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Conditions for establishing a sustainable expertise network

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Contents

1 Foreword

The objective of the SITEX project (EURATOM- FP7) is to identify the conditions and means in order to establish an international network for harmonizing European approaches to technical expertise of geological repositories for radioactive waste, as a support to national nuclear authorities. The SITEX Project brought together 15 organisations representing technical safety organisations (TSOs) and safety authorities, as well as Civil Society outreach specialists during a 24 month Concerted Action.

SITEX plans are to establish the conditions required for developing a sustainable network of technical safety experts who have their own skills and analytical tools, independently of the implementers, and who are capable of conducting their own research programs.

In that perspective, this document lays the foundation for the expertise function in the context of the safety review of Radioactive Waste Geological Disposal on the basis of several sources listed below. It identifies conditions and means of a sustainable expertise function in the concerned countries. It also identifies the needs of international cooperation between organizations carrying expertise function in the context of an international SITEX network whose creation is considered.

The sources used for this report are:

- International and national standards and guides (defining the expectations of regulators),
- An inventory of the expertise function in SITEX partner countries and an overview of the needs of harmonization of expertise as part of technical support and inspection for national regulators,
- An overview of the methodologies used in the context of a Safety Case Review (SCR) and an inventory of the needs of harmonization of these methodologies and of specific training required to implement the SCR,
- An inventory of Research & Development (R&D) programs, facilities implemented and modelling carried out by organisations involved in SITEX,
- An overview of expectations of other stakeholders in terms of interaction with the expertise function (notably on the basis of the results of the SENEC Workshop in Slovakia, and the exchanges organised with Waste Management Organisations (WMOs) in the framework of IGD-TP.

2 Summary

The Deliverable D6.1 identifies the conditions and means to ensure the existence of a sustainable expertise function, at national level, in the countries concerned by the SITEX project. This report also presents a common understanding (shared by the SITEX participants) of the function of expertise and its missions, as well as a review of the various institutional setting of expertise functions in the different national contexts. It also considers the requirements of the other stakeholders (Civil Society, implementers) regarding their interactions with the national expertise function. The different needs

and missions of the national expertise function along the Decision Making Process (DMP), have been identified in respect with and are related to: Safety Case Regulatory Review, Implementation of Research in Safety, Training of Experts in charge of regulatory review and Interaction with Civil Society. Regarding these different functions, the report identifies the potential areas of cooperation, exchanges or sharing of resources that could be developed by the future SITEX network. These opportunities are further developed in deliverable D6.2 “Terms of Reference of the SITEX Network”.

3 Characterization of the national expertise function at the national level

This section is outlining the various tasks of the national expertise function, detailing the requirements that govern the implementation of these tasks and the skills and knowledge that are necessary to perform these tasks. It describes the interactions of the expertise function with other stakeholders and at first with national safety authorities (regulators) and specifies the different types of existing expertise function according to the various national institutional frameworks represented within SITEX.

3.1 Definition of the national expertise function in the governance of radiological waste management (RWM)

The expertise function contributes in activities carried out in the context of the regulatory review of Safety Case in order to provide the technical and scientific basis of safety for:

- Decisions by the national regulatory body,
- Ensuring that regulatory expectations are clearly communicated to and interpreted by the implementer,
- Improving the quality of the interactions with Civil Society (CS) in the decision making process (DMP) in order to contribute to build a robust review of the Safety Case.

These activities (see sub-section 3.3 of this report for a more detailed description) can be assigned to experts inside or outside the regulatory body and include:

- Conducting safety review and developing the capacities to understand and assess the Safety Case,
- Contributing to inspections,
- Implementing R&D in safety,
- Interacting with CS along the review process and developing appropriate governance patterns to conduct this interaction.

In order to implement its activities, the expertise function must in particular rely on the following requirements:

- **Ensuring transparency**, this may involve public release of its assessments and reports, interactions with civil society, etc. (refer to SITEX D4.1 and D 5.2 and sub-section 3.2.2 of this report),
- **Demonstrating the independence of its resources and competences** vis-à-vis the implementer in order to avoid conflicts of interest (sub-section 3.2 of this report) notably regarding acquisition and use of scientific and technical knowledge,

These requirements contribute to guaranty the independence of the expertise function in particular vis-à-vis the implementing function.

According to the various national contexts, the expertise function is carried out within different types of institutional framework. Several actors may also contribute to the expertise function within the same national institutional framework**.**

The expertise function can be performed inside the regulatory body**:**

- **Included in the national safety authority body** as it is the case in the following contexts: CNSC in Canada, SSM in Sweden, ENSI in Switzerland,
- **Performed by subsidiary of National Safety Authority** as it is the case for the national safety authority FANC in Belgium and its technical subsidiary Bel°V.

But expertise functions can be also performed outside the regulatory body:

- **By an independent technical safety organization** (TSO) officially responsible for supporting the authority as IRSN for ASN in France and GRS for Federal State Authority in Germany,
- **By Universities, research institutes or other external organizations** like consultants or NGOs specialized in various disciplines at stake regarding safety as it is the case for LEI in Lithuania, UJV in Czech Republic, DECOM in Slovakia, NRG in Netherland. Public and private research organizations as well as Civil Society Organizations can also provide expertise in more specific fields of expertise such as governance, transparency implementation, law, etc.

The role and the interactions of the expertise function with the other stakeholders involved in the DMP are represented in the following scheme (**Figure 1**):

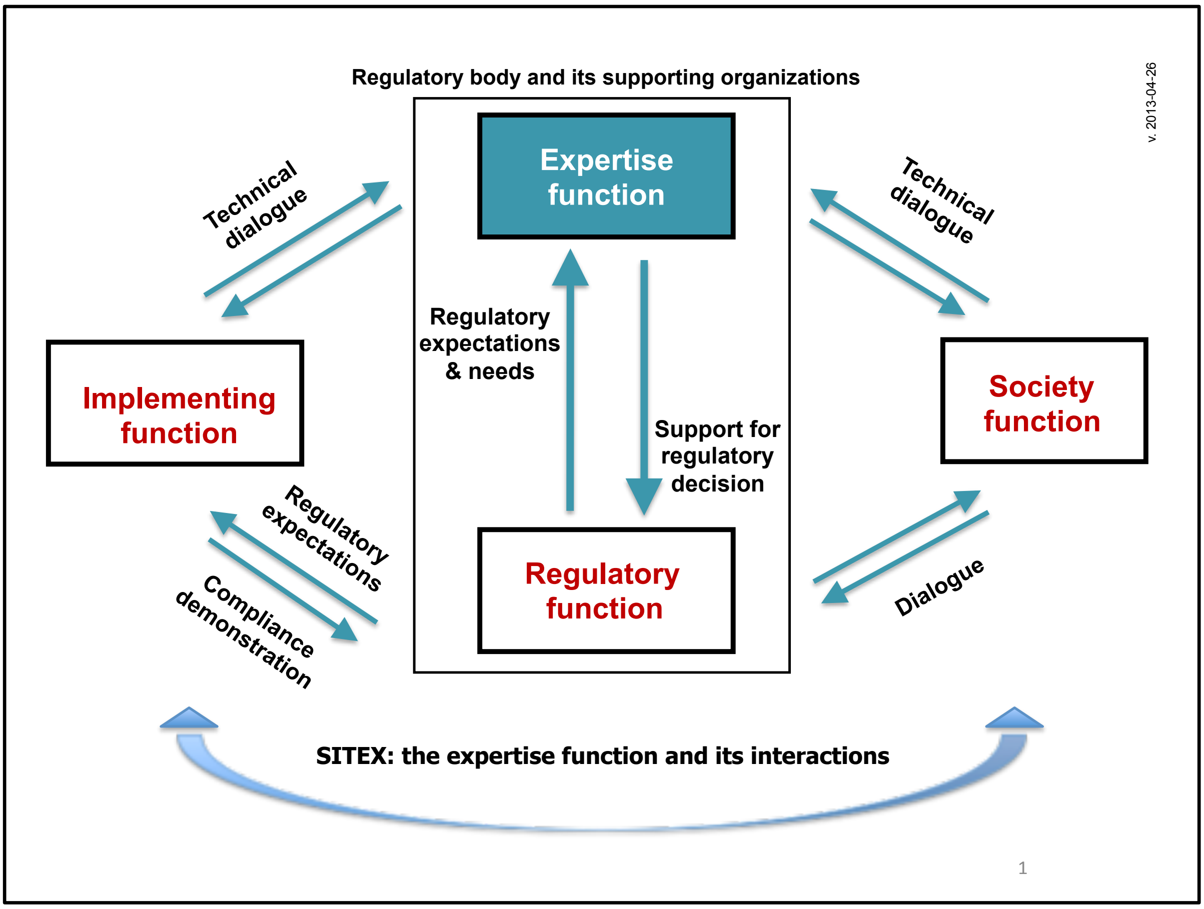

Figure 1: The expertise function and its interactions

Interactions between the expertise and regulatory functions contribute in:

- Developing the safety requirements and conditions that have to be fulfilled in order to meet the general safety objective of protecting human and the environment against the hazards associated to ionizing radiations ("Regulatory expectations");
- Assessing the compliance with these requirements and conditions ("Compliance demonstration").

