specific actors identified by WMOs, TSOs and REs and their number of indications in the different phases of a national RMW programme. The responding TCC provided only generic answers. Note that WOs and NGOs are not shown in the diagram, since they were indicated using the option generic answers.

4.2.3 Actors identified by Waste Management Organisations (WMOs)

The phase-specific answers to Part 2 of the 1st UMAN questionnaire (Column 6 in Fig. 2) of the responding *WMOs* and the number of indications for each actor category are shown in Fig. 5 and Tab. 5. With a total of 85 indications (84 phase-specific indications and 1 generic indication) the *Regs* show the highest number of indications among all identified actors across all phases. The *Regs* are predominantly indicated in phase 0 (27 indications) and phase 1 (20 indications) (Fig. 5, Tab. 5). Their number of indications decreases to a total of 6 indications in phase 2, 18 indications in phase 3, 12 indications in phase 4 and 1 indication in phase 5 (Fig. 5, Tab. 5). The *Mins* reveal the second highest number of indications among all actors and across all phases with a total number of 59 phase-specific indications. Their number of indications shows a clear preference in the phases 0 (13 indications), 1 (9 indications), 3 (12 indications) and 4 (19 indications). In phase 2 (5 indications) and phase 5 (1 indication) the *Mins* reveal the lowest number if indications (Fig. 5, Tab. 5). The *TCCs* show a total number of 39 phase-specific indications with a clear dominance of indications in phase 0 (14 indications) and phase 1 (15 indications). In phases 2 to 4 their number of indications varies from 2 to 4, respectively. *TCCs* are not indicated in phase 5 (Fig. 5, Tab. 5). The *REs* show a total of 26 indications (25 phase-specific, 1 generic indication) across the phase 0 (15), phase 1 (9) and phase 2 (2) (Fig. 5, Tab. 5). The *TSOs* are indicated 25 times in the phase 0 (6 indications), phase 1 (5 indications), phase 4 (14 indications) (Fig. 5, Tab. 5). Both, *Muns* and *GSs* illustrate a total of 18 phase-specific indications. While the *Muns* reveal a relatively homogenous distribution across the phases 0 to 4, the *GSs* are dominantly indicated in phase 0 (5 indications) and phase 1 (indications) (Fig. 5, Tab. 5). The WGs are indicated 9 times with 4 indications in phase 0, 2 indications in phase 1 and 1 indication in phases 2 to 4, respectively. In total, the *SAs* are exclusively indicated in phase 3 (1 indications) and phase 4 (7 indications) (Fig. 5, Tab. 5). Both, the *Govs / Legs* and *EAs* reveal a total of 6 indications. Except of phase 0 (2 indications), the *Govs / Legs* reveal only 1 indication in the phases 1 to 4, respectively (Fig. 5, Tab. 5). The *OCs* reveal a total number of 6 indications including 5 phase-specific and 1 generic indication (phase 0 = 1 indication,

phase 1 = 2 indications, phase 3 = 1 indications, phase 4 = 1 indication) (Fig. 5, Tab. 5). *CSs* are indicated 4 times, split into one indication in phase 0 and phase 1 and two generic indications (Fig. 5, Tab. 5). The *TSs* show only 1 indication in phase 0 (Fig. 5, Tab. 5). The *MAs* are indicated 19 times including 15 phase-specific and 4 generic indications. The *MAs* show a clear focus in phase 0 with a total of 10 indications (phase 1 = 1 indication, phase 2 = 2 indications, phase 3 = 1 indication, phase 4 = 1 indication) (Fig. 5, Tab. 5).

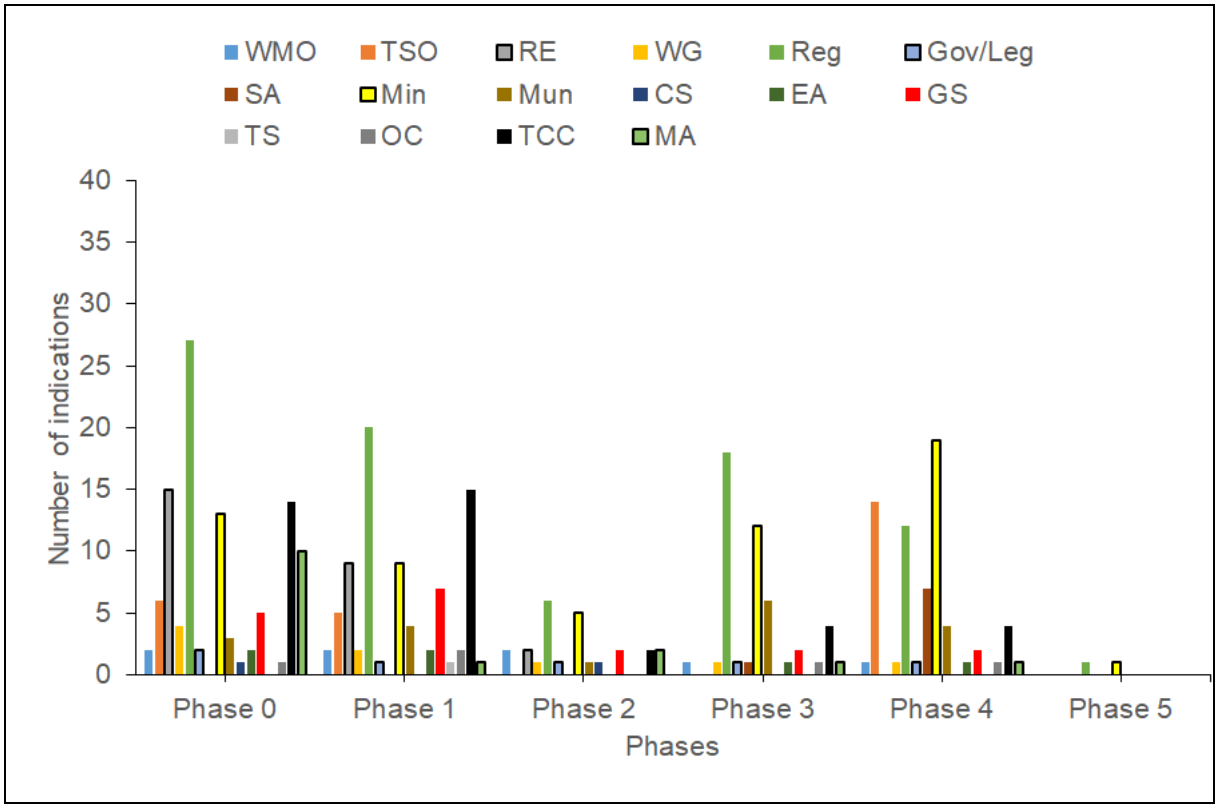

Figure 5 – Phase-specific actors identified by WMOs and their number of indications in the different phases of a national RMW programme. Note that WOs and NGOs are not shown in the diagram since they were indicated using the option generic answers

Actor	Phase 0	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase-specific answers	Generic answers
WMO	2	2	2	1	1	0	8	0
TSO	6	5	0	0	14	0	25	0
RE	15	9	2	0	0	0	26	1
WG	4	2	1	1	1	0	9	0
WO	0	0	0	0	0	0	0	1
Reg	27	20	6	18	12	1	84	1
Gov/Leg	2	1	1	1	1	0	6	0
SA	0	0	0	1	7	0	8	0
Min	13	9	5	12	19	1	59	0
Mun	3	4	1	6	4	0	18	0
CS	1	0	1	0	0	0	2	4
EA	2	2	0	1	1	0	6	0
NGO	0	0	0	0	0	0	0	1
GS	5	7	2	2	2	0	18	0
TS	0	1	0	0	0	0	1	0
OC	1	2	0	1	1	0	5	1
TCC	14	15	2	4	4	0	39	0
MA	10	1	2	1	1	0	15	4

Table 5 – Identified actors by WMOs and their number of indications. The column ´phase-specific´ answers sums up all indications that were given with phase reference. Note that generic answers were exclusively provided by NAGRA (Switzerland).

4.2.4 Actors identified by Technical Support Organisations (TSOs)

The phase-specific answers to Part 2 of the 1st UMAN questionnaire (Column 6 in Fig. 2) of the responding *TSOs* and the number of indications for each actor category are shown in Fig. 6 and Tab. 6. *WMOs* are given the highest number of indications across all 5 phases (53 phase-specific and 1 generic indication). The *WMOs* are predominantly indicated in phase 0 (10 indications) and phase 1 (20 indications). In phases 2 to 5 the indications vary between 1 in phase 5 and 8 in phase 3 (phase 2 and 4 = 7 indications) (Fig. 6, Tab. 6). With a total of 35 indications (34 phase-specific and 1 generic indication) the *Regs* are predominantly indicated in phase 1 (17 indications). In the phases 0 (6 indications), 2 (2 indications), 3 (4 indications), 4 (4 indications) and 5 (1 indication) the number of indications decreases (Fig. 6, Tab. 6). The *REs* are indicated 20 times including 19 phase-specific indications and 1 generic indication. They are indicated across the phases 1 to 4 with a focus on phase 0 (5 indications) and phase 1 (8 indications). In the phases 2 to 4 they are indicated twice in each phase (Fig. 6, Tab. 6). Indications for the *GSs* are well balanced throughout the phases 0 to 4 since they show 2 indications in each phase (Fig. 6, Tab. 6). The *OCs* are exclusively indicated in phases 0 (3 indications) and 1 (6 indications) (Fig. 6, Tab. 6). In total, *WGs* show 11 indications (8 phase-specific and 3 generic indications) distributed across the phases 0 to 4 (phase 0 = 3 indications, phase 1 = 2 indications, phase 2, 3 and 4 = 1 indication) (Fig. 6, Tab. 6). Both, the *CSs* and the *Govs / Legs* are indicated 5 and 4 times, respectively. The *CSs* reveal 2 and 3 indications in phases 0 and 1, whereas the *Govs / Legs* are indicated 1 time in phase 0 and 3 times in phase 1 (Fig. 6, Tab. 6). The *TCCs* show a total of 2 indications including 1 phase- specific indication in phase 1 and 1 generic indication (Fig. 6, Tab. 6). The *TSOs* and *Mins* have only 1 generic indication, respectively (Tab. 6).

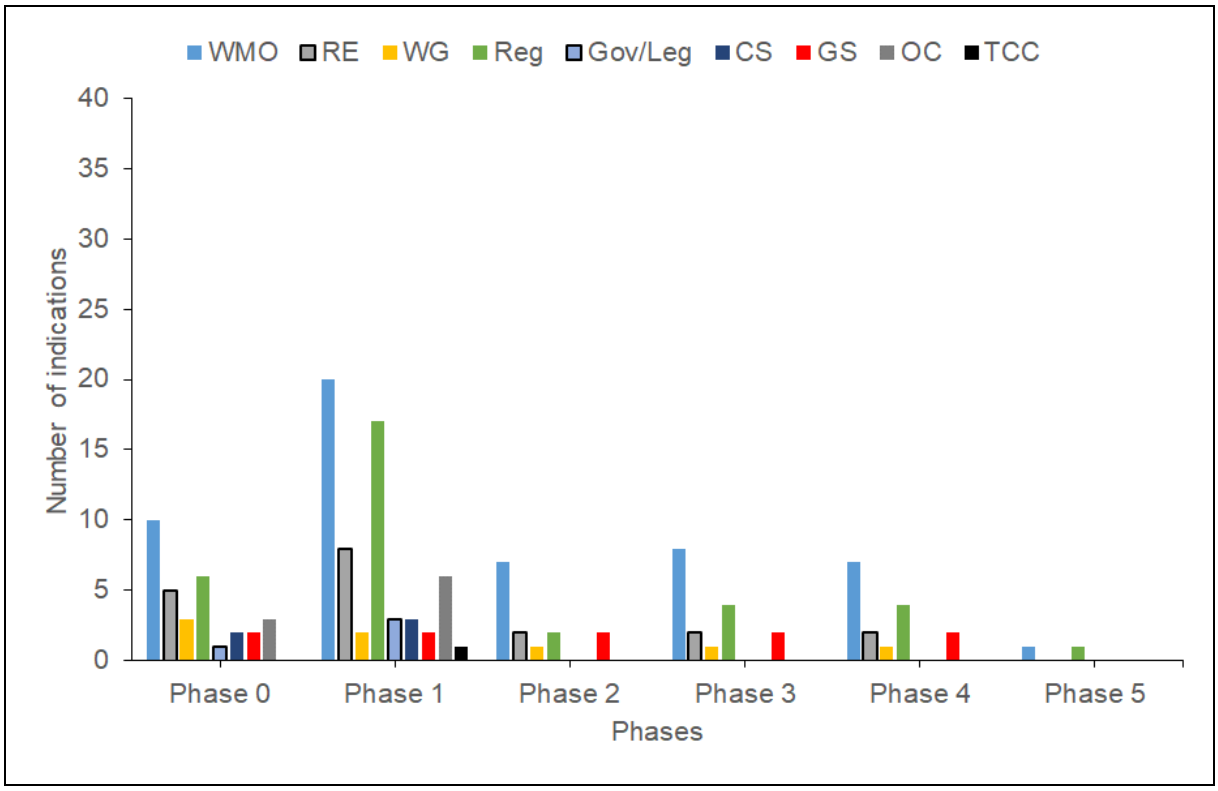

Figure 6 – Phase-specific actors identified by TSOs and their number of indications in the different phases of a national RMW programme. Note that TSOs, WOs, SAs, Mins, Muns, EAs, NGOs, TSs and MAs are not shown in the diagram since they were indicated using the option generic answers.