Assessing compliance with safety requirements requires strong technical support from the expertise function. This includes several activities such as independent R&D, reviewing of safety demonstration and inspections. In order to provide the regulatory function with an adequate decision support, the regulatory needs associated with the evaluation of conformity have to be clearly formulated and communicated to the expertise function.

The expertise function interacts with the implementing function through technical dialogue with WMOs. For example this dialogue can include technical exchanges on R&D issues and on the adequacy of the approaches followed to tackle safety issues. These discussions can occur inside or outside the formal review of a Safety Case.

Finally, the expertise function also has to interact with the society function. It is indeed requested from the Civil Society to interact on the definition of the R&D programme carried out by expert's bodies and on Safety Case review with a specific emphasis on the assessment of the safety strategy and safety concept adopted by the implementer.

3.2 Basic requirements of the expertise function

SITEX Deliverable D4.1 identified basic requirements to achieve the missions of the expertise function (competence, transparency and independence). After this work of SITEX D4.1, additional discussions updated the conclusions on this topic. SITEX finally identifies three key conditions that are required in order to implement expertise and ensure the required level of quality of the expertise function:

- **Competence, experience and knowledge** notably provided by resources and skills independent from implementers (notably regarding safety, scientific and technical knowledge) in order to avoid conflicts of interests,
- **Transparency and proximity to the public**, involving public release of its assessments and reports and interactions with CS,
- **Impartiality when delivering a technical opinion** mainly afforded by the above requirements.

As already mentioned above, the implementation of these three key conditions contributes to allow the **independence** of the expertise function.

3.2.1 Competence, experience and knowledge

In general terms, the concept of competence is related to a proven ability to use appropriate knowledge and skills when studying or working on specific tasks, be they professional or personal. It is generally considered as a set of knowledge, skills and attitudes (KSAs) that are needed to perform a particular task (e.g., SARCoN). Whereas knowledge is the body of facts, principles, theories and practices that are related to a specific field of work or study, skills are the ability to apply knowledge and use know-how to complete tasks and solve problems. As developed below the competence of experts in this report also entails professional experience.

Staffing and competences of experts

As for other fields of technical expertise, the generalist experts (or nuclear facility experts) examining a Safety Case of Radioactive Waste Geological Disposal (RWGD) are those who know the installation and manage the whole technical review by recognising the main issues and identifying the topics that need further in-depth review using specific competences. They can be differentiated from the specialist experts, who have one or several of the specific technical competencies (developed in section 7 of this report), and on which the generalist experts can back on to build the global review of the Safety Case. The review of a Safety Case is combining the different views of specialist experts and generalist experts that have each important complementary role. Depending on countries, the review can be managed by one generalist expert gathering the reviews of specialist experts, or conversely by one of the specialist experts. Depending on how the review is managed, generalist experts are needed or not. The staff managers may also play their role.

3.2.2 Transparency and proximity with the public

As specified by the Forum on Stakeholder Confidence (FSC) in the 2013 NEA Annotated Glossary on the Stakeholder Confidence in Radioactive Waste Management, transparency

"includes not only allowing access to information (passive transparency) but also effort to provide information to interested parties and to unveil the logic behind decisions and processes (active transparency)".

In the perspective of SITEX, transparency towards stakeholders may also include several requirements such as:

- To **inform the public** by publishing the results of expertise that support decisions of the regulatory body,
- To make explicit and public, prior to the decision making process, the "**rules of the game**" (requirements and way to verify that they are applied, through technical review and inspections),
- To maintain over time, **consultations** with interested parties in the decision process and in particular with the Civil Society at national and local levels.

The SITEX participants agree with the fact that the implementer has a primary responsibility of demonstrating the public that the Safety Case is appropriate. However, the experts have also an important role in dialoguing with the public. The main expectation from the Civil Society is not only information, but is also to receive appropriate answers to their questions to institutional actors. In this perspective, the views and concerns of the public are to be duly taken into account along the DMP by Public authorities and their expertise function. They also have to provide the public with detailed explanations on the way the results of public participation have been taken into account in the decisions.

There is no available guidance on the way to conduct exchanges between experts and the Civil Society. This question is addressed in the 8th section of this report.

Demonstrating transparency appears to be necessary for all participating organisations in RWM. Transparency is expected all along the development of the project including the operational phase. However, the implementation of transparency depends on each country. A minimal requirement appears to be the dissemination of neutral and objective information (for example by publishing approved documents).

3.2.3 Impartiality

Impartiality is a fundamental requirement in order to be able to deliver neutral technical opinion to decision makers and ensure trust in the scientific arguments and confidence in the overall review process. Impartiality relies on competence as stated above and on the capability to avoid conflict of interest of the expertise function with implementing function. Absence of conflict of interest is mainly provided by the availability of independent means from the implementers and its subcontractors, provided by sufficient resources support, i.e. independent means and tools necessary to carry out the review process, including the results of R&D implemented in safety used for the purpose of assessing the safety demonstration.

Absence of conflict of interest

Participants of SITEX consider the absence of conflict of interest between expertise function and implementing function as essential for conducting impartial safety review. Regarding nuclear regulatory body and it is generally "guaranteed" by the country's legal framework (Czech, Belgium, France, Switzerland…).

However, the situation is sometimes less clear when considering some expertise activities being funded not directly by the implementers but via the channel of governmental organisations. To avoid conflict of interest, the role of an independent technical safety organisation must therefore be limited to issues in which it will not be directly involved as a contracting organisation for WMOs.

Thus, no difference has been identified in the definition and the way to maintain independence of expertise function between countries participating to SITEX. However, insuring independence of experts in the facts remains a continuous challenge for several participating organisations especially in small countries, due to the fact that the best experts in very specialized fields of research are sought after at the same time by the implementer and for the independent review.

Resources support for expertise function

Because of time constraints, it is of crucial importance to be able to anticipate the development of knowledge and resources required to assess risks posed by nuclear facilities in the future, and in particular by waste management safety. Identifying very early the scientific issues that have to be addressed in priority enables optimisation of the resources allocated to research. These resources should be periodically assessed with respect of the progress made in studies, of the new issues to be taken into account. They should be duly planned, according to needs of regulatory review agenda.

Thus, the needs for financial and human resources should be commensurate with the level of required expertise. This topic is already developed in several guides, although what is meant by the existence of "required financial and human resources" for the expertise function is not detailed. It can be understood that this requested level of resource is expected to allow performing both research in safety and expertise at the same time so as to maintain the scientific competences. This is for example the case in France with the resources allocated to the TSO (IRSN) for building research programmes, developing internal scientific skills and safety assessment capabilities performed by dedicated teams.

Where limited resources are available at national level, the existence of a sustainable expertise function network at European (or wider) level could represent a useful tool to reinforce occasionally the existing resources in order to provide national regulators with an appropriate expertise function where needed.

SITEX considers that independence of expertise function, in particular vis-à-vis the implementing function, may be achieved, provided that the three above conditions are met.

3.3 Tasks and activities of the expertise function

Assessing compliance with safety requirements requires strong technical support from the expertise function. This includes several activities such as: reviewing the safety demonstration, achieving independent R&D and interacting with the Civil Society.

3.3.1 Reviewing the Safety Case

The overall goal of regulatory review is to check that the disposal facility will not cause an unacceptable adverse impact on human health or safety, or on the environment, both now and in the future. To achieve this goal, the review process will typically rely on the following objectives:

- To determine whether the Safety Case has been developed to an acceptable level (in terms of its quality and the detail and depth of understanding displayed) and whether it fits for purpose,
- To verify that the Safety Case and the assumptions on which it is based comply with, or are in accordance with, accepted principles for radioactive waste management and regulatory requirements and expectations,
- To determine whether the Safety Case provides an adequate and appropriate basis to demonstrate that the proposed facility will be operated safely and provides reasonable assurance of an adequate level of safety in the period after closure,
- To verify that relevant measures for mitigating unlikely potential effects have been identified and addressed, and that adequate follow-up plans for their implementation have been developed,
- To determine whether issues required by the regulatory body to be addressed by the operator have been clearly identified,
- To identify any unresolved issues and to verify that plans for resolving these issues have been developed.

Reviewing activities considered in the framework of SITEX encompass the review of the Safety Case as well as of documents such as programmes and plans (e.g. R&D programmes, monitoring programmes, etc.).

In order to ensure the quality and success of a review, the expertise function should have personnel with relevant expertise and hands-on experience in safety assessment of radioactive waste facilities and should have either in-house expertise or should have access to specialists in all the key disciplines for safety involved in such assessment. The team of experts in charge of a review typically includes a project manager responsible for overall coordination and for the verification that the Safety Case and its review process are consistent with regulations as well as senior specialists responsible for peer reviewing, integrating and synthesizing comments from other specialists.

The review should be also conducted using a level of resources that is commensurate with the level of complexity of the Safety Case and the potential risks associated with the disposal facility under consideration.

3.3.2 Implementing R&D activities in safety

R&D work in safety is essential for the experts' scientific and technical ability, because it maintains or improves their competence, it contributes to their independence and it helps to reinforce the reliability of the expertise system in the eyes of the public.