Actor	Phase 0	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase-specific answers	Generic answers
WMO	10	20	7	8	7	1	53	1
TSO	0	0	0	0	0	0	0	1
RE	5	8	2	2	2	0	19	1
WG	3	2	1	1	1	0	8	3
WO	0	0	0	0	0	0	0	0
Reg	6	17	2	4	4	1	34	1
Gov/Leg	1	3	0	0	0	0	4	0
SA	0	0	0	0	0	0	0	0
Min	0	0	0	0	0	0	0	1
Mun	0	0	0	0	0	0	0	0
CS	2	3	0	0	0	0	5	0
EA	0	0	0	0	0	0	0	0
NGO	0	0	0	0	0	0	0	0
GS	2	2	2	2	2	0	10	0
TS	0	0	0	0	0	0	0	0
OC	3	6	0	0	0	0	9	0
TCC	0	1	0	0	0	0	1	1
MA	0	0	0	0	0	0	0	0

Table 6 – Identified actors by TSOs and their number of indications. The column phase-specific answers sums up all indications that were given with phase reference.

4.2.5 Actors identified by Research Entities (REs)

The phase-specific answers to Part 2 of the 1st UMAN questionnaire (Column 6 in Fig. 2) of the responding *REs* and the number of indications for each actor category are shown in Fig. 7 and Tab. 7. In total, the *WMOs* show 27 indications (26 phase-specific indications and 1 generic indication) distributed over the phases 0 (12 indications), 1 (4 indications) and 2 (10 indications) (Fig. 7, Tab. 7). The *Regs* show 14 phase-specific (phase 0 = 6 indications, phase 2 = 7 indications and phase 4 = 1 indication) and 2 generic indications (Fig. 7, Tab.7). *WGs* are indicated 9 times including 2 indications in phase 0 and 7 indications in phase 4 (Fig. 7, Tab. 7). Similarly, the *REs* are indicated 4 times in phase 0 and 3 times in phase 2. In addition, the *REs* reveal 1 generic indication (Fig. 7, Tab. 7). The *TCCs* (2 indications) and *MAs (3 indications)* show the lowest number of indications. While the *TCCs* are indicated 1 time in phases 0 and 2, respectively, the *MAs* show 3 indications in phase 0 (Fig. 7, Tab. 7). The *Mins* and *GSs* show 3 and 1 generic indication(s), respectively (Tab. 7).

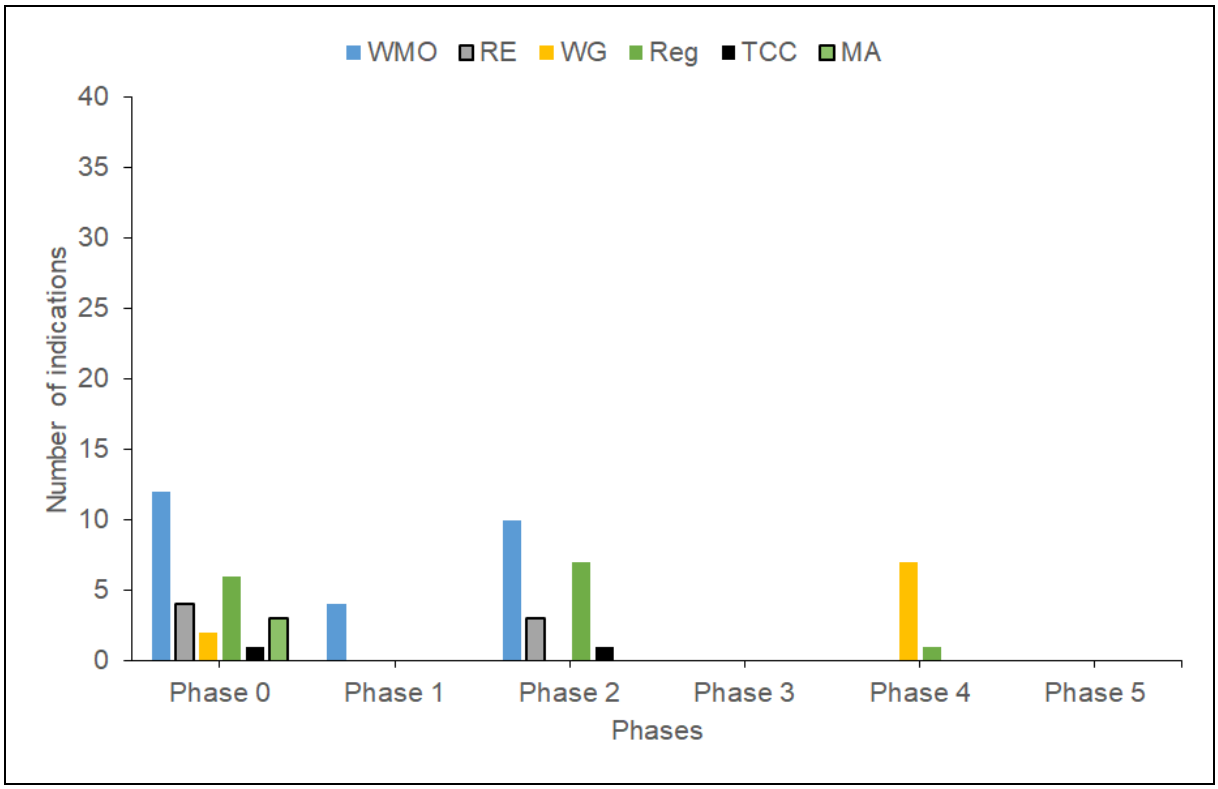

Figure 7 – Phase-specific actors identified by REs and their number of indications in the different phases of a national RMW programme. Note that TSOs, WOs, GOVs /Legs, SAs, Mins, Muns, CSs, EAs, NGOs, GSs, TSs, and OCs are not shown in the diagram since they were indicated using the option generic answers.

Actor	Phase 0	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase-specific answers	Generic answers
WMO	12	4	10	0	0	0	26	1
TSO	0	0	0	0	0	0	0	0
RE	4	0	3	0	0	0	7	1
WG	2	0	0	0	7	0	9	0
WO	0	0	0	0	0	0	0	0
Reg	6	0	7	0	1	0	14	2
Gov/Leg	0	0	0	0	0	0	0	0
SA	0	0	0	0	0	0	0	0
Min	0	0	0	0	0	0	0	3
Mun	0	0	0	0	0	0	0	0
CS	0	0	0	0	0	0	0	0
EA	0	0	0	0	0	0	0	0
NGO	0	0	0	0	0	0	0	0
GS	0	0	0	0	0	0	0	1
TS	0	0	0	0	0	0	0	0
OC	0	0	0	0	0	0	0	0
TCC	1	0	1	0	0	0	2	0
MA	3	0	0	0	0	0	3	0

Table 7 – Identified actors by REs and their number of indications. The column phase-specific answers sums up all indications that were given with phase reference. Note that generic answers were exclusively provided by ICHTJ (Poland) and LEI (Lithuania).

4.2.6 Actors identified by TCC

EnviroCase from Finland is the only responding *TCC* and did not provide phase-specific indications. Rather it generically indicated *WMOs*, *WGs*, *Regs*, *Mins*, *TSOs*, *TCCs* and *REs* in the response to Part 2 of the 1st UMAN questionnaire (Column in Fig. 2).

4.3 Functions assigned to responding organisations

The responding organisations were asked to provide both their functions (as actors of category *WMO*, *TSO*, *RE* and *TCC*) and functions of the identified *other actors* in Part 2 of the 1st UMAN questionnaire (Columns 5 and 6 - 7, respectively, in Fig. 2). Since the information on the functions of the *other actors* is very sparse, the analysis focuses on the responsibilities of the responding organisations (i.e. the functions of actors of category *WMO*, *TSO*, *RE* and *TCC*). Generally, the analysis presents the data provided in Part 2 of the 1st UMAN questionnaire given by the responding organisations. Some of the functions stated by the responding organisations might deviate from the original definitions made by e.g. EURAD itself or the IAEA for these actors. In case assigned functions are suspect to be biased, a general remark is provided in the text.

An overview of the phase-specific functions played by the responding organisations in each phase of a RWM programme is depicted in Figures 8 – 11 for *WMOs*, *TSOs*, *REs* and *TCC*, respectively. The number of indications given by the responding organisations for every function in the specific phase of a RWM programme, plotted in Figures 8 – 11, is shown in Table 8.

Organisation	Function	Phase 0	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
WMO	a	47	37	28	29	32	3
	b	47	55	43	40	42	3
	c	9	10	9	8	13	1
	d	46	45	42	35	35	3
	e	48	48	35	31	35	2
	f	14	16	16	13	13	0
	g	4	4	4	4	4	0
	h	4	0	3	0	0	0
TSO	a	12	10	7	7	7	1
	b	8	7	7	7	7	1
	c	1	0	0	0	0	0
	d	18	12	12	12	12	2
	e	19	23	17	17	17	3
	f	9	10	10	10	10	2
	g	9	15	8	7	7	1
	h	13	6	0	0	0	0
RE	a	1	0	0	0	0	0
	b	0	0	0	0	0	0
	c	1	0	0	0	0	0
	d	18	13	22	11	14	0
	e	5	6	8	4	0	0
	f	0	0	0	0	0	0
	g	0	0	0	0	0	0
	h	8	7	7	7	7	0
TCC	a	4	4	4	4	4	0
	b	3	3	3	3	3	0
	c	0	0	0	0	0	0
	d	3	3	3	3	3	1
	e	4	4	4	4	4	1
	f	4	4	4	4	4	1
	g	0	0	0	0	0	0
	h	0	0	0	0	0	0

Table 8 – Phase-specific number of indications of functions according to the self-assessment of WMOs, TSOs, REs and TCC.

4.3.1 Functions assigned to Waste Management Organisations (WMOs)

The phase-specific answers to Part 2 of the 1st UMAN questionnaire (Column 5 in Fig. 2) of the responding *WMOs* and the number of indications for each function are shown in Fig. 8 and Tab. 8. *WMOs* consider functions a (initiation/planning), b (execution/implementation), c (funding), d (research) and e (safety assessment) in phases 0 – 5 of a RWM programme, functions f (CS participation) and g (regulatory oversight) in phases 0 – 4. Function g was stated by only 1 *WMO*. Since a *WMO* is the implementer of a RWM programme, it cannot account for the regulatory oversight at the same time according to the current international standards. In this context function g is either misunderstood as regulatory oversight is a function ascribed to *Regs* or it is a consequence of a facilities history. On the other hand, function g could be interpreted rather as safety and not regulatory oversight. Function h (any other involvement) was stated in phases 0 and 2 (Fig. 8, Tab. 8).

Functions a, b, d and e have the highest number of indications. The number of indications in phases 0 to 5 in case of function a is 47, 37, 28, 29, 32 and 3; in case of function b 47, 55, 43, 40, 42 and 3; in case of function d 46, 45, 42, 35, 35 and 3; in case of function e 48, 48, 35, 31, 35 and 2.

In contrast, functions c, f and g are less often identified in phases 0 and 5 and are assigned the following number of indications: in case of function c 9, 10, 9, 8, 13 and 1; in case of function f 14, 16, 16, 13, 13 and 0; in case of function g 4, 4, 4, 4, 4 and 0. Function h has 4 indications in phase 0 and 3 indications in phase 2.

A relatively constant number of indications in phases 0 to 4 can be observed for functions f and g, while in phases 0 to 3 for functions c and d.

In phase 0 functions a - h are considered with dominance of functions a, b, d and e. In phase 1 functions a – g are indicated with functions a, b, d and e revealing the highest number of indications. In phase 2 functions a – h are stated, in which functions a, b, d and e dominate. In phase 3 functions a – g are considered, in which functions a, b, d and e dominate. In phase 4 functions a – g are stated with dominance of functions a, b, d, e. In phase 5 functions a - e are stated; this phase reveals the lowest number of indications provided by *WMOs*.

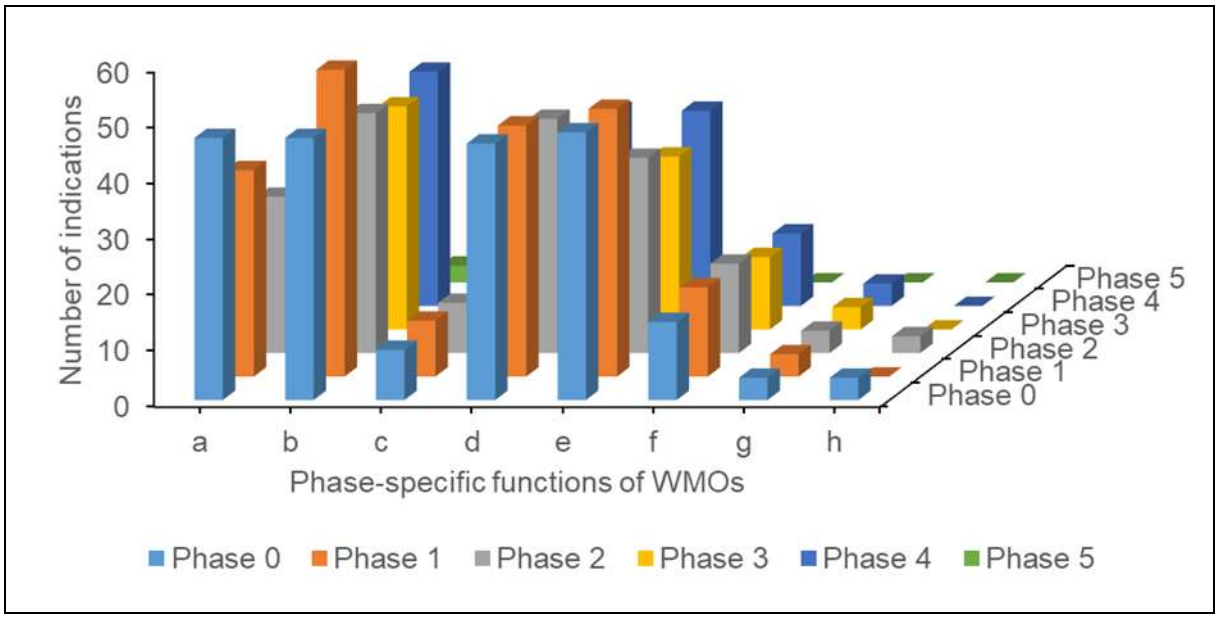

Figure 8 – Identified phase-specific functions of responding organisations of category WMO

4.3.2 Functions assigned to Technical Support Organisations (TSOs)

The phase-specific answers to Part 2 of the 1st UMAN questionnaire (Column 5 in Fig. 2) of the responding *TSOs* and the number of indications for each function are shown in Fig. 9 and Tab. 8. The results corresponding to the replies of *TSOs* show that functions a (initiation/planning), b (execution/implementation), d (research), e (safety assessment), f (CS participation) and g (regulatory oversight) are considered in phases 0 to 5, while function c (funding) is considered in phase 0 and function h (any other involvement) in phases 0 and 1 (Fig. 9, Tab. 8). Two *TSOs* stated function b as one of their responsibilities, which according to the current international standards is the responsibility of *WMOs*. Therefore, from today´s point of view, a *TSO* cannot be in charge of execution/implementation of a RWM program but special conditions due to history may exist that requires *TSO* support to *WMOs* during execution / implementation.

The highest number of indications is assigned to functions d and e, which yields in phases 0 to 5 in case of function d 18, 12, 12, 12, 12, and 2; in case of function e 19, 23, 17, 17, 17 and 3.

These functions are followed by functions a, b, f and g, which have a very similar number of indications: in case of function a 12, 10, 7, 7, 7 and 1; in case of function b 8, 7, 7, 7, 7, and 1; in case of function f 9, 10, 10, 10, 10 and 2; in case of function g 9, 15, 8, 7, 7 and 1. Clearly, functions a and e reveal a constant number of indications in phases 2 to 4, functions b, d and f in phases 1 to 4.

The lowest number of indications is attributed to function c with 1 number of indications in phase 0 as well as function h with 13 and 6 numbers of indications in phases 0 and 1, respectively.

In phase 0 functions a - h are considered with dominance of functions a, d, e and h. In phase 1 functions a – h are indicated with functions e, and g revealing the highest number of indications. In phases 2 to 4 functions a – g are stated, in which function e dominates. In phase 5 functions a - e are stated; this phase reveals the lowest number of indications provided by *TSOs*.

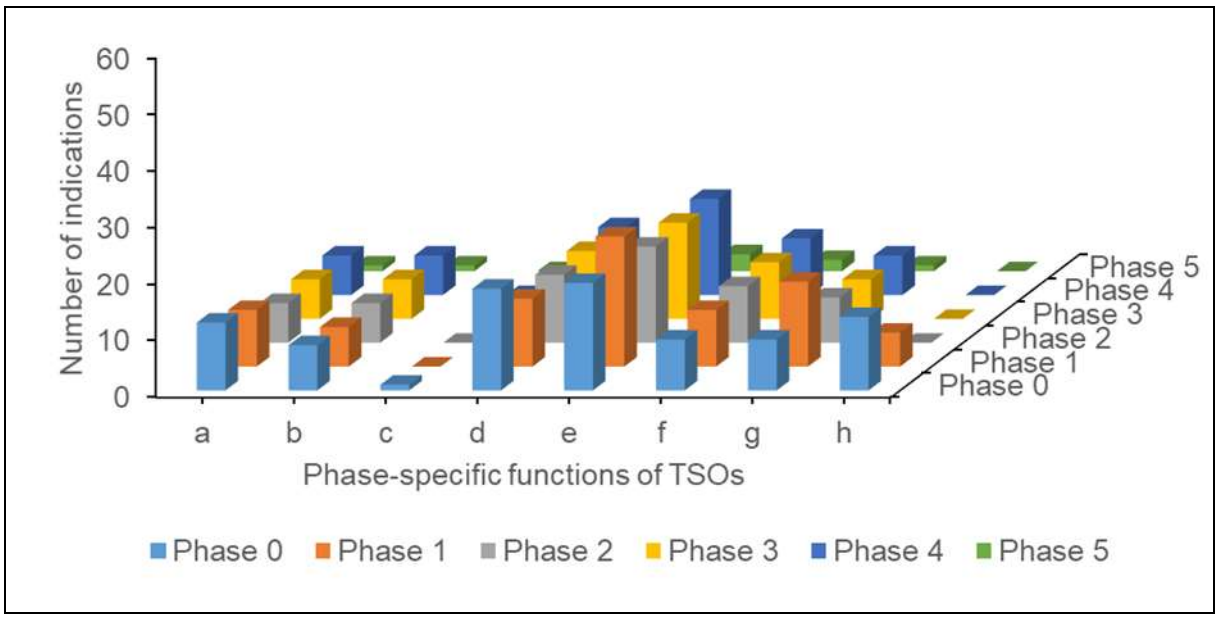

Figure 9 – Identified phase-specific functions of responding organisations of category TSO

4.3.3 Functions assigned to Research Entities (REs)

The phase-specific answers to Part 2 of the 1st UMAN questionnaire (Column 5 in Fig. 2) of the responding *REs* and the number of indications for each function are shown in Fig. 10 and Tab. 8. The functions considered by *REs* are functions d (research) and h (any other involvement) assigned to phases 0 – 4 as well as function e (safety assessment) assigned to phases 0 - 3 (Fig. 10, Tab. 8). No functions are identified in phase 5. Additionally, one responding organisation indicated function a (initiation/planning) in phase 0 and one organisation function c (funding) in phase 0.

Function d reveals the highest number of indications: 18, 13, 22, 11, 14 and 0 in phases 0 to 5, respectively. Function h has the second highest number of indications, almost equally distributed in phases 0 – 4: 8, 7, 7, 7, 7 and 0. Function e is given the lowest number of indications: 5, 6, 8, 4, 0 and 0.

In Phase 0 functions a, c, d, e and h are listed, however function d dominates in this phase. In phases 1 to 3 functions d, e and h are mentioned with dominating function d. In phase 4 both functions d and h are considered, in which function d dominates. In phase 5 no functions are assigned.

4.3.4 Functions assigned to Technical Consulting Company (TCC)

The phase-specific answers to Part 2 of the 1st UMAN questionnaire (Column 5 in Fig. 2) of the responding *LTP (*categorised as *TCC)* and the number of indications for each function are shown in Fig. 11 and Tab. 8. The answers given by one *TCC* allow to conclude that the most relevant functions

for this organisation type are functions a, b, d, e and f (Fig. 11, Tab. 8). Functions a (initiation/planning) and b (execution/implementation) are identified in phases 0 to 4, while functions d (research), e (safety assessment) and f (CS participation) in phases 0 to 5.

In phase 0 to 5 function a has the following number of indications 4, 4, 4, 4, 4 and 0; function b 3, 3, 3, 3, 3 and 0; function d 3, 3, 3, 3, 3 and 1; functions e and f 4, 4, 4, 4, 4 and 1. All the aforementioned functions are almost equally distributed in phases 0 to 4.

In phases 0 to 4 functions a, b, d, e and f are considered and have almost the same number of indications. In phase 5, functions d, e and f are identified and have the same number of indications. Further, phase 5 is assigned the lowest number of indications.