The R&D objectives set by the expertise function usually differ from the R&D objectives set by the implementer. The expertise function will mostly investigate issues directly related to safety with the objective to check the adequacy of the approaches followed by the implementer to reach the safety objective. The expertise function may decide to initiate R&D work where it considers that there is a need for additional studies beyond those undertaken by the operator. There may also be situations in which the expertise function requires independent R&D work so that it can apply suitable critical considerations in its review and assessment. Special attention will be usually given to the detection of possible inadequate choices, hypothesis or assumptions, knowledge gaps, incompleteness, inconsistencies, mistakes (of reasoning or of implementation), etc. The R&D carried out by the expertise function is therefore more a "complement to" and "a verification of" than a "duplication of" the R&D activities performed by the implementer.

More specifically, regulatory R&D activities carried out in support of reviews and inspections may contribute to one or several of the following objectives:

- To develop expertise,
- To identify key safety issues,
- To develop its own tools for independent review of e.g. assumptions, models and approaches,
- To verify whether a logical and justified path has been followed to optimise protection,
- To verify safety (performance & radiological impact),
- To check technical feasibility,
- To develop inspection strategies and techniques.

3.3.3 Interacting with Civil Society

The public is considered in this study as the "end user" of the decision-making process. The ultimate mission of expertise function is to enhance nuclear safety in the public interest. This mission is linked with the capacity of the expertise function to identify the priorities and concerns of the public and therefore necessitates regular interactions with the public. It also entails the expertise function to provide the public with its expertise and to make itself available to answer the questions of the public and to provide it with information and explanations on the technical review conclusions.

4 Expertise function and Decision Making-Process

This section investigates the types of activities performed by the **Regulatory function** along the progress of the **Decision Making Process** (DMP) that would require close interactions with the **Expertise function** in order to implement the regulatory review. These activities relate to the review of a safety case and of the implementer's R&D program and to inspection. Needs for further clarification or development of requirements and guidance for practical application of safety principles are investigated.

4.1 Structure of the regulatory review and related expertise needed

4.1.1 Phases of the Decision Making Process

The exact definition of the phases and decision-making points that cover the development and implementation of a geological disposal facility differs among national programmes. In nearly all programmes, formal decisions are expected at least from the point of repository construction and, in some countries, regulatory decisions will also be needed in earlier phases e.g. during the conceptualization and siting phases. Political decisions may also be required (i.e., legislative decisions, local referendum) in addition to the regulatory process.

SITEX considers in this report the following six key phases in the development of a geological disposal: (1) conceptualization, (2) siting, (3) reference design, (4) construction, (5) operation, and (6) post-closure. These phases described below provide a broad description of the progressive development of a repository and of its safety case. As such, they are used in SITEX as a generic stepwise process that frames the needs for expertise and technical support.

1. **The conceptualization phase**, during which an implementer considers potential sites and design options, establishes the safety strategy and carries out preliminary assessments. Regulatory review of the work at this stage should guide the implementer on the likelihood of achieving the necessary demonstration of safety and should help the implementer decide whether to commit resources to move to the next phase of the project.

2. **The siting phase**, during which the implementer identifies potentially suitable sites that are compatible with the design concept in terms of the safety strategy adopted and characterizes these sites based on a preliminary Safety Case to the extent that a decision can be made on the preferred site(s).

3. **The reference design** (and application for construction) **phase**, during which the implementer adapts the conceptual design to the site properties, finalises and validates the design of the disposal facility, and develops the Safety Case, to support the implementer's application to construct, operate and close the facility. This is used by the regulator to decide whether to grant a licence for the implementer to construct the facility and is a crucial milestone in the development of a repository.

4. **The construction** (and application for operation) **phase**, during which the implementer demonstrates that the facility was built as planned and in accordance with the terms of the

construction licence. Towards the end of this phase the implementer will present its final overall approach for operation and a draft concept for closing the facility. In preparing for operation, the implementer will need to demonstrate safety during operation and radiation protection of workers and members of the public. The regulator would typically decide whether to grant a separate licence before emplacement of waste in the facility would commence. It should be noted that construction activities are generally expected to be carried on beyond the construction phase (i.e. during the operational phase).

5. **The operational phase**, during which the implementer emplaces waste packages in the disposal facility. During this phase, the implementer may build new disposal units, and backfill and possibly seal, either temporarily or permanently, parts of the disposal facility where waste emplacement has been completed. During this phase, the implementer also develops an application to close and seal the facility, and prepares a draft plan for post-closure institutional controls, monitoring and surveillance. Towards the end of this phase the regulator will decide whether to grant a licence for the implementer to close and seal the facility. When the licence is granted, the implementer proceeds to the closure of the facility.

6. **The post-closure phase**, at the start of which the implementer provides evidence to demonstrate that the disposal facility was closed in accordance with safety requirements and presents a firm plan for institutional controls and continuing monitoring and surveillance. At this stage the regulator will confirm what controls, monitoring and surveillance are required and for how long.

The following **Figure 2** relates these phases to the pre-licensing, licensing and post-closure periods.

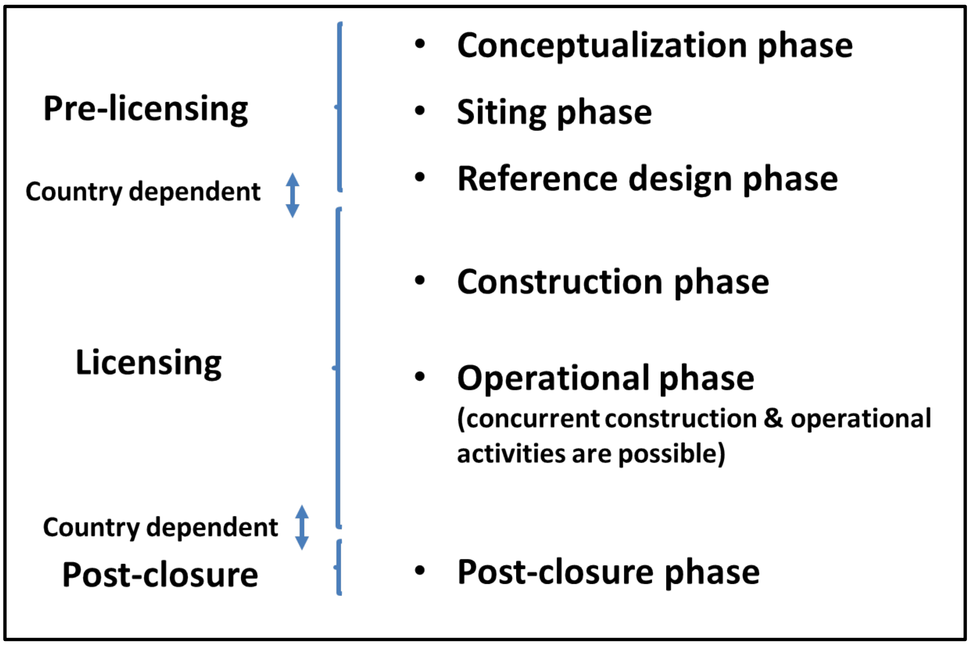

Figure 2. Repository development phases versus pre-licensing, licensing and post-closure periods

4.1.2 Areas of expertise needed by regulatory function

This sub-section identifies the support needed by regulatory function from expertise function at the different repository development stages. The safety issues that must be assessed by the regulatory body at the different stages of repository development determine the expertise and technical support needed to perform this independent appraisal.

Six areas of expertise needed to support the regulatory function have been defined:

- Safety strategy and policy
- Management
- Waste
- Site
- Engineering
- Operational safety

They cover the safety issues to be considered when reviewing documents from the implementer and during inspections.

Expertise is needed to verify the adequacy of the **safety strategy** defined by the implementer. The safety strategy is defined as the high-level approach for achieving safe disposal. The safety strategy is intended to define objectives and principles to guide the overall project development. Hence, the safety strategy should address the implementation of the "governing principles". The safety strategy should also identify the safety functions of the disposal system (containment and isolation), as well as those allocated to its components. Moreover, the safety strategy should describe all the approaches, processes and methods that will ensure that the disposal facility meets the safety objective.

Expertise is needed to verify the **management** system built by implementer. The implementer should establish, document, maintain, assess and continuously update a management system during all the activities to be carried out from site characterization to closure of the facility and, as required by the regulator, post-closure activities. The objectives of the management system are in particular:

- To ensure that the implementer has set up an appropriate organization (including staffing, skills, experience and knowledge) and processes to address any requirement or recommendation resulting from the regulations, from regulatory assessment of the project and/or from peer review,
- To ensure that the implementer competently undertakes all relevant activities required to be implemented and to ensure the quality of the deliverables,
- To ensure that R&D programmes related to safety-relevant issues are appropriately defined and properly implemented,
- To take into account international feedback from similar facilities elsewhere,

- To ensure that key information, data and their provenance are recorded and preserved.