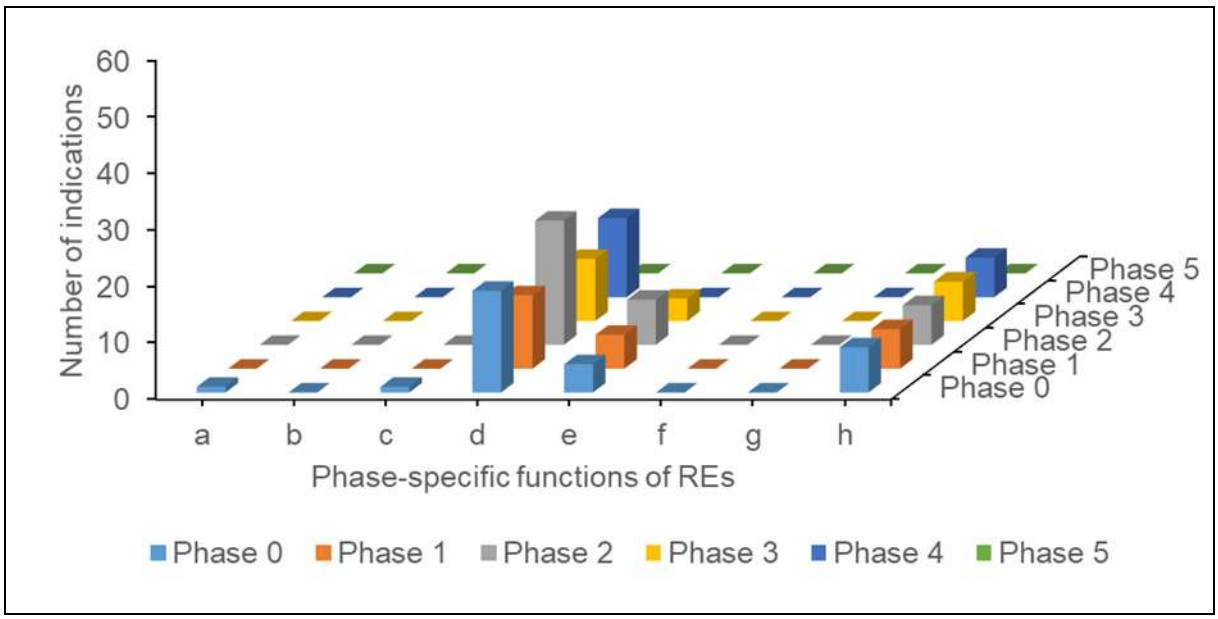

Figure 10 – Identified phase-specific functions of responding organisations of category RE

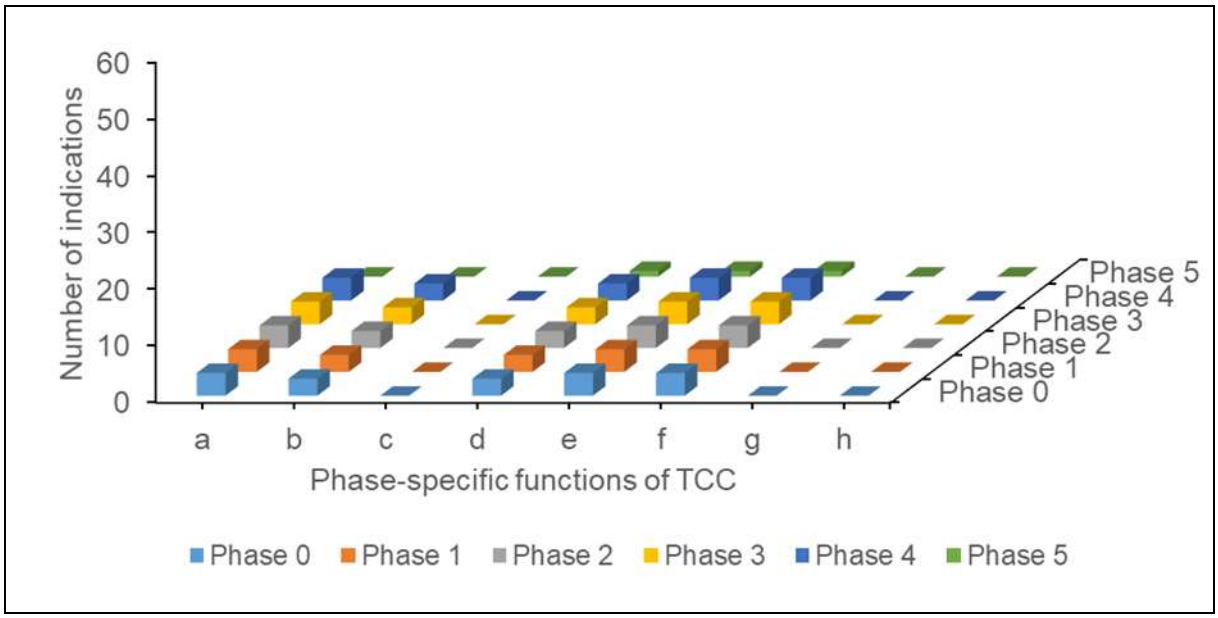

Figure 11 – Identified phase-specific functions of the responding organisation of category TCC

5. Interpretation of the results

5.1 Identified actor categories

As a result of the analysis of the 1st UMAN questionnaire, 18 different actor categories were identified (Section 4.2.1, Tab. 4). Two groups of actors may be distinguished: the first group of actors is represented by the organisations which actively contributed to the 1st UMAN questionnaire (*´contributing actors´*) and the second group of actors are those specified as ´actors´ by the *contributing actors*. In the following, they are denominated *´other actors´*, following the terminology used in column 6 of the table in Part 2 of the 1st UMAN questionnaire (Fig. 2). Due to the decision made on the target group of the questionnaire recipients, the contributing actors were *WMOs*, *TSOs, REs* and one *TCC* (Tab. 2). Thus, 4 out of 18 actors are the *contributing actors*, 14 are the *other actors*. This difference between these two groups of actors has to be kept in mind when interpreting the results of the questionnaire analysis.

Among all the responding organisations, *WMOs* provided the widest spectrum of actors likely due to the specifics of their function, which requires continuous analysis of the stakeholders and the assessment of the corresponding risks and opportunities.

To gain an overview of the number of indications attributed to each actor category, we focus on the actors with the highest numbers of indications (including *phase-specific answers* from column 8 and *generic answers* from column 9 in Table 4). However, it has to be taken into account that the number of indications does not necessarily reflect the importance of an individual actor. In order to gain a first and impression about the actors that play a fundamental role in all phases of a RWM programme, the analysis is restricted to those actors with the highest number of indications. The succession of the *contributing actors* on the basis of the total number of indications over all phases is as follows: 1. *WMOs*, 2. *REs*, 3. *TSOs*, while the succession of the *other actors* is as follows: 1. *Regs*, 2. *Mins*, 3. *TCCs*, and further on 4. *WG*s and 5. *GS*s. From the aforementioned succession, it becomes evident which *other actors* play a significant role in a RWM programme from the contributing actors´ point of view. For the majority of the *contributing actors* and the *other actors*, most indications are available in phase 0, phase 1 and phase 4. This result reflects the current stage of the national RWM programmes (Tab. 3). Regarding GD (for HLW including SNF), the countries are mainly involved in phases 0 and 1, presently. The operational and closure phase 4 is addressed exclusively for NSD and GD of LLW and/or ILW.

Solely *Regs* and *Mins* are indicated in all phases, most probably due to their specific functions as regulatory oversight and programme owners. *TSOs* support *Regs* and sometimes *WMOs* (under consideration of the function b ´execution/implementation´ indicated in the questionnaire), therefore they are strongly involved in phase 0 and phase 1. However, this interpretation is solely based on the data from the questionnaire. Given that *WMOs* and *Regs* are involved in all phases (Tab. 4), *TSOs* would be expected to be involved across all phases. The maximum of *TSO* indications falls however into phase 4, whereas the indications of *Regs* decrease and indications of *Mins* increase in this phase. Thus, based on the data given in the questionnaire, there might be some evidence that *Mins* fulfill the functions of *Regs* in phase 4 as there is no phase-indicated argument that can explain the decrease of the indications of *Regs*. *Mins* seem to have different roles in different phases of the radioactive waste disposal process. According to the IAEA (2011c) the regulatory oversight is solely assigned to *Regs*. However, the increasing number of indications of *Mins* in phase 4 could indicate takeover of function g (regulatory overview) by *Mins* due to the ´historic´ RWM programmes and facilities licensed under past regulations and political conditions.

Based on the answers to the 1st UMAN questionnaire it appears to be difficult to separate the roles of the individual actors defined in the questionnaire Part 2. The roles of individual actors often vary depending on the chosen approaches applied in national radioactive waste management programmes, on the national framework as well as on different political and administrative systems. Additionally, the difficulty to strictly divide functions among actors across different countries is also related to the great variability of involved actors, depending on the specific issue under consideration or the specific stage of a facility`s life cycle or the RWM programme in each country. Hence, the roles of individual actors

may be different in different phases and sometimes intertwined. Doubtless, international standards (e.g. IAEA, 2011c; Council Directive 2011/70/EURATOM) should be valid and applied to all RWM programmes and facilities, however, it might take time to transfer the current standards to a ´historic´ RWM programme or facility.

It is noted that the actor categories defined through the 1st UMAN questionnaire is somewhat different from the basic (simplified) classification of stakeholders commonly used in initiatives on transparency and participation of interested parties in RWM programmes (an example of a simplified actors system is given by Martell and Ferraro, 2014). However, this questionnaire clearly showed the diversity of approaches and organizational measures taken to ensure the safe implementation of RWM programmes in the individual countries participating in this survey.

5.2 Functions of the identified actors

5.2.1 Functions of the responding organisations

The functions fulfilled by the actors of the first group were further characterised based on their self-assessment (Tab. 8) and by taking international requirements on roles and responsibilities into account. These actors identified their own functions in every programme phase considering the functions a – h predefined in Part 2 of the 1st UMAN questionnaire (Column 5 in Fig. 2). This provides information on the specialisation and roles of the individual *contributing actors*. In case some functions are not indicated by any respondent as expected, an effort was made to figure out whether *other actor* overtakes this responsibility. The self-assessment of *WMOs*, *TSOs*, *REs* and one *TCC* is described below and complemented by some examples of their tasks, particularly considering the safety case. The latter is of main interest in many countries and for Tasks 4 and 5 of the UMAN WP.

The main attention of actors with a high number of indications is mostly focused on activities related to the creation and implementation of a suitable RWM programme including policy and legal framework (phase 0) and the site evaluation and selection (phase 1), design and technical solutions for disposal facilities and activities directly or indirectly related to safety assessment and safety case.

Particular attention when analysing the actor functions, interest and impact was paid on the activities related to the safety case of disposal facilities as these fall into the scope of WP UMAN. The safety case is an integration of arguments and evidence that describe, quantify and substantiate the safety of the disposal facility and the associated level of confidence. In a safety case, the results of the safety assessment – i.e. the calculated numerical values of safety indicators and their evaluation against quantitative safety standards – are supplemented by a broader range of evidence that gives context to the conclusions or provides complementary safety arguments, either quantitative or qualitative. A safety case is the compilation of underlying evidence, models, designs and methods that give confidence in the quality of the scientific and institutional processes as well as the resulting information and analyses that support safety.

The development of the safety case is an iterative process that evolves with the development of the disposal facility and should be used throughout all steps to guide the site selection process, the facility design, excavation and construction activities, operation of the facility and its closure. It should be used to identify research and development needs, to identify and establish limits, controls and conditions at the various steps, and primarily to provide the basis for the licensing process. It will also be the main vehicle of communication with interested parties, in terms of explaining the safety features and how a reasonable level of safety will be ensured (IAEA, 2012).

Functions attributed to *WMOs*

WMOs cover all functions (Fig. 8). Examples of safety case relevant activities and functions mentioned by respondents of category *WMO* are as follows:

- Regular update of the safety case,

- Execution / implementation of knowledge of the waste inventory (volume, radiological content and physico-chemical properties, etc.) in order to define an adequate disposal route both in terms of safety and economic viability,
- Evaluation of engineered barrier system (EBS) properties, functions and long-term performance in connection with the safety assessment and implementation of this knowledge,
- Determination of the reference environmental situation before the repository exists in the frame of safety case development and safety analyses,
- Performance assessment, safety case development and safety analyses:
    - assessment of possible long-term evolutions of performance and safety indicators
    - quantification of safety margins within activities carried out to understand rock properties, radionuclide transport and long-term geological evolution
    - ensuring that safety assessment / analysis represent state of the art methods of science and technology,
    - mainly qualitative assessments at each site in the phase of site evaluation and selection.

The number of indications is high in phases 0 – 4 regarding functions ´initiation and planning´ (function a), ´execution and implementation´ (function b), ´research´ (function d), ´safety assessment´ (function e) with maximum indications in phases 0 and 1, again reflecting the phases at which most countries presently are.

´Funding´ (function c) was not defined in details in the replies to the questionnaire. In general, it can be assumed that the initial funding of a RWM programme is in the responsibility of waste producers and/or programme owners. However, other organisations as *WMO*s, *TSO*s and *Reg*s take over financial management tasks and funding of research projects and reporting to the programme owner. Under consideration of the responsibilities of *WMOs* it can be however deduced that this function refers to RWM programme-related funding, such as RD&D projects, Safety Case development and Safety Case review. Thus, it can be concluded that costs of activities of *REs*, *TCCs* and in case of the ´historic´ RWM programmes and facilities also costs of activities of *TSOs* were allocated to *WMOs* at least in parts. Hence, *WMOs* play the role of a demand carrier and receive and use the results of *REs*, *TCCs* and sometimes *TSOs*. However, it is necessary to state that services offered by *TSOs* are predominantly financially managed by *Regs* to which they provide technical support and sometimes by the state/ ministries (e.g. IRSN, France). The number of indications regarding ´funding´ (function c) is below that attributed to ´CS participation´ (function f).

Based on the comparable number of indications, there is an evidence that *WMOs*, in certain/many cases are not fully responsible for ´funding´ (function c) and ´CS participation´ (function f). Additional sources of funding are ensured/available for *REs* (e.g. EU projects, national RD&D programs, other sources). The ´CS participation´ can be ensured by both *WMOs* and *Regs,* however with different objectives.

With regards to function g ´regulatory oversight´, which was indicated only once in the questionnaire, it can be stated that in most countries and phases the functions of *WMOs* and *Regs* are separated. Indeed, the international standards such as IAEA (2011c) and the Council Directive 2011/70/EURATOM (2011) require that the competent regulatory authority is functionally separate from any other body or organisation concerned with the management of spent fuel and radioactive waste, in order to ensure effective independence from undue influence on its regulatory function. The single indication made in the questionnaire may by interpreted in two ways: either as a misunderstanding of the meaning of the function ´regulatory overview´ by the respondent or as a function indeed assigned to a WMO as a consequence of operating a historic facility.

Functions attributed to *TSOs (and TCC)*

As functions provided to the 1st UMAN questionnaire by one responding *TCC* and the *TSOs* overlap (Figs. 9 and 11) it was decided to consider these both actors together for a simplicity of the analysis. According to the definitions of the identified actors (see 4.2), it is noteworthy to mention that a *TCC* and a *TSO* can have similar functions when providing technical support to *Regs*. However, the main focus of this analysis is on the functions of the *TSOs*.

TSOs may cover all functions (Fig. 9) as indicated by the analysis of the responses to the questionnaire. Function c ´funding´ is however indicated only once and in phase 0. However, the functions of *TSOs* are strongly dependent on the specific conditions and requirements of individual countries. Examples of safety case relevant activities and functions mentioned by respondents of category *TSO* are provided below:

- Support to regulatory oversight in the field of performance assessment, safety case development, and safety analyses,
- Safety review of documentation related to predisposal activities - radioactive waste characterisation, treatment, packaging and storage and source term understanding for disposal,
- Safety review of documentation related to the disposal concepts:
    - definition of engineered barriers, study of rock properties, radionuclide transport and long-term geological evolution, disposal facility design and the practicalities of construction, operation and closure,…
- Independent safety assessment, performance assessment, and safety analyses including scenario development, modelling of long-term evolution, assessment of some interaction processes and RN transport as well as independent calculations for technical review,
- Identification of safety issues to be treated in the license and preparation of relevant legal framework,
- Technical review of the research programs for siting and for licensing, of the use of their results in the safety case.

A comprehensive overview of review, RD&D and inspection activities typically needed at each phase of a disposal programme in support of the regulatory functions fulfilled by regulators can be found in Lemy et al. (2013).

Currently, *TSOs* are mainly involved in the establishment, evaluation and review of the safety case and related safety assessment (Fig. 9). Although *TSOs* obtained most indications in phase 0 and phase 1 – reflecting the phases at which most countries currently are - they are involved significantly in phases 2 - 4; phase 5 is partly addressed, too. This can be explained by the fact that safety cases and assessments are required in all phases, e.g. due to a step by step licensing procedure, to recertification issues, or the necessity to regularly update the state-of-the-art in research and technology during the implementation of the disposal programme. In phases 0 – 4, *TSOs* are strongly involved in research activities and work close together with *REs as well*. Additionally, their involvement in the ´regulatory oversight´ (function f) is emphasized. Solely in phase 0, *TSOs* are involved in funding activities. By experience, this occurs before a waste management organizational structure is established and therefore a *TSO* might be mandated to initiate the first steps in RWM and/or may be involved in advising on/development of a robust funding mechanism. *TSOs* may also fund R&D activities like PhDs (e.g. Bel V, Belgium and IRSN, France). With respect to their broad involvement in the radioactive waste disposal process (except of funding), *TSOs* may be characterised as highly qualified organizations administrating cross-sectional and networking tasks.

Functions attributed to *REs*

When ignoring the function ´other involvement´ (function h), it can be stated that *REs* are exclusively involved in ´research activities´ (function d) and ´safety assessment´ (function e). Examples of safety case relevant activities and functions mentioned by the respondents of category *REs* are given below:

- Safety assessment - radioactive waste characterisation, treatment, packaging and storage (pre-disposal activities), and source term understanding for disposal in connection with safety assessment,
- Evaluation of engineered barrier system (EBS) properties, function and long-term performance in connection with safety assessment,
- Safety assessment - understanding the properties of rock, radionuclide transport and long-term geological evolution,
- Research in the field of performance assessment, safety case development, and safety analyses - update performance assessments, safety case and safety analysis integrating new achieved site data, new knowledge, refined models and improved input data,
- Long-term safety and performance assessment calculations; sensitivity and uncertainty analyses for surface and geological repositories,
- Testing performance assessment methodologies and safety and performance assessment calculations / models to address effects of site/host formation uncertainties.

Naturally, *REs* safety assessment related activities take place in phase 0 to 4 with maximum intensity in phase 2, probably because the safety assessment and the safety case accompanying the application for a license to construct and operate the facility have to be completed during this phase. As well, research activities and other involvements of *REs* terminate before the post-closure phase starts. Solely in phase 0, *REs* may be involved in other activities like RWM programme initiation and funding, support in the decisions on the choice of the long-term solution, setting the target dates of the different steps of site selection and determination of selection criteria. By experience, this occurs before a waste management organizational structure is established and therefore a national *RE* is commissioned to perform the first steps in RWM. With respect to their very selective functions *REs* provide highly specialised knowledge-based services in the radioactive waste disposal process.

Summary

The roles and responsibilities of *contributing actors* were identified based mainly on their self-assessment. Generally, the functions indicated by the *contributing actors* correspond well to their responsibilities defined in the international standards (e.g. IAEA, 2011c; Council Directive 2011/70/EURATOM). However, a few additional functions, contradictory to the international regulations, were recognised (e.g. function g ´regulatory oversight´ by *WMOs*, function b `execution/ implementation` by *TSOs* and support to *WMOs*), which may result from the running of ´historic´ RWM programmes and facilities by some countries, to which the international standards have not been fully applied yet. *WMOs* play the role of the demand carrier, being involved in all functions. *TSOs* mostly support *Regs*, however they also interact with *WMOs* to ensure compliance with *Regs´* requirements. The results show that *TSOs* provide support to both *Regs* and *WMOs;* in the latter case *TSOs* overtake the functions of *TCCs*. *REs* are in turn linked to *WMOs*, *TSOs* and/or *Regs*, executing highly specialised tasks. They may also run their own R&D programme.

Remarkably, ´funding´ (function c), ´CS participation´ (function f) and ´regulatory oversight´ (function g) are only indicated on medium or low level by *WMOs* as the demand carrier. Additionally, a low number of indications of these functions has been provided also by *TSOs* and *REs*. Thus, it is of interest to clarify, which other actors fulfill these functions (i.e. functions c, f, g). The activities of *TSOs* and *REs* are not fully covered by their own financial resources (´funding´), therefore it is supposed that these

actors will benefit from additional financial sources provided by *other actors* mentioned in column 6 in Part 2 of the 1st UMAN questionnaire. Thus, attention is drawn to the second group of actors (i.e. the *other actors*) in order to discuss their roles and functions.

5.2.2 Functions of the *other actors*

No self-assessment of the *other actors* is available. Therefore, they cannot be classified according to their functions, directly. To gain anyhow an overview of the functions of the *other actors*, the number of indications of these actors provided by all individual contributors to the 1st UMAN questionnaire (i.e. the *contributing actors*) is considered for each phase (Tab. 5 – Tab.7).

To simplify this step, the *other actors* with similar activities and functions are aggregated, particularly if they show a low number of indications. Hence, *CS* / *EAs* / *NGOs*, representing a spectrum of civil society organisations are indicated as *CS**; *WGs* and *WOs* being responsible for the radioactive waste as *WG**; *OCs* and *TSs* representing specialised technical consulting service in early phases as *OC**. Referring to their definitions (see 4.2.1) it could be expected that particularly the functions of *OC** are underestimated throughout a RWM programme. Note that the spectrum of functions of *TCCs* seems to be nearly identical to that of *TSOs* except of ´regulatory oversight´ (function g) (Tab. 8, Fig. 9, Fig. 11). ´Regulatory oversight´ is assigned to *TSOs*, solely. This function characterises the difference between *TSOs* and *TCCs*, however this conclusion is made on the basis of the response from one *TCC*.

Functions of the *other actors* identified by *WMOs*

Regarding *WMOs*, *Regs* is their decisive counterpart with the maximum of indications. Except for phase 2 (site characterisation) and phase 5 (post closure) the number of indications is constantly high. Of interest is the high number of indications of *Mins* showing a trend comparable to *Regs*. However, *Mins* can play many roles. In respect to the ´historic´ RWM programmes and facilities, *Mins* may act as *WMOs*, *Regs* or a licensing authority comparable to *SAs* in different countries. *Mins* may also fund parts or some of the activities involved in the programme (e.g. in Belgium) as a consequence of a legacy waste and state responsibility in this matter. Additionally, besides the *contributing actors TSOs* and *REs*, the *other actors TCCs* and *GSs* are very often indicated in phases 0 and 1, which reflects the necessity to include geological research and investigation issues already in phase 0 and phase 1 of the radioactive waste disposal process. *Muns* are also often indicated with maximum of indications in phase 3 (repository facility construction). However, it is unusual that *Muns* are not seen as a key actor in phase 2, since they are an important stakeholder involved in the siting process (e.g. in Switzerland) and involvement also during the site characterization phase can be expected. This probably depends on the national programmes specifc roles of *Muns*.

Functions of the *other actors* identified by *TSOs*

TSOs denominate a higher number of actors than *REs.* Besides *WMOs*, again *Regs* show a high number of indications, since *Regs* use the services offered by *TSOs*. Regarding the function ´regulatory oversight´ *TSOs* are linking *WMOs* and *Regs*, a function of *TSOs* that is transparently highlighted. Furthermore, a strong link is given to *REs*. An intensive interaction of *TSOs* with *WGs*, *GSs*, *OCs* may exist as well. This may underpin their cross-sectional and networking tasks as safety assessments and performance assessments need a coupling of several aspects that is reflected by the interactions of *TSOs* with other specialised actors. There was an indication of *Mins* by *TSOs*. *Mins* can play an important role in the context of funding as another source of funding for *TSOs* and *REs*, e.g. they can manage selected areas of the national RD&D programme.

Functions of the *other actors* identified by *REs*

WMOs and *Regs* show a high number of indications, but limited to phases 0 - 3. Additionally, *REs* interact with *WGs* preferentially in phase 4 – the operational phase of the facility – in connection with the acceptance of radioactive waste into the repository and the demonstration of compliance with the approved waste acceptance criteria. The driving factor of this peculiarity is probably that only *REs* own the necessary infrastructure and equipment to handle and to investigate radioactive waste, e.g. in order to specify its composition or to characterise it for documentation issues. Clearly, *REs* interact with other *REs* to exchange the research results. It has to be remarked that there were 3 indications of *Mins* as an *other actor* but on a generic level.

Summary

The self-assessment provided by the responding organisations confirms generally the actor classification and definition given in Section 4.2.1 except for actor *Mins*. *Mins* seem to have more and different functions going far beyond the definition given in Section 4.2.1, depending on the country and the type of facility. This aspect cannot be clarified through the analysis of the 1st UMAN questionnaire and its interpretation because *Mins* as *other actors* were not asked to provide a self-assessment of their functions.

Attention is drawn to the very low number of indications of *CS**. This result can be understood in three ways:

(1) They are in fact neglected in various phases of radioactive disposal,

(2) One of the main actors responsible for *CS* participation, *Regs*, did not contribute to the 1st UMAN questionnaire and as a consequence, *CS* as *other actor* is not captured,

(3) The 1st UMAN questionnaire respondents could be mainly technical staff focusing on technical aspects of RWM programme rather than on socio-economical issues.