Expertise in the characterization, processes, phenomenology and modelling associated with the **waste** to be disposed of, is needed to verify compliance with safety requirements related to the following issues:

- Prevention of the risks of criticality and possible disturbances, etc.,
- Development of waste acceptance criteria and their respect by conditioned waste,
- Characterisation, knowledge and system understanding: waste-related FEPs, etc.,
- Uncertainties: identification of waste-related uncertainties and the needs for further research if needed (characterisation, behaviour, etc.),
- Scenario development for assessing ageing of waste packages,
- Models used in the Safety Assessment: how basic knowledge is used to derive the process evolution with time of the conditioned waste (source term modelling), the modelling of interactions between the waste form and other repository components, etc.

Expertise in **site** characterization, phenomenology and modelling is needed to verify compliance with safety requirements related to the following issues:

- Site selection: favourable and not favourable properties of site for selecting location for disposal,
- Design: compatibility with the host environment, design basis external events, etc.,
- Construction: preservation of the safety functions of the host environment, etc.,
- Monitoring: baseline, confirmation of host rock behaviour and assumed site conditions, strengthening of system understanding, confidence building in models, verification of compliance with conditions of authorization, etc.,
- Characterisation, knowledge and system understanding: Site-related FEPs, characterization programme, etc.,
- Uncertainties: identification of site-related uncertainties, their management and further needs for R&D programmes,
- Scenario development for assessing possible behaviour and evolution of site,
- Safety assessment models: modelling of host rock behaviour, radionuclide transport in the geosphere, biosphere, external events and processes (earthquakes, glaciation, etc.).

Expertise in EBS characterization, phenomenology, modelling, design and construction is needed to verify compliance with safety requirements related to **engineering** issues:

- Site selection: consideration of the adequacy of design with site characteristics,
- Design: assets and drawbacks with respect to operational safety and safety after closure,

- Construction: adequacy of methods and strategy with respect to possible damage of host rock, concomitant activities during operation, etc.,
- Operation: investigations and feedback of information on operating experience, assessment of operational limits and conditions, management of modifications, etc.,
- Monitoring: baseline, confirmation of assumed EBS behaviour, strengthening of system understanding, confidence building in models, verification of compliance with conditions of authorization, etc.,
- Characterisation, knowledge and system understanding: EBS-related FEPs, etc.
- Uncertainties: identification of EBS-related uncertainties and their management (R&D, etc.),
- Scenario development for assessing interactions and global evolution of EBS,
- Safety assessment models: modelling of EBS behaviour, radionuclide transport in the EBS, internal events and processes (gas migration, alkaline plume, etc.).

Expertise in the different aspects associated with **operational safety** is needed to verify compliance with safety requirements related to the following issues:

- Design: design of the handling equipment, design basis accidents, etc.
- Operation: investigations and feedback of information on operating experience; operational limits and conditions, occupational and public exposure; handling and emplacement of waste, etc.,
- Waste acceptance: what are the criteria ensuring operational safety? , etc.,
- Monitoring: monitoring of occupational exposures, etc.,
- Characterisation, knowledge and system understanding: use of operating experience, etc.,
- Models,
- Operational safety assessment.

4.2 Sharing of experience and cooperation to further harmonization

This sub-section presents the main technical and safety requirements that have been identified for more exchange between experts in order to clarify their meanings and to better share the way to review their application by the implementer.

The issues were identified based on **high level** safety requirements on which international consensus exists:

- Draft WENRA Safety Reference Levels (SRL): A SRL is defined as a requirement against which the situation of WENRA member states is assessed. It is the responsibility of each country to implement actions to ensure that SRLs are reached. There is also an engagement to transpose SRLs into national regulatory frameworks,

- IAEA safety fundamentals and requirements,
- EC Directive 2011/70/Euratom on Radioactive Waste & SF Management,
- ICRP recommendations.

The safety issues were reviewed within the following categories:

- Governing principles,
- Safety policy & strategy,
- Management,
- Site selection,
- Design,
- Construction,
- Operation,
- Closure & Decommissioning,
- Period after closure and institutional controls,
- Waste acceptance,
- Monitoring,
- Safety Case and assessment,
- Objectives and scope, Graded approach, SC/SA content vs. regulatory decision steps,
- Characterisation, knowledge and system understanding.

Existing regulatory guidance associated with these safety issues were analysed with the aim of understanding commonalities or potential differences between guidance. Needs for clarification or additional requirements were discussed.

A total of 90 issues were identified (see SITEX D2.1 and D2.2) from which 33 were considered with a high interest. The topics with the highest priority are:

- The interpretation of ICRP 122 (related to radioactive waste) regarding the radiation protection principles applied to geological disposal and the weighting of criteria when applying optimization to site selection,
- Programme for site characterisation,
- Possible Features Events & Processes that have to be considered in scenarios,
- Development of the "design basis":
  - Characteristics of radioactive waste and site,

- Normal and anticipated operational conditions, possible accidents,
- Disturbing FEPs during operation whose consequences may affect post-closure safety,
- Hazards linked to concurrent activities (handling of radioactive waste and building of disposal areas)

The priorities are therefore given to the first phases of the development of a repository: the site selection and the concept development.

5 Expertise Function and Safety Case review

This section 5 deals with the technical review of the Safety Case. By definition, **expertise function** is limited to safety and technical/scientific areas (see **Figure 3** below) and the aspects related to administrative/regulatory issues (national legal framework, financial consideration, etc.) are the duty of **regulatory function**.

5.1 Description of the Safety Case and Safety Case Review

5.1.1 General description of the Safety Case

The Safety Case is a concept of nearly 10 years-age; it has already been discussed in the frame of many international projects (see PAMINA report D1.1.4, MESA report, EPG report 2011-Draft; WENRA Report 2012-Draft, IAEA project PRISM report) and in various international guides (e.g., IAEA SSG-23). The **Figure 3** is an illustration of a way to structure the content of a "comprehensive" Safety Case, divided into several units, as presented in the IAEA SSG-23. This conceptualization is used below by SITEX to develop the review process and propose a possible common approach for implementing in practice the regulatory review.

The international guidance associates the Safety Case to the concept of "stepwise approach". As a matter of fact, the geological disposal concept develops progressively, from siting to closure steps and the level of detail and types or arguments expected by the reviewer at each phase vary accordingly.

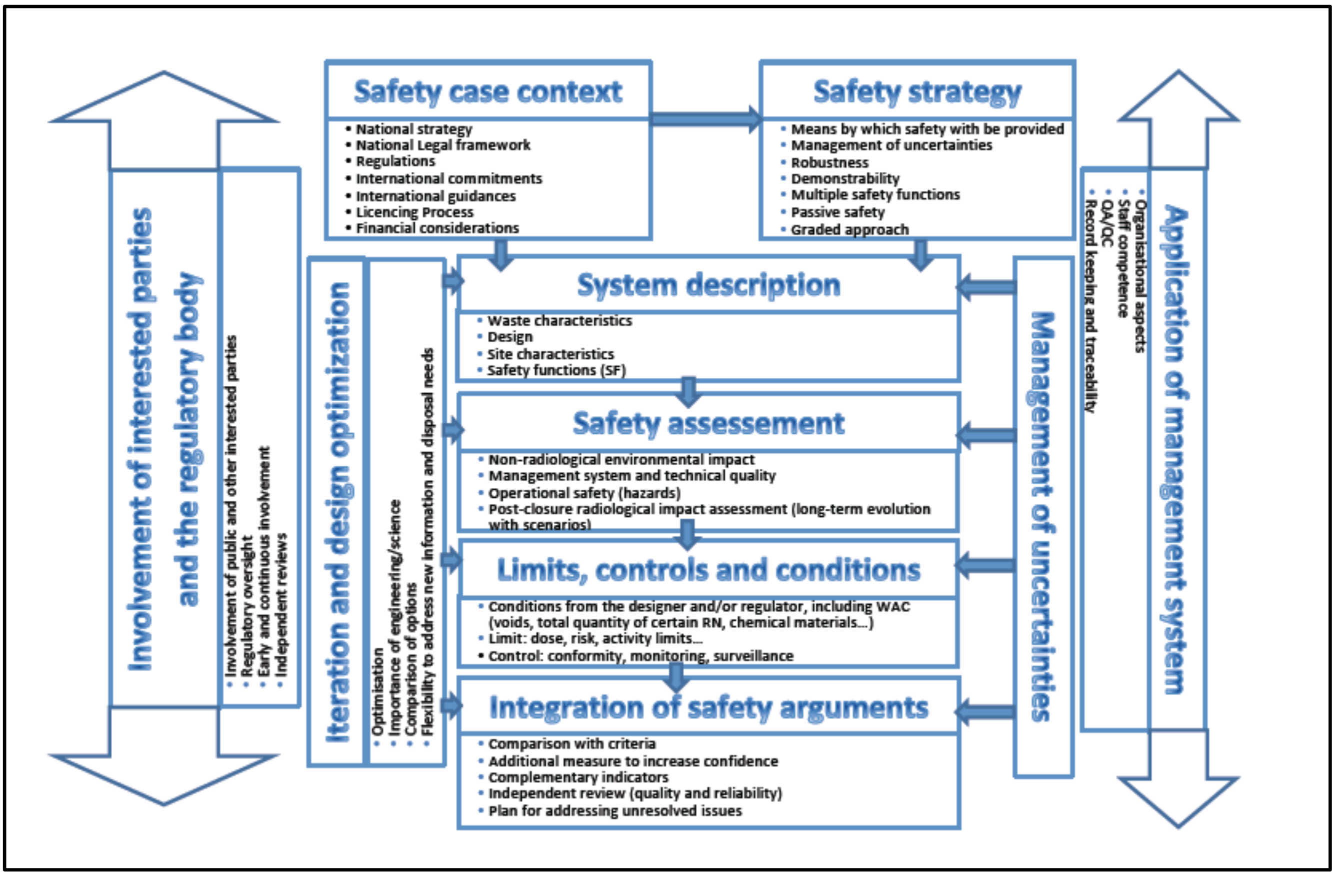

Figure 3. Contents of the Safety Case (modified from IAEA SSG-23 and PRISM Report)

5.1.2 Particularities of Safety Case for geological disposal facilities

In comparison with the Safety Case for other nuclear facilities, the Safety Case for geological disposal facilities has notably the following characteristics:

- The deep geological disposal is **constructed and operated in concomitance**, and this operation lasts over periods of time much longer than the time currently planned for operating NPP or surface disposals,
- The definition of the concept and the safety demonstration rely mostly on results provided by **R&D programs**, and very often these programs run in parallel with the development of the Safety Case. These results are integrated progressively within the Safety Case and the reviewer must be able to appraise whether the data used in the safety demonstration reflects correctly the progress of the research and is sufficient to gain confidence in the demonstration,
- The demonstration of safety addresses specific issues such as **very long time period** after closure and a **very large volume** of geological medium, both items being not fully accessible

to detailed observations but requiring **numerical modelling** and assumptions in order to assess the possible behaviour of the deep geological disposal,

The above characteristics justify the need for the reviewer to prepare the review with the aim of **anticipating** as far as possible the **skills and knowledge** that should be available at the time of the review:

- By collecting the experience feedback on hazards from existing nuclear facilities and from other types of facilities that would be of interest to assess construction and operational safety, and how current practices should be completed to account for the geological disposal,
- By following as closely as possible the progress of the research program implemented by the operator, as well as the development of the disposal concept in order to check the relationship between the concept proposed and the level of knowledge acquired; this implies having sufficient exchanges with the implementer outside of the technical review periods,
- By identifying early the key safety issues that require development of knowledge in order to:
    - Anticipate the scientific arguments that should be informed by the implementer in the Safety Case,
    - Carry out its own research program where needed (see section 6 of this report) to support the development of skills necessary to assess the scientific results provided by the implementer.

Regarding this anticipation activity, the IAEA GEOSAF project (The International Intercomparison and Harmonisation Project on Demonstrating the Safety of Geological Disposal,) recommends p.6 that "*some guidance should be provided on the preparatory activities to be undertaken by the assessors to be ready for the technical and regulatory review*".

5.1.3 Successive Steps of Safety Case Review

Taking into account the existing guidance (ASAM Regulatory Review Draft Report and IAEA SSG23) defining a four-phase stepwise approach of Safety Case Review, the SITEX participants have modified and completed it. Nevertheless, they agree to look at this approach as an "ideal" way to manage the review, because this is not systematically the case in practice for several reasons that are developed below.

1. The "inception" or **"pre-review" phase** generally occurs prior to receipt of any documents from the implementer. During this phase, the frame of the technical review is roughly defined: the required content of the implementer's report has to be described by the regulatory body, the subject and initial planning or cut-off date of the review have to be defined in agreement between the implementer, the regulator and the experts (see SITEX D 4.1).
2. During the **initial review phase**, the Safety Case has been released and the review team, to whom documentation and support is provided, is set up. The experts make an initial evaluation of the implementer's documents to assess the completeness of the file and the availability of supporting documents (administrative admissibility). If the document is considered admissible, a formal

request by the safety authority may be sent to the experts. The experts provided a preliminary analysis to identify the first main trends of the review, the most important possible disagreements with the implementer, the needed expertise and the ability of the review (to detect blocking issues…). This normally involves a launching meeting with the implementer to find agreement on the content of the review and whether the general information and documentation provided by the implementer is sufficient or not to be able to start the review process in good conditions (see SITEX D4.1).

3. The **main technical review phase** begins with a checking of issues that should be more developed and informed. Generally, these complements are obtained by a set of questions sent to the implementer or by exchanges in technical meetings. This phase may last several months or years; it includes the development of detailed review comments and evaluation of additional information provided by the implementer in response to comments. Numerical modelling may be carried out by the review team to assess the calculation results provided by the implementers; the same way, the experts may rely on laboratory measurements, observations on analogs, compilation of existing publications, etc. The results of R&D obtained by experts during the preparation of the technical review (when anticipated before or during inception phase) are used to set out arguments on the review.

   The expert opinion are collected (if necessary, meetings are organised within expert's team). Finally, a draft high-level technical review of the documentation is presented to the implementer and is used to organize the final technical dialog between the review team and the implementer. The final review report is finalized after this meeting, taking explicitly into account agreements with the implementer generally on minor issues but presenting recommendations on issues where implementer must improve the Safety Case.

4. During the **completion phase**, the main conclusions of the review are summarised and used by the **regulatory function**, together with conclusions drawn from inspections, from international peer reviews if exist, from the conduct of its own activities where relevant, to inform the decision making process (concluding statements). The outcomes and feedback from the technical review are used to identify the "knowledge gaps" and issues to be dealt with in priority by the implementer. The regulator makes requests in that perspective. In parallel, review team considers its own programme of work (including possibly R&D) in order to anticipate the next review step.

5.2 Proposal for a review methodology

The issues discussed above are organisational aspects of the review work. In practice, the core of the review work is the establishment of technical opinion that will be delivered to the regulatory function in terms of scientific and safety arguments derived from the analysis of the safety demonstration provided by the implementer. The SITEX participants propose a draft grid of analysis (see **Table 1**) associated to hold point corresponding to the end of **site investigation and selection phase** and decision to enter the reference design phase**.** The purpose of this grid is to try to standardize the approach that could be followed to assess the relevance of the Safety Case and identify the issues where sufficient information is provided and where improvement is needed. This grid of analysis is divided in **8 main sections**. The first one presents the main **expected outcomes of the Safety Case**. The **focus of the technical review** is described in the second section.

The following sections correspond to the expected content of the main parts of a Safety Case that should be informed by the implementer when addressing site selection: **safety strategy, assessment basis, safety assessment, optimization and management of uncertainties,** as well as integration of the safety arguments. At this phase, "Limits, controls and conditions" (see **Figure 3**) is not considered because assumed to be premature. For each section, the following **Table 1** describes what to check in priority in the Safety Case. The sections dedicated to the assessment basis and to the safety assessment present development of some key questions that structure the review. Finally, the Safety assessment is split with aspects corresponding to site and engineering assessment and to radiological and non-radiological impact assessment.

Table 1- Draft grid for site investigation and selection phase

<table>
<tr><td>Stage</td><td colspan="2">SITE INVESTIGATION AND SELECTION PHASE (Leads to decision to select site and start reference design phase)</td></tr>
<tr><td>Safety Case</td><td colspan="2">• Identifies and confirms potentially suitable sites for implementing a GD and for demonstrating the safety; characterization must be sufficient to allow taking a decision to select a site.
• Identifies the key uncertainties and shows as far as possible how they can be managed.
• Describes at least one design option, which presents good prospects of feasibility in the site, in the sense that it relies on proven and/or easily demonstrable features and is able to accommodate uncertainties related to the expected performance of the various components of the disposal system.</td></tr>
<tr><td>Focus of the technical review</td><td colspan="2">• To review how implementer confirms the expected properties of the host rock (e.g. isolation and containment) ; are the candidate sites characterized and investigated to a level allowing the selection of one (or more) preferred sites?
• To review the compatibility between the design(s) developed in the previous conceptualization phase and the potential site(s)
• To review how the overall concept (design + site) is adapted and refined taking into account the new data collected from investigation and characterization of the host rock and surrounding environment (iterative process)
• To gain sufficient confidence in implementer’s capability to demonstrate that at least one design option presents good prospects of feasibility, in the sense that it relies on proven and/or easily demonstrable features and is able to accommodate uncertainties related to the expected performance of the various components of the disposal system.</td></tr>
<tr><td>Safety strategy</td><td colspan="2">What to check:
• Site acceptance criteria (not necessarily quantitative, but also qualitative) established by implementer on the basis of siting requirements which are at least:
➢ Containment and isolation capabilities;
➢ Long term stability;
➢ Reduction of likelihood of human intrusion (no presence of exceptional underground resources).
• Implementer’s proposals on how the technical feasibility of the disposal facility will eventually be substantiated, using the results of the program of investigations planned during the previous conceptualization phase =
• Approach developed to implementing engineering solutions and monitoring</td></tr>
<tr><td>Assessment basis</td><td>What to check:
Relevant features, events and processes should be identified
• Verify the quality of the basic characteristics of the host rock and surrounding environment (geological, geochemical, hydro-geological and mechanical properties) as well as those of the potential construction materials of the engineered components, using the experts’ R&D and knowledge.
• The state-of-the-art knowledge on the properties of component materials important for the disposal safety should be established.
• The assessment methods, models, computer codes and databases must be shown to be reliable.
• Inventory of the waste packages, with sufficient evidence that the provided data cover with adequate margins the important features for designing a safe disposal facility (check number and volume of waste packages,</td><td>Key questions to be answered:
• Are the basic researches on characteristics of the host rock and surrounding environment carried out?
• Are the basic characteristics of the potential construction materials of the engineered components assessed?
• Has the inventory of the waste packages been determined with adequate margins?
• Are the mechanisms identified and quantified?
• Which interactions are characterized?
• Confidence in demonstrability of physical-</td></tr>
</table>