It should be noted however that, according to the international standards (e.g. IAEA, 2011c; Council Directive 2011/70/EURATOM), Member States shall ensure that necessary information on the management of spent fuel and radioactive waste be made available to the general public. This obligation includes ensuring that the competent regulatory authority informs the public in the fields of its competence. Member States shall also ensure that the public receives the necessary opportunities to participate effectively in the decision-making process regarding spent fuel and radioactive waste management in accordance with national legislation and international obligations.

The involvement and interest of *CS* in RWM programmes and in particular in the management of uncertainty will be addressed in Task 5 of the UMAN WP.

Similarly to *CS**, there is a remarkable low number of indications for *Govs*, which in reality represent key actors in RWM programmes. According to IAEA (2011c) and OECD/NEA (2020) the *Govs* are ´required to establish and maintain an appropriate governmental, legal and regulatory framework for safety within which responsibilities shall be clearly allocated for disposal facilities for radioactive waste to be sited, designed, constructed, operated and closed. This shall include: confirmation at a national level of the need for disposal facilities of different types; specification of the steps in development and licensing of facilities of different types; and clear allocation of responsibilities, securing of financial and other resources, and provision of independent regulatory functions relating to a planned disposal facility.´

5.3 Discussion on biases and uncertainties related to the identified actors

The analysis of the replies of the responding organisations to the 1st UMAN questionnaire is burdened with certain biases that originate both from the side of the responding organisations and the persons

involved in the analysis of the replies. Possible biases related to the responding organisations, that were identified in the course of the analysis, encompass:

- Incomplete answers provided to the questionnaire resulting in a biased picture of the actors involved in a RWM programme and their role / functions.
- Incorrect answers provided to the questionnaire resulting from misunderstanding of the requests formulated in the questionnaire / unclear formulation of the requests in the questionnaire.
- Lack of knowledge of the national framework or of the stakeholders involved in a RWM programme due to e.g. the available knowledge and experience reflecting the current phase of the national RWM programme; the character of the functions played by the replying organisations in national RWM programme.
- Imprecise separation of individual phases of national programmes.

When considering the performed analysis of the responses to the 1st UMAN questionnaire, the following biases are identified:

- Misinterpretation of the information provided to the questionnaire due to the very different detail levels and the way the information was entered in the questionnaire (i.e. problematic allocation of functions to the actors).
- Incorrect classification of the actors identified by the responding organisations due to the lack of knowledge on the political / administrative system of the countries represented by the responding organisations. As a result, some important actors with unclear functions, often country-specific, might be categorised as ´*Miscellanoeus Actor*´, which in turns affects the overall picture of the actors involved in a RWM programme.
- Neglecting the ´generic answers´ (i.e. phase non-specific answers) when analysing the actors involvement in the phases of a RWM programme.
- Possibly low representativeness of the results due to the fact that the group of the respondents to the questionnaire was narrowed to three different types of organisations, namely *WMOs*, *TSOs*, *REs* as well as one *TCC*.

The uncertainties related to actors' definition and their involvement in a RWM programme, identified on the basis of the answers to Part 2 of the 1st UMAN questionnaire, are presented in Table 9. They should be included into the list of the uncertainties to be managed within the phases and themes of a RWM programme considered in EURAD. Moreover, they constitute a valuable input to UMAN Subtask 3.4 where uncertainties related to human aspects potentially relevant to safety and the decision-making process are identified. The work of Subtask 3.4 is used as an input to Subtask 4.2 ´*Compilation and review of available information on possible uncertainty management options*´.

In this context, the results documented in the present report are extremely valuable as they provide a unique overview of different actors and their occurrence and functions in different phases of a RWM programme. As uncertainties are often phase-related, this knowledge can be helpful to address uncertainties and to reduce / mitigate them as this report identifies the important actors and their functions for each phase. Most of the uncertainties presented in Table 9 cannot be ´simply´ eliminated and/or reduced by developing the degree of knowledge through RD&D activities. They can be positively influenced by the timely and active involvement of all interested actors and a transparent process.

Theme / Phase	**Uncertainties**
Across all topics and the RWM programme phases	Real involvement of all necessary actors and their influence on RWM programme
Theme 1 – Managing implementation and oversight of a waste management program (mainly in phases 0 - 1)	Building confidence in the programme, possible resistance from local communities
Theme 5 – Geological disposal facility design and the practicalities of construction, operation and closure	Special arrangements required by environmental actors and municipalities
Theme 6 – Siting and licensing	Expression of interest / VETO right of municipalities – it can have an impact on: - the regulatory framework and licensing process - increasing the time required for the entire approval and licensing process

Table 9 – Uncertainties related to actors definition and their functions as identified based on the replies to the 1st UMAN questionnaire

6. Recommendations for future EURAD activities

The analysis of the replies of the responding organisations to the 1st UMAN questionnaire shows that the identified actors (i.e. both the ´*contributing actors*´ and the ´*other actors*´) involved in the RWM programme represents a very complex system of stakeholders with strong dependencies and interactions among each other. In order to improve the understanding and the transparency of these complex interactions among the identified actors, it might be of interest to apply a social network analysis to visualise these interactions graphically using a database as complete as possible. Through this analysis, potential instable parts and points of time of instability of the interaction network can be identified in order to reduce the uncertainties that cannot be ´simply´ eliminated and/or reduced by knowledge development through RD&D activities.

7. Synthesis of the results

For the purposes of a better visualisation of the results of the analysis of the replies to the 1st UMAN questionnaire and their more convenient application by the users, collected data are presented in a tabular form. The phases of a RWM programme at which identified actors are involved are provided in Table 10. The actors involved in RWM programme phases is marked by symbol ✓; in case of no indication provided by the responding organisations the cell was left empty. ´Generic answer´ means that solely a generic answer (i.e. phase non-specific) was provided by the responding organisations.

The functions of the organisations that responded to the 1st UMAN questionnaire (i.e. the contributing actors of category WMO, TSO, RE and TCC) are provided in Table 11 for the different phases of a RWM programme based on their self-assessment. The functions recognised by the responding organisations as their responsibility are marked by symbol ✓.

Actor	Phase of RWM programme					
	Phase 0	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
WMO	✓	✓	✓	✓	✓	✓
TSO	✓	✓			✓	
RE	✓	✓	✓	✓	✓	
WG	✓	✓	✓	✓	✓	
WO			✓			
Reg	✓	✓	✓	✓	✓	✓
Gov/Leg	✓	✓	✓	✓	✓	
SA				✓	✓	
Min	✓	✓	✓	✓	✓	✓
Mun	✓	✓	✓	✓	✓	
CS	✓	✓	✓			
EA	✓	✓		✓	✓	
NGO	Generic answer	Generic answer	Generic answer	Generic answer	Generic answer	Generic answer
GS	✓	✓	✓	✓	✓	
TS		✓				
OC	✓	✓		✓	✓	
TCC	✓	✓	✓	✓	✓	
MA	✓	✓	✓	✓	✓	

Table 10 – Syntheses of the contributing and other actors and their involvement in the different phases of a RWM programme, based on the answers to the 1st UMAN questionnaire and seen from the perspective of the responding organisations (i.e. the contributing actors of category WMO, TSO, RE and TCC).

Phase of RWM programme	Actor	Actors´ function							
		a) Initiation and Planning	b) Execution / Implementation	c) Funding	d) Research	e) Safety Assessment	f) Civil Society Participation	g) Regulatory oversight	h) Any other involvement
Phase 0	WMO	✓	✓	✓	✓	✓	✓	✓	✓
	TSO	✓	✓	✓	✓	✓	✓	✓	✓
	RE	✓		✓	✓	✓			✓
	TCC	✓	✓		✓	✓	✓		
Phase 1	WMO	✓	✓	✓	✓	✓	✓	✓	
	TSO	✓	✓		✓	✓	✓	✓	✓
	RE				✓	✓			✓
	TCC	✓	✓		✓	✓	✓		
Phase 2	WMO	✓	✓	✓	✓	✓	✓	✓	✓
	TSO	✓	✓		✓	✓	✓	✓	
	RE				✓				✓
	TCC	✓	✓		✓	✓	✓		
Phase 3	WMO	✓	✓	✓	✓	✓	✓	✓	
	TSO	✓	✓		✓	✓	✓	✓	✓
	RE				✓	✓			✓
	TCC	✓	✓		✓	✓	✓		
Phase 4	WMO	✓	✓	✓	✓	✓	✓	✓	
	TSO	✓	✓		✓	✓	✓	✓	
	RE				✓	✓			
	TCC	✓	✓		✓	✓	✓		
Phase 5	WMO	✓	✓	✓	✓	✓			
	TSO	✓	✓		✓	✓	✓	✓	
	RE								
	TCC			✓	✓	✓			

Table 11 – Syntheses of the contributing and other actors and their functions in the different phases of a RWM programme. The synthesis shows the data provided in Part 2 of the 1st UMAN questionnaire given by the responding organisations (i.e. the contributing actors of category WMO, TSO, RE and TCC). Some of the functions stated by the responding organisations might deviate from the original definitions made by e.g. EURAD itself or the IAEA for these actors. For more information on this, the reader is referred to Section 4.3 and Chapter 5.

8. Conclusions

Characterisation of the actors with respect to their engagement into all phases of the RWM programme has been achieved on the basis of the analysis of the replies of the responding organisations to the 1st UMAN questionnaire i.e. *WMOs*, *TSOs*, *REs* and one *TCC*. These replies allowed the identification of the individual actors, their classification into 18 actors´ categories as well as the determination of the´*contributing actors*´ functions and responsibilities in each phase of the RWM programme. The actors identified in this study represent actors involved in the management of all types of radioactive waste with geological disposal and near-surface disposal considered as endpoint. The categories of the actors identified in this report represent a very important input for UMAN Subtask 4.3 ´*Preferences of the different actors on uncertainty management options*´, in which preferable options of uncertainties management are to be assigned to these actors.

Grouping of the actors identified at national level by the responding organisations from 19 countries was challenging due to the specifics of their national RWM programmes (including their current implementation stage), political and administrative systems. In addition, the functions of some individual actors seems to be intertwined and thus a strict division of their roles is very difficult. Further difficulties arise from the fact that the roles of the actors in the countries running RWM programmes and disposal facilities licensed under different political systems do not fully correspond to the responsibilities defined by the current international standards as the implementation of the latter is a long process. However, an effort was made to introduce standard (i.e. country non-specific) actors´ categories. The 18 identified categories of actors include the ´*contributing actors*´ who answered to the 1st UMAN questionnaire (i.e. the actors of category *WMO*, *TSO* / *TCC* and *RE*) and the ´*other actors*´ (i.e. the actors identified by the contributors to the 1st UMAN questionnaire).

A particularly comprehensive characterisation of the ´*contributing actors*´ has been achieved through the self-assessment of the roles and responsibilities of the responding organisations participating in the 1st UMAN questionnaire. The responding organisations identified a wide spectrum of ´*other actors*´ that play a role in the RWM programme. However, it is questionable whether responding organisations are capable at this stage to provide detailed information on the roles and interests of the ´*other actors*´ for all phases of the RWM programme.

The types and number of actors identified varied among the responding organisations, reflecting the different approaches employed in the national RWM programmes as well as the different national frameworks and thus political and administrational systems of the countries represented by these respondents. Particularly in the early implementation phases of a RWM programme, it can be expected that the overall framework of RWM, including the system of allocation of competencies and description of the decision-making process, is still evolving, and therefore the functions of all actors are not fully clarified. It should be also underlined that the responding organisations identify all actors from the group ´*contributing actors*´, i.e. actors of category *WMO*, *TSO/TCC* and *RE*.

The results show clearly the complexity of the stakeholder system, consisting of numerous and very different actors characterised by very strong interactions and dependencies, indirectly indicated in the provided definitions of the actors´ categories. This stakeholder system is very multidisciplinary and includes organisations and individuals with different technical, political, scientific and societal backgrounds. Actors involved in policy-making process, establishment of international standards/requirements and research at international level (IAEA, OECD/NEA, etc.) were not recognised by the respondents. The actual picture of the actors might be affected by all the actors categorised as Miscellaneous Actors. Moreover, a slightly different pattern of actors can be expected when extending the group of the 1st UMAN questionnaire respondents to other categories of actors identified in this study, depending on their professional field, roles and interest.