	radionuclide inventories, activities, thermal output, chemical composition, toxic content, gas emission, etc.).		chemical mechanisms? • Quality of data?
Safety assessment	Preliminary site and engineering assessment	What to check: • Demonstration of the ability of each component of the disposal system to fulfill its expected function (This will primarily consist in identifying the disturbances that might affect the disposal system and its components, these being of internal (thermal, chemical, mechanical, radiological, nuclear,etc.) or external (intrusion, climate change, seismicity) origin (Structures, Systems and Components). • Feasibility assessment, based on the known characteristics of the host rock, which gives consideration on the suitability and effectiveness of the techniques.	Key questions to be answered: Effectiveness of safety functions, performance of barriers: • Range of possible disturbances identified and quantified? • Confidence in industrial feasibility assessment on the suitability and effectiveness of the techniques (including excavation)? Effectiveness of total system: • Is disposal system robust? Which complementarities? No common modes of failure and/or lack of compensation of (postulated) dysfunction? • Were enough possible evolutions or events considered for determining the robustness of the total system?
	Radiological and non-radiological impact assessment	What to check: • Scenarios developed (at least normal evolution and taking into account the main disturbances identified, checking the main assumptions and simplifications • Conceptual models • Confidence of the order of magnitude of the impact of the disposal system	Key questions to be answered: • Are scenarios derived systematically? • Are results of reasonable confidence (available safety margins)? • Is impact verified as not unacceptable? • Are the uncertainties sufficiently covered (comprehensive)?
Optimization, management of uncertainties	What to assess: Adaptation of the R&D program to the results of analysis by the implementer		
Integration of the safety arguments and evidence	What to assess: Updated information on compliance with the safety strategy in respect of both the evolving design and the safety assessment approach (demonstration that the Safety Case still provides an overall integration of the safety arguments and evidence from the assessments above, the Safety Case should specifically update the points addressed during the previous phase, proposals for a program of site and design qualification).		

5.3 Sharing and cooperation on Safety Case review within the SITEX network

The identified needs of cooperation that the SITEX network could fulfil regarding the way to manage technical Safety Case review are linked to the development of additional technical review grids on the basis of the model developed in sub-section 5.2 for the following hold points:

- End of conceptualization phase, leading to decision to start site investigations,
- End of reference design development and application for construction phase, leading to decision to start construction,
- End of first construction phase and application for operating the disposal, leading to decision to start operation,
- End of operation and closure of the disposal, leading to decision to enter post-closure phase.

During **operation** of the disposal, the operator may build new disposal vaults, and develop activities for backfilling and possibly sealing, either temporarily or permanently, parts of the disposal facility where waste emplacement has been completed. Such decision should be based on the analysis of the limits, controls and conditions to be met during operation that guaranty the safe behaviour of the disposal are key elements to be clearly defined by the operator and reviewed by the experts. Any deviation from the expected behaviour should be identified and treated in a proper manner. The way to review such activities and deliver technical opinion to the regulatory function is a key challenge for the expertise function that would deserve specific attention from SITEX network.

6 R&D resources and needs of the expertise function

This section presents the rationales that guide the identification of scientific skills needed to review the Safety Case that are implemented by expertise function (mainly the technical safety organisations) to develop this scientific skills where needed. This scientific knowledge is associated to the key safety issues associated to operational and post-closure phases (6.1). A part of this knowledge is acquired through R&D programmes implemented by the expertise function (6.2). Section 6.3 assesses the opportunities for cooperation between SITEX partners on R&D programmes considering available tools and competencies amongst SITEX.

6.1 Scientific knowledge associated to the review of key safety issues

When reviewing the safety case, experts address in particular (see section 5 of the present report) these specific aspects of the safety case demonstration:

- The justification of **the methods** used to obtain data and the confidence in the data,
- The justification of **the processes** that govern the performance of the components and their ability to achieve the safety functions,
- The description of the **evolution** of the disposal taking into account the influence of the uncertainties and the occurrence of various **possible expected or unexpected events and perturbations**,
- the due consideration of the **potential hazards** that could impair safe **operation** of the waste emplacement, and the influence of accidents during operational phase on the long term safety

Considering the above expectations, SITEX partners proposed to structure the needs for scientific knowledge along the technical domains listed below:

- The quality of the data **on which rest the safety demonstration;**
- The understanding of the complex processes **which may potentially influence the long term safety of the geological disposal;**
- The assessment of the future evolution **(in spatial extent and intensity) of these potential processes, as well as the assessment of their impact on the DGD safety,**
- the **potential hazards** that could occur during construction and **operation** of deep geological disposal.

Each of technical domains is described in the following subsections. For each subsection, a set of scientific and technical knowledge considered as necessary for performing the review is identified. Furthermore, these needs for knowledge will be further analysed on a case-by-case basis, and derived into research activities where necessary.

Based on these national contributions, the SITEX participants have developed a common view on the key safety issues and the related needs for knowledge acquisition in order to perform a relevant review. This analysis deals in particular with long-term safety but questions arising from operational safety are addressed as well. The influence of construction/operational actions and potential accidents on long-term safety is a key concern. Depending of organisations, needs for knowledge are already derived into R&D programs (see SITEX D3.2) or used as basis to identify further R&D actions, possibly undertaken through joined programming activities.

6.1.1 Quality of input data

The quality of the long-term and operational safety demonstrations that will be provided by the operator for the GD facility notably rests on the quality of the data, which characterize the GD system. The quality of the data evaluated by the operator for the operational and long-term safety demonstrations principally depends on their accuracy and relevance, as well as on their representativeness of the in situ properties of the GD system.

A need for knowledge regarding this issue is therefore the adequacy and relevance of methods available for the evaluation of data necessary for long-term and operational safety demonstrations.

GD is a large complex multi-barrier system, being constructed in heterogeneous host rock massives. Therefore not all the information can be easily generalized. Data can suffer from both simplification of complex system, processes and time scales and from size reduction, namely due to the limited size of research laboratory with respect to the overall dimensions of the GD and its environment. Therefore the data may not be fully representative of the whole GD system and of its future evolution. Consequently, TSOs and safety authorities should develop confidence in:

- The methods for data acquisition and its extrapolation in time (e.g. for the long-term safety demonstration),
- The validity of up-scaling approaches for the data evaluated at small scale in order they can be representative for the whole GD system,
- The methods allowing capturing the heterogeneities of the system.

Confidence in the time extrapolation in terms of data for the safety demonstration may notably be built by understanding the complex processes and phenomena that will alter the evaluated data under repository conditions (see sub-section 6.2). The coupling between the Thermal, Hydrological, Mechanical and Chemical (THMC) properties of the GD system is of particular concern for the extrapolation in time of the evaluated data.

Deliverable SITEX D3.1 develops the different scientific and technical issues of data quality associated to the different components of the GD that must be addressed by the reviewer for preparing the review of the Safety Case.

6.1.2 Understanding of Complex processes

In order to design the GD facility and to demonstrate its operational and long-term safety, operators have to develop understanding of the key processes (i.e. Thermal, Hydrological, Mechanical, Chemical and radiological processes and their related couplings), which govern the evolution of the GD system. Experts and safety authorities have to assess whether the operator correctly understands and describes those processes. This assessment is performed by considering the following tasks related to:

- The processes on which rest the performances of the four main components of the disposal system (waste forms, canister and overpacks, Engineered Barrier System (EBS) and geosphere). The validation of such processes relies in particular on the implementation of various demonstration tests at different scales and in different contexts (sealing concept, construction of underground vaults and tunnels, etc.). Context representative of disposal conditions supposed to occur at short and long terms is a key issue to be addressed by the implementer to design the demonstration tests; in that perspective, reviewers must be able to deliver opinion on the relevance of demonstration tests with respect to the safety concern to be addressed,
- The processes resulting from potential internal and external perturbations of the disposal system are linked with events occurring during the operation or after closure. Following sources for internal perturbation can be considered: interactions between the four main repository components (waste/host-rock; waste/EBS; EBS/host-rock), construction and operation of the disposal. Regarding external perturbations, it can be considered: climate change, glaciation and influence of permafrost, seismicity, flooding, etc. Where needed, demonstration tests must be implemented by the operator in order to qualify the perturbations and the reviewer must be able to deliver opinion about the relevance of the tests and the interpretation derived by the operator.

SITEX Deliverable D3.1 develops the different scientific and technical issues related to the complex processes associated to the different perturbations of the geological disposal that must be addressed by the reviewer for preparing the review of the Safety Case.

6.1.3 Assessment of extent, intensity and impact of processes

In order to demonstrate operational and long-term safety of the repository, operators have to assess the spatial extent and the intensity of the processes resulting from the internal and external perturbation of the geological disposal system (see sub-section 6.1.2) and the potential radiological impact that would results from these evolutions. This assessment is carried out by modelling activities.

The review of these estimations relies first on the assessment of the hypothesis selected and in particular the set of data used to feed the models (see sub-section 6.1.1) and the processes possibly to occur (see sub-section 6.1.2). The reliability of the physical and numerical models developed by the operators, the comprehensiveness of scenarios modelled and the methodology followed to manage the uncertainties are key parts of the review that request development of specific skills of the reviewer in the following fields:

- **The definition of features, events and processes (FEPs) and scenarios of GR development**. FEPs that are potentially important for the safety of the disposal system should be identified. Moreover, FEPs screening and scenario development should be supported by experimental demonstration and natural analogue observations,
- **The definition of models** that are able to calculate the extent and intensity of processes resulting from internal and external perturbations and to estimate their influence on human health and on the environment (including dose). But the unavoidable abstraction and simplification (of mechanical, hydrological, thermal and chemical processes) influences the calculations and the reviewer has to understand to what extent these simplifications may undermine the confidence in the safety demonstration… In particular, the transient processes occurring during first tens, hundreds, thousands years have potential influence on the long-term behaviour of the disposal. Modelling such processes and their interactions is a challenging task that requires to establish simplification but with sufficient assurance of not underestimating the levels of magnitudes of the phenomena.
- **The management of uncertainties** e.g. up-scaling, mathematical representation of processes, abstraction/simplification of complexity, long-term extrapolation, lack of knowledge, etc.) that remains a key issue in gaining confidence in the safety demonstration. But the accurate assessment of the above tasks (quality of data, intrinsic performances of components and their interactions, adequacy and completeness of evolution scenarios, considering the so called "what if" scenarios), is a major step in identifying uncertainties that are satisfactorily covered and those which remain of concern and would require further investigations or analysis,
- **The monitoring issue**. Monitoring should confirm the reference state of the system (normal/expected evolution) as expected and demonstrated in the Safety Case. Assessing the relevance of monitoring methodology (targets to be monitored, duration, location, processes investigated, etc.) requires anticipation from the reviewer in order to develop his own understanding on how should be derived the monitoring strategy and what are the devices, processes and overall expectations of the monitoring. In particular, the capability of the monitoring strategy to identify deviations from expected behaviour is a key issue to be assessed carefully.

6.1.4 Operational safety

In terms of methodology of regulatory review, the existing methods already used for various nuclear facilities remains valid and serve as basis for reviewing safety of the operation of geological disposal. But some specific risks or situations need to be addressed without any substantial feedback experience from the operation of existing nuclear facilities (management of concomitant activities linked to construction and emplacement of waste in the same time, management of fire in a nuclear or close to nuclear installation but in underground conditions…). Parameters associated to the characterization of the considered risks (fire, flood…) needs to take into account the peculiarities of such a facility. Finally, the identification of Limits, Controls and Conditions for the operational phase have to be defined by the implementer to consider:

- The safe domain of operation and allow to come back in this domain in case of deviation (monitoring);
- The relationship between the safe domain of operation and possible deviations.

The conditions that guaranty the long-term safety are a remaining challenge: the numerous links between pre- and post-closure arguments of the safety case call indeed for a methodology to verify continuously that the operator is always on the right track to achieving its target, namely the conditions of the disposal at the time of closure which form the basis of the demonstration that the facility is sure on the long term. With this respect, monitoring strategy is a key challenge.

For the detailed description of types of knowledge required for performing the regulatory review, see SITEX deliverable D3.1.

6.2 Identification of existing technical and scientific tools

The main aim of this sub-section is to identify R&D actions that are already performed by the SITEX partners and/or considered of major interest regarding the peculiarity of the geological disposal national programs. In SITEX D3.1, each participating organization has determined:

- The key safety issues which characterize their national radioactive waste Geological Disposal (GD) project,
- The associated R&D actions that are or should be undertaken in order to ensure a high level technical review of the Safety Case developed by the operator.

Considering the technical and scientific issues to be assessed when implementing the regulatory review, Experts and some regulatory bodies have developed scientific capabilities to carry out their own research program where they consider that:

- Knowledge developed by WMOs **must be completed,**
- **An independent view** must be developed in order to be able to develop contradictory exchanges between implementer and reviewer.

In both cases, the scientific program implemented by the expertise function is focused on **key safety issues** and related scientific concerns and especially on main phenomena where related uncertainties must be assessed.

Two main scientific activities are performed by the expertise function for the development of independent skills: **implementation of experimental works and computational simulations**. They represent a potential pool for mutualisation of competencies and share of tools, with the view to ensure availability of as large as possible set of scientific and technical tools allowing to cover the potential needs of expertise function at European level.

6.2.1 Cartography of experimental installations

The following table summarises the scientific installations, available for SITEX partners. The identified installations comprise labs, preferentially focused on radiochemistry, and underground research laboratories. Both types of installations are usually highly sophisticated and demanding for maintenance. Moreover, educated and trained staff is needed. Therefore some of beneficiaries have solved the lack of such an installation by subcontracting with other institutions (see **Table 2** below).

Table 2. Summary of the scientific installations available for SITEX beneficiaries for potential R&D actions

Partner	Labs	Coop/ Subcontracting	URL/ Cooperation in URL	Monitoring (which kind)
BELV FANC	No	IRSN, universities	No, coop in Mont Terri and Tournemire	geomechanics
CNSC	CANMET-MMSL (radiochemistry, chemistry)	IRSN, universities	No, coop in Tournemire	Radionuclides in soil and water
UJV Rez, a.s.	UJV (radiochemistry, migration properties, buffer+backfilil properties, package properties)	Universities, research institutions	No, coop in GTS and Josef gallery	Groundwater (GW) properties Radionuclides in soil, water and air
IRSN	LAME (physical, radiological, and chemical characterizations of soils, rocks, and waters)	Universities, BelV, FANC, CNSC, IBRAE, SECNRS	Yes, Tournemire Cooperation in Mt. Terri	Geomechanical properties GW properties System parameter evolution and interactions (T, seatide,etc.) Radionuclide monitoring (Rn)
GRS	Geoscientific lab (geochemical and geotechnical issues)	Universities, research centres	Yes (salt mine). Cooperation in Mt. Terri, Bure, GTS	Environmental monitoring (soil, water, air)
LEI	Installation for heat transfer	No	No	Currently not
NRG/ELI	Hot Cell Lab and actinide lab (NRG)	Yes (TNO, Uni Utrecht, GRS)	No, coop with HADES	Cooperation with foreign URLs; in situ demonstration of innovative monitoring techniques
DECOM	No	Yes (GUDS, TechUni)	No	Cooperation (VUJE): Radionuclides in soil and air

6.2.2 Cartography of modelling capacities

The following table summarises modelling codes, available for SITEX partners. The modelling codes are used namely for radiation protection activities, inventory calculations, heat transfer modelling, geochemistry, geomechanics, transport & migration for the purpose of independent calculations in order to review the safety assessment developed by the WMOs and assess the role of uncertainties.

Table 3 Summary of the modelling capacities available for SITEX beneficiaries to cover specific R&D issues

Beneficiary	RadProtection/ Inventory	Heat transfer	Geochemistry	Geomechanics	Transport, migration	Safety assessment
BELV FANC	**RadProtection: MCNPX**		**PHREEQC**		**HYDRUS 1D, HYDRUS 2D STANDARD**	**MELODIE (IRSN), batch calc., sensitivity analyses (own code)**
CNSC		**COMSOL**		**COMSOL**	**MODFLOW, CORMIX**	
UJV Rez	**Inventory: SCALE, ORIGEN 2.2**	**TOUGH2**	**PHREEQC, GWB, TOUGHREACT**		**TOUGH2, FEFLOW**	**GOLDSIM, PAGODA, Amber, RESRAD**
IRSN	**RadProtection: SYMBIOSE, AQUAREJ, FOCON 96, ISIS (fire)**		**PHREEQC, HYTEC**	**CASTEM, LAGAMIN**	**DIPHPOM, nSIGHTS (hydraulic tests)**	**MELODIE**
GRS		**TOUGH2**	**PHREEQC**	**FLAC3D**	**TOUGH2, MARNIE, FLAC3D, Spring**	**MARNIE**

Beneficiary	RadProtection/ Inventory	Heat transfer	Geochemistry	Geomechanics	Transport, migration	Safety assessment
LEI	**Inventory: MCNPX, SCALE** **RadProtection: MCNPX, Visiplan, Microshield, MicroSkyshine, SCALE**	**ANSYS/ FLUENT**		**COMSOL**	**AMBER, DUST, GENII, GWSCREEN, GoldSim, Petrasim (TOUHG2), COMSOL, Compulink, CHAN3D**	**AMBER, DUST, GENII, GWSCREEN, GOLDSIM, COMPULINK, CHAN3D**
NRG	**Inventory: DANESS** **RadProtection: MCNPX, Visiplan, Microshield, MicroSkyshine, SCALE**	**TASTE**	**TOUGHA2, TOUGHREACT ORCHESTRA**	**EMOS (compaction)**	**EMOS, REGIS II.1, ORCHESTRA**	**EMOS, LOPOS, PORFLOW, ORCHESTRA**
DECOM	**ORIGEN, Scalem Helios (cooperation)**				**MODFLOW, HYDRUS (VUJE)**	**GOLDSIM, AMBER**

6.3 Opportunities for cooperation

The current R&D national programmes yielded by experts and regulatory bodies are characterized by various levels of maturity depending on the progress of the national disposal programmes. For this reason, it appears quite difficult to draw full common lessons and perspectives in terms of R&D joint programming regarding the various key questions identified. This objective could be envisaged by addressing two main categories of scientific issues:

- Issues related to processes where the scientific community already made progress and where additional efforts would address **specific works on already well developed concepts in selected host rock (for more advanced programmes),**
- Issues related to **generic scientific topics and assessment methodology** that concern any kind of programmes at various level of development.