The functions and responsibilities from the self-assessment of the responding organisations correspond well to the roles of the actors of categories *WMO*, *TSO* and *RE*, assumed in the definitions of the actors´ categories provided in Section 4.2.1. As a result of the strong interactions and dependencies among the ´*contributing actors*´ and the ´*other actors*´ in the framework of a RWM programme, activities of *WMOs*

with a low number of indications can signify that organisations of a supporting / consulting character can be mandated to carry out activities associated with functions for which WMOs are responsible.

Generally, the ´*other actors*´ are identified for all phases of a RWM programme, however with varying numbers of indications and actor categories, depending on the type of the responding organisations providing the information. The highest number of actors is attributed particularly to phases 0 and 1, while the lowest to phase 5. The widest spectrum of the actors is provided by *WMO*s and further by *TSO*s, while the narrowest by *RE*s. *TSOs*, among other responsibilities, provide support to *Regs*, which also communicate with a wide range of actors in the performance of their functions in a RWM programme. Therefore, *TSOs* as their supporting organisations should also have awareness of actors involved in the process. According to the results, the actors with the highest number of indications are *Regs*, *WMOs*, *Mins*, *REs*, *TCCs*, *WGs* and *TSOs,* i.e. those involved in framing and implementing the RWM programme, the decision-making process, regulatory overview, etc. Surprisingly, *CS* and *EAs* show a considerably lower number of indications than expected.

It should be also underlined that the results of the analysis of the responses to the 1st UMAN questionnaire do not imply or provide arguments that certain actors should officially be involved in the RWM programme.

The analysis of the replies of the responding organisations to the 1st UMAN questionnaire shows a need for the establishment of a more specific and detailed picture of the ´*other actors*´ (i.e. the actors of categories different from *WMOs*, *TSOs* and *REs*), involved in the RWM programme. This finding represents a very important input for the activities planned within Task 5 ´*Interactions between all categories of actors, including Civil Society*´ of UMAN. There could be a chance to refine the analysis of the ´*other actors*´ *e.g.* on a basis of a self-assessment of their roles, interests and possible influence during the planned seminars. Further, heterogeneous communities of ´*other actors*´ could be established, contributing to future EURAD activities. Moreover, the uncertainties associated with the roles, interests and impact of the identified actors, relevant to all themes and all phases of a RWM programme, could be considered in Subtasks 3.4 and 4.2 of UMAN when characterizing and analysing the management options of uncertainties related to human aspects.

Appendix A. Definition of EURAD phases of a RWM programme

Phase 0: Policy, framework and programme establishment - selection of suitable disposal options at a national level as government policy / commitment by national government to pursue and support the achievement of this goal. This often includes the creation of a waste management organisation (WMO) and establishing the appropriate regulatory oversight. Safety-documentation produced in this phase would be focused on meeting regulations for the safe storage and potentially conditioning /packaging of waste so that it is compatible with the options for the safe management of radioactive waste, including geological disposal. This phase may also consider the establishment of a regulated financing mechanism and a financing system to ensure that prioritised RD&D can be completed (IGD-TP, 2015).

Phase 1: Site Evaluation and Selection (generic studies and site selection) - a broad range of RD&D studies is required to support effective decision making on the approach to site selection, concept selection and site characterisation. Safety-documentation produced in this phase is typically aimed at demonstrating broadly the relative safety of disposal for available geology and concept scenarios to support effective decision making in relation to siting. Consideration for societal aspects may begin in this phase, for example consulting and involving national stakeholders on the process for site selection. A Strategic Environmental Assessment (SEA) may be undertaken in this phase in order to assess the environmental impact of a facility (IGD-TP, 2015).

Phase 2: Site characterisation (site characterisation and safety assessment for conceptual design) - surface-based investigation of a potential site or sites (prior to going underground) including geology-specific RD&D studies to aid final site-selection and concept-selection. Safety-documentation produced in this phase is typically adapted to site-specific (or geology-specific) conditions and will address local community requirements (in addition to national stakeholders previously involved in phase 2) to support decision making on final site selection and concept selection. This phase includes refinement of engineered barrier concepts, preliminary engineering design for constructability, establishment of baseline site conditions, and regulatory approval of a continuation of the investigations from an underground facility at one or more sites. The planning of this phase may integrate an Environmental Impact Assessment (EIA) procedure to assess the environmental impact(s) supporting the site(s) selected for building an underground facility (IGD-TP, 2015).

Phase 3: Repository facility construction (sites /underground development, demonstration and construction) - detailed site characterisation and design testing (including site-specific underground testing). This will include the construction of access ways (shafts or ramp) to the host rock; underground characterisation of the host rock; testing of excavation and construction techniques; formulation of a detailed repository design; and the establishment of a detailed operational safety case. All this leads to seeking of regulatory approval to proceed to facility construction at the site. Detailed design work, and further development of license-oriented operational and long-term safety cases will continue throughout construction of the facility. Via licensing, it is likely that national regulatory permits would be staged during construction, with a first step of in-situ testing of a non-active pilot facility. This process would be achieved by progressive excavation, construction and fitting out of emplacement areas, leading to the decision to begin emplacement of waste. The safety case at this phase is mature and is often used to support licensing of a site. This phase may consider an update of the EIA procedure supporting the decision for construction (IGD-TP, 2015).

Phase 4: Operations and closure - includes the period of waste emplacement and any extended period of operation (open access ways and monitoring) beyond completion of emplacement. Thereafter, the remaining works include sealing and closure operations leading to the post-closure phase and the decision to cease active control (IGD-TP, 2015).

Phase 5: Post-closure - begins at the time when all the engineered containment and isolation features have been put in place, operational buildings and supporting services have been decommissioned and

the facility is in its final configuration. After its closure, the safety of the disposal facility is provided for by means of passive features inherent in the characteristics of the site and the facility and the characteristics of the waste packages, together with certain institutional controls, particularly for near surface facilities. Such institutional controls are put in place to prevent intrusion into facilities and to confirm that the disposal system is performing as expected by means of monitoring and surveillance. Monitoring may also be carried out to provide public assurance. The license will be terminated after the period of active institutional control, when all the necessary technical, legal and financial requirements have been fulfilled (IAEA, 2011b).

Appendix B. 1st UMAN questionnaire – selected parts

Introduction

Dear colleague,

The recently started European Joint Programme EURAD initiates a step change in European collaboration among waste management organizations (WMO), technical support organizations for regulators (TSO) and research entities (RE) as well as in interactions with civil society and other stakeholders (international organizations, waste generators…) towards safe radioactive waste management. Uncertainty is a cross-cutting issue within the different scientific themes and phases[1] identified in the Roadmap and in the Strategic Research Agenda of EURAD.

While the involvement of stakeholders is essential to the decision-making process at all phases of a radioactive waste management programme, decisions associated with each of these phases have to be made in the presence of both irreducible and reducible uncertainties. Some of these uncertainties decrease as new information becomes available (e.g. "as-built" properties, monitoring data, RD&D results…) whereas activities associated with the programme (process modelling, safety assessment…) can also lead to new viewpoints and sometimes new uncertainties. At the end of the process, uncertainties will inevitably remain but it should be demonstrated that these uncertainties do not undermine safety arguments. Hence, the management of uncertainties[2] represents a key part of successful programme planning and is central to the safety case[2] of waste management facilities providing the arguments and evidence demonstrating their safety. Dealing with uncertainties associated with waste disposal facilities is particularly challenging due to the long timescales over which wastes will continue to be generated and packaged, and disposal facilities will be constructed and operated, and the very long timescales during which the radiotoxicity of the waste remains significant after disposal.

EURAD gives the opportunity to its participants to network on such methodological and strategic issues and challenges that are common to various national programmes and in direct links with scientific and technical issues. In this context, an "Uncertainty Management multi-Actor Network (UMAN)" has been created to share knowledge and discuss common methodological/strategical challenges in developing a common understanding among the different categories of actors (WMOs, TSOs, REs & Civil Society) on uncertainty management and how it relates to risk & safety. In cases where a common understanding is beyond reach, the objective is to achieve mutual understanding on why views on uncertainties and their management are different for different actors. The first step consists in an assessment of these different views. The questionnaire in appendix B attempts to collect answers to the following key questions:

- Who are the actors involved in the different phases of a disposal programme?
- What are their characteristics and roles in the programme and the management of uncertainties?
- What are your views on the types of uncertainties that need to be addressed in the safety assessment and safety case of radioactive waste disposal facilities?
- What is your opinion on how these uncertainties might evolve over time throughout the different phases of a disposal programme?
- What approaches can be used to manage these uncertainties?
- What are your expectations regarding stakeholder involvement in the management of uncertainties?

Your views on these questions constitute a key input to the UMAN WP and are needed to initiate several WP activities, in particular:

[1] See appendix A for the definition of these phases.
[2] See Appendix A for an explanation of this term.

- the compilation, review and comparison of uncertainty management strategies and approaches that can be used in a radioactive waste disposal programme (Subtask 2.1);
- the identification of the views of different actors on the types of uncertainties relevant to the safety assessment and the safety case and on their possible evolutions throughout the different programme phases (Subtask 3.1);
- the identification and characterization of the different actors across the entire radioactive waste management process (Subtask 4.1).

These subtasks will in turn provide the framework for other WP activities such as the identification and characterization of potentially safety-relevant uncertainties associated with specific topics (e.g. site characteristics, human aspects,…) (Subtasks 3.2 to 3.5) or the analyses and reviews of possible options for management of specific uncertainties - recognizing the preferences of different kinds of actors (Subtasks 4.2 and 4.3). Furthermore, answers to the questionnaire will constitute a valuable input to the interactions between all categories of actors including Civil Society that will take place in the framework of Task 5.

We will thus very much welcome any answer to this questionnaire.

We thank you very much in advance for your cooperation.

The UMAN WP Board & the leaders of WP Subtasks 2.1, 3.1 & 4.1

What do we expect from you?

To what questions should you answer?

The questionnaire comprises the following parts:

- Part 1: Background information;
- Part 2: Identification, characteristics and roles of actors involved in radioactive waste management programmes;
- Part 3: Views on the types of uncertainties that need to be addressed in safety cases and their possible evolution throughout the programme phases;
- Part 4: Strategies for managing uncertainties;
- Part 5: Expectations of actors regarding stakeholder involvement.

The questionnaire includes two categories of questions:

- Questions related to the national framework for radioactive waste management. These questions are particularly addressed to WMOs and TSOs.
- Questions on your views on different aspects of uncertainty management and stakeholder involvement.

How should you answer ?

- You can directly answer in this word document. Please return your completed questionnaire to astrid.goebel@bge.de and nina.mueller-hoeppe@bge.de

When should you answer?

We would appreciate if you could provide your answers by the 24th of September 2019.

Part 1 - Background information

1. E-mail address:

2. Your name and surname:

3. Organisation unit:

4. Your role in the organization unit.

   a. Please select your field(s) of work:
      - ☐ Research on safety-relevant processes or on the performance of individual barriers of a disposal facility;
      - ☐ Safety assessment
      - ☐ Management
      - ☐ Other (please specify)

   b. Please explain briefly your role in your organization unit and your background.

The following questions concerning the mission and current phase of national disposal programme(s) should be answered by WMOs and TSOs (they are generally more aware of the current status of the national programme). However, the view of your organization unit would be greatly appreciated.

5. What is the mission of your national radioactive waste disposal programme(s) ?

   Provide information on the programme mission, which might be, for example, to develop a near-surface disposal facility for the nation's short-lived intermediate level waste, or a geological disposal for spent fuel from civil nuclear power reactors.

6. At what phase is/are the radioactive waste disposal programme(s) ?

The programme(s) might be at an early stage of concept development with no particular disposal site or geological environment identified (Phase 0: Policy, framework and programme establishment), a site identification and selection process may be ongoing (Phase 1: Site evaluation and site selection), characterisation of a candidate site(s) may be underway while licence may be being sought for construction (Phase 2: Site characterisation), the facility may be under construction (Phase 3: Facility construction), disposal operations may be progressing (Phase 4: Facility operation and closure) or the facility may be closed (Phase 5: Post-closure).

Part 2 – Identification, characteristics and roles of actors involved in radioactive waste management programmes

The objective of this questionnaire's part is in this early step to gather comprehensive information about actors involved at each phase of a radioactive waste disposal programme. Based on your responses the identified actors will be characterised and grouped with respect to their roles in the programme, their possible contribution to the management of uncertainties and views on uncertainties and risks. Your response will be an important contribution to improve mutual understanding of the different stakeholders and will be provided to the other UMAN tasks for further consideration.

Within BGE your organization unit is asked to fill in the table hereunder considering the current status of its national radioactive waste management (in particular disposal) programme. The structure of the table is based on the programme phases and themes identified in the EURAD roadmap. Please answer,

as far as possible, for each phase and each theme. In case an assignment to a phase is not possible please use the line “Generic Indication - no phase reference” for your response.

1. [column 3] Is this phase/theme relevant for your organization unit?

Please either choose “?” (no information available/I do not know), “Y” (Yes, this phase/theme is relevant for my organization unit) or “N” (No, this phase/theme is not relevant for my organization unit).

2. [column 4] Is this information for this phase/theme available?

Please either choose “Y” (Yes, I can give indication for my organization unit) or “N” (No, I am not able to give an indication).

2. [column 5] What functions/roles do you identify for this phase and theme considering the different actors in your organization unit involved in the national waste management programme?

a. Initiation / Planning

b. Execution / Implementation

c. Funding

d. Research

e. Safety Assessment

f. Civil Society Participation

g. Regulatory oversight

h. Any other involvement (please specify)

3. [column 6] Do you identify any further stakeholders having an interest in or a potential impact on uncertainties and their management? If yes, please provide the names of these organizations and specify the roles of the actors.

4. [column 7] Please explain what are the interests in or potential impact on safety and uncertainties of all identified actors (indicated in column 5 and 6)?

COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4	COLUMN 5	COLUMN 6	COLUMN 7
Phase	**Theme**	**Phase/theme relevant for your organization unit? (?/Y/N)**	**Information available? (Y/N)**	**Functions of your organization unit:** **a) Initiation/Planning** **b) Execution/Implementation** **c) Funding** **d) Research** **e) Safety Assessment** **f) CS Participation** **g) Regulatory oversight** **h) Any other Involvement**	**Other actors (optional, if identified): Name and roles**	**Interests and potential impact on safety and uncertainties of actors (indicated in column5 and 6)**
Generic answers (not phase-specific)						
Phase 0 Policy, Framework & Programme Establishment	Theme 1 Managing implementation and oversight of a waste management programme					
	Theme 2 Radioactive waste characterization, treatment, packaging and storage (Pre-disposal activities), and source term understanding for disposal					
	Theme 3					

COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4	COLUMN 5	COLUMN 6	COLUMN 7
Phase	**Theme**	**Phase/theme relevant for your organization unit? (?/Y/N)**	**Information available? (Y/N)**	**Functions of your organization unit:** **a) Initiation/Planning** **b) Execution/Implementation** **c) Funding** **d) Research** **e) Safety Assessment** **f) CS Participation** **g) Regulatory oversight** **h) Any other Involvement**	**Other actors (optional, if identified): Name and roles**	**Interests and potential impact on safety and uncertainties of actors (indicated in column5 and 6)**
	Engineered barrier system (EBS) properties, function and long-term performance					
	Theme 4 Geoscience to understand rock properties, radionuclide transport and long-term geological evolution					
	Theme 5 Geological disposal facility design and the practicalities of construction, operation and closure					
	Theme 6 Siting and licensing					
	Theme 7					

COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4	COLUMN 5	COLUMN 6	COLUMN 7
Phase	**Theme**	**Phase/theme relevant for your organization unit? (?/Y/N)**	**Information available? (Y/N)**	**Functions of your organization unit:** **a) Initiation/Planning** **b) Execution/Implementation** **c) Funding** **d) Research** **e) Safety Assessment** **f) CS Participation** **g) Regulatory oversight** **h) Any other Involvement**	**Other actors (optional, if identified): Name and roles**	**Interests and potential impact on safety and uncertainties of actors (indicated in column5 and 6)**
	Performance assessment, safety case development, and safety analyses					
Phase 1 **Site Evaluation & Selection**	Theme 1 Managing implementation and oversight of a waste management programme					
	Theme 2 Radioactive waste characterisation, treatment, packaging and storage (Pre-disposal activities), and source term understanding for disposal					
	Theme 3 Engineered barrier system (EBS) properties, function and long-term performance					

COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4	COLUMN 5	COLUMN 6	COLUMN 7
Phase	**Theme**	**Phase/theme relevant for your organization unit? (?/Y/N)**	**Information available? (Y/N)**	**Functions of your organization unit:** **a) Initiation/Planning** **b) Execution/Implementation** **c) Funding** **d) Research** **e) Safety Assessment** **f) CS Participation** **g) Regulatory oversight** **h) Any other Involvement**	**Other actors (optional, if identified): Name and roles**	**Interests and potential impact on safety and uncertainties of actors (indicated in column5 and 6)**
	Theme 4 Geoscience to understand rock properties, radionuclide transport and long-term geological evolution					
	Theme 5 Geological disposal facility design and the practicalities of construction, operation and closure					
	Theme 6 Siting and licensing					
	Theme 7 Performance assessment, safety case development, and safety analyses					
Phase 2	Theme 1					

COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4	COLUMN 5	COLUMN 6	COLUMN 7
Phase	**Theme**	**Phase/theme relevant for your organization unit? (?/Y/N)**	**Information available? (Y/N)**	**Functions of your organization unit:** **a) Initiation/Planning** **b) Execution/Implementation** **c) Funding** **d) Research** **e) Safety Assessment** **f) CS Participation** **g) Regulatory oversight** **h) Any other Involvement**	**Other actors (optional, if identified): Name and roles**	**Interests and potential impact on safety and uncertainties of actors (indicated in column5 and 6)**
Site Characterization	Managing implementation and oversight of a waste management programme					
	Theme 2 Radioactive waste characterisation, treatment, packaging and storage (Pre-disposal activities), and source term understanding for disposal					
	Theme 3 Engineered barrier system (EBS) properties, function and long-term performance					
	Theme 4 Geoscience to understand rock properties, radionuclide transport and long-term geological evolution					

COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4	COLUMN 5	COLUMN 6	COLUMN 7
Phase	**Theme**	**Phase/theme relevant for your organization unit? (?/Y/N)**	**Information available? (Y/N)**	**Functions of your organization unit:** **a) Initiation/Planning** **b) Execution/Implementation** **c) Funding** **d) Research** **e) Safety Assessment** **f) CS Participation** **g) Regulatory oversight** **h) Any other Involvement**	**Other actors (optional, if identified): Name and roles**	**Interests and potential impact on safety and uncertainties of actors (indicated in column5 and 6)**
	Theme 5 Geological disposal facility design and the practicalities of construction, operation and closure					
	Theme 6 Siting and licensing					
	Theme 7 Performance assessment, safety case development, and safety analyses					
Phase 3 **Repository Facility Construction**	Theme 1 Managing implementation and oversight of a waste management programme					
	Theme 2					

COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4	COLUMN 5	COLUMN 6	COLUMN 7
Phase	**Theme**	**Phase/theme relevant for your organization unit? (?/Y/N)**	**Information available? (Y/N)**	**Functions of your organization unit:** **a) Initiation/Planning** **b) Execution/Implementation** **c) Funding** **d) Research** **e) Safety Assessment** **f) CS Participation** **g) Regulatory oversight** **h) Any other Involvement**	**Other actors (optional, if identified): Name and roles**	**Interests and potential impact on safety and uncertainties of actors (indicated in column5 and 6)**
	Radioactive waste characterisation, treatment, packaging and storage (Pre-disposal activities), and source term understanding for disposal					
	Theme 3 Engineered barrier system (EBS) properties, function and long-term performance					
	Theme 4 Geoscience to understand rock properties, radionuclide transport and long-term geological evolution					
	Theme 5 Geological disposal facility design and the practicalities					

COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4	COLUMN 5	COLUMN 6	COLUMN 7
Phase	**Theme**	**Phase/theme relevant for your organization unit? (?/Y/N)**	**Information available? (Y/N)**	**Functions of your organization unit:** **a) Initiation/Planning** **b) Execution/Implementation** **c) Funding** **d) Research** **e) Safety Assessment** **f) CS Participation** **g) Regulatory oversight** **h) Any other Involvement**	**Other actors (optional, if identified): Name and roles**	**Interests and potential impact on safety and uncertainties of actors (indicated in column5 and 6)**
	of construction, operation and closure					
	Theme 6 Siting and licensing					
	Theme 7 Performance assessment, safety case development, and safety analyses					
Phase 4 **Repository Facility Operation & Closure**	Theme 1 Managing implementation and oversight of a waste management programme					
	Theme 2 Radioactive waste characterisation, treatment, packaging and storage (Pre-disposal activities), and					

COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4	COLUMN 5	COLUMN 6	COLUMN 7
Phase	**Theme**	**Phase/theme relevant for your organization unit? (?/Y/N)**	**Information available? (Y/N)**	**Functions of your organization unit:** **a) Initiation/Planning** **b) Execution/Implementation** **c) Funding** **d) Research** **e) Safety Assessment** **f) CS Participation** **g) Regulatory oversight** **h) Any other Involvement**	**Other actors (optional, if identified): Name and roles**	**Interests and potential impact on safety and uncertainties of actors (indicated in column5 and 6)**
	source term understanding for disposal					
	Theme 3 Engineered barrier system (EBS) properties, function and long-term performance					
	Theme 4 Geoscience to understand rock properties, radionuclide transport and long-term geological evolution					
	Theme 5 Geological disposal facility design and the practicalities of construction, operation and closure					
	Theme 6 Siting and licensing					

COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4	COLUMN 5	COLUMN 6	COLUMN 7
Phase	**Theme**	**Phase/theme relevant for your organization unit? (?/Y/N)**	**Information available? (Y/N)**	**Functions of your organization unit:** **a) Initiation/Planning** **b) Execution/Implementation** **c) Funding** **d) Research** **e) Safety Assessment** **f) CS Participation** **g) Regulatory oversight** **h) Any other Involvement**	**Other actors (optional, if identified): Name and roles**	**Interests and potential impact on safety and uncertainties of actors (indicated in column5 and 6)**
	Theme 7 Performance assessment, safety case development, and safety analyses					
Phase 5 **Post-closure Phase**						

Appendix C. Definition of radioactive waste types according to IAEA (2009)

Very short lived waste (VSLW) is ´waste that can be stored for decay over a limited period of up to a few years and subsequently cleared from regulatory control according to arrangements approved by the regulatory body, for uncontrolled disposal, use or discharge. This class includes waste containing primarily radionuclides with very short half-lives often used for research and medical purposes´ (IAEA, 2009).

Very low level waste (VLLW) is ´waste that does not necessarily meet the criteria of exempt waste* (EW), but that does not need a high level of containment and isolation and, therefore, is suitable for disposal in near surface landfill type facilities with limited regulatory control. Such landfill type facilities may also contain other hazardous waste. Typical waste in this class includes soil and rubble with low levels of activity concentration. Concentrations of longer lived radionuclides in VLLW are generally very limited´ (IAEA, 2009).

Low level waste (LLW) is waste that is suitable for near-surface disposal and may include material that requires shielding and containment for up to several hundred years because of its activity, as well as low concentrations of long-lived radionuclides. In some countries, such wastes are categorised as low and intermediate level short-lived waste (LILW-SL) and low level long-lived waste (LLW-LL) (after Hicks et al., 2020).

Intermediate level waste (ILW) is waste that contains long-lived radionuclides in quantities that require longer term containment and isolation (i.e., geological disposal). In some countries, such wastes are categorised as intermediate level long-lived waste (ILW-LL) (after Hicks et al., 2020).

High level waste (HLW) is ´waste such as spent nuclear fuel (SNF) and vitrified waste from spent fuel reprocessing that contains higher concentrations of radionuclides than ILW and requires containment and isolation in a geological disposal facility. In some countries, HLW refers only to vitrified waste from reprocessing; wastes such as spent nuclear fuel (SNF) are categorised separately´ (Hicks et al., 2020).

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*Exempt waste (EW): Waste that meets the criteria for clearance, exemption or exclusion from regulatory control for radiation protection purposes (IAEA, 2009).

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