It is also clear that regarding the geological disposal program development, the opportunities for R&D joint programing become more specific as knowledge pool extends and uncertainties all together decrease (see following **Figure 4**). At this step of the SITEX project, the set of major scientific issues to be well understood by the reviewer is not formally turned into a strategic research agenda.

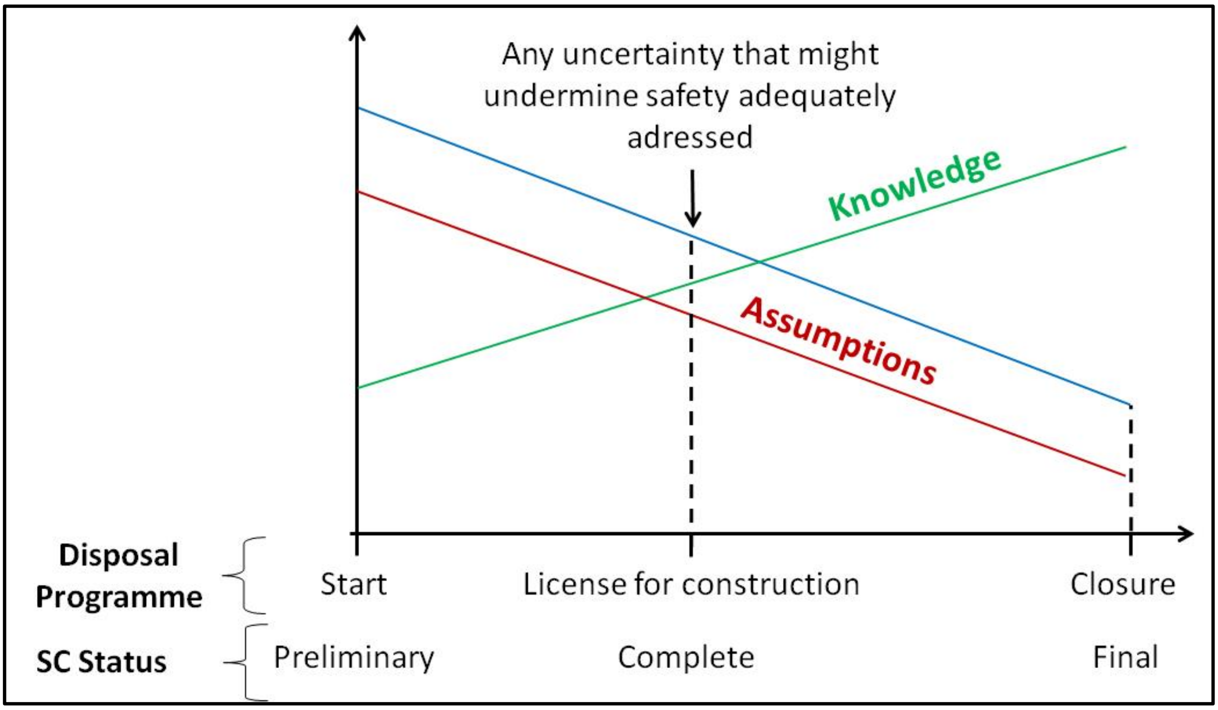

Figure 4: Knowledge pool increase following the disposal programme development (F.Lemy, F. Bernier, Euradwaste, 2013)

Following topics are examples of **generic issues** or less advanced scientific questions that would deserve joint programming between SITEX partners:

- Modelling coupled processes during **transient phase** (i.e. evolution of data, etc.) that would capture the evolution of the disposal from the creation of the disposal to the permanent state that governs its long-term behaviour,
- **Upscaling methods**: from lab scale to site,
- Accounting for **uncertainties** and parameterization of **scenarios,**
- Methods for characterizing **natural resources** in the vicinity of the disposal, with due account **of human intrusion** scenarios,
- **Monitoring** and measurement methods,
- Behaviour of **concrete** under disposal conditions,

- Performance of **seals** under disposal conditions and identification of key parameters that drive their performance,
- Behaviour of **interfaces** between components and their role on the propagation of perturbations through the disposal (comprising the **role of gas** produced by corrosion).

Following topics are examples of more concepts **specific issues** that could be addressed on a basis of specific interactions between partners:

- **Waste matrix** and source term behaviour with time that govern radionuclides release out of the waste package: **bitumen**, **glass fracturing**, gas release, IRF, etc.,
- Container/waste package degradation due to: corrosion, **μ-organisms, radiolysis**, etc.,
- **Host rock characterization**: methods to detect **heterogeneities**, **water pathways**, etc.

7 Competences and training of experts

This section presents the main types of work performed by experts ("profiles of experts") to do the technical review, identified by the SITEX project, so as to adjust a specific program of teaching dedicated to each of these different profiles (see deliverable D4.2). For that purpose, it identifies needs on training and competences in the SITEX network. It also summarises the target audience of the training program, the organisation of the training programme with training modules and tutoring, and the plan of development of the training course.

7.1 Four expert profiles for technical review

The section 5 of this report developed a definition of the generalist and specialist experts and their areas of competences (see also deliverable D4.1 of the SITEX project). These competences are used in this section to identify the different functions (or roles) played by experts in the review of the safety case of deep geological disposal. These different profiles of experts may be organized into several ways, depending on the level of detail desired (number of identified profiles). The following list identifies a selection of possible profiles (which is not necessarily comprehensive), for which specific training courses could be defined.

The main required expert profiles needed for evaluating the safety case for geological disposal and identified for training and tutoring are the following:

- **Environmental scientists** and **specialists of hazards** linked to natural features, events and processes, who can **carry out R&D** and are able to use their scientific knowledge in environmental science to argue their expertise,
- **Specialists in construction and operational safety**, as material & civil engineers and scientists as well as conventional underground experts and radiation protection specialists in charge of assessing hazards due to materials and waste; these experts may also **carry out R&D** and use it to argue their expertise in the different **hazards possibly to occur during construction and operation**,
- **Numerical modellers, mathematicians and experts in computer code development**, who have a transversal role, carrying out scientific calculations and implementing software programs well-suited with the needs for expertise (including all types of models such as integrated models or process models, for long-term safety as well as for operational safety); these **experts generally carry out R&D in order to develop computational methods,**
- **Generalist experts** and **experts in safety** who both have a central role in the expert team: they have a **global view** and understanding of the different aspects of the Safety Case and coordinate the review team; they are in charge of **integrating** inputs in the review provided by the other experts of the team.

7.2 Target audience and nature of the training programme

The Training Programme will be addressed to all experts fulfilling a "technical expertise function" and involved in the different steps of the licensing of geological disposal facilities.

The different training modules, summarized below in **Figure 5**, are designed to build-up competences of these experts participating in the review of the Safety Case of deep geological disposal.

The design of the SITEX Training Programme will focus on the use of interactive teaching methods involving trainees as much as possible in the learning process. The SITEX Training Programme represents one step among the complete expert professional development that includes the formation for new entrants in a safety organisation, the "Basic Training Programme" and the "Advanced Training Programme". The "SITEX Training Programme", corresponds to a core curriculum-training module on licensing geological disposal and to different training and tutoring periods that enable the transfer of know-how all along a carrier development.

The "Basic Training Programme" and the "Advanced Training Programme" are already proposed by various national and international institutions (IAEA, NEA, ENSTTI…). As an example, ENSTTI's training programme entitled "Induction to nuclear safety" is a 4 week-long programme that could be considered as a "basic training programme". ENSTTI's induction course includes nuclear safety infrastructure, reactor safety, incident & accident and finally, fuel cycle.

The complete "SITEX training programme" is composed of 3 successive steps, including:

I. A "**basic module**" ("A"),

II. Four training "**specialization modules**" ("B" to "E") dedicated to the different experts' profiles (B- "environmental experts"; C- "numerical modellers"; D- "operational risk experts"; E- "generalist experts"),

III. A **tutoring module** ("F") in another team of experts of the SITEX network.

The "**SITEX training programme**" can be summarized in the following **Figure 5**.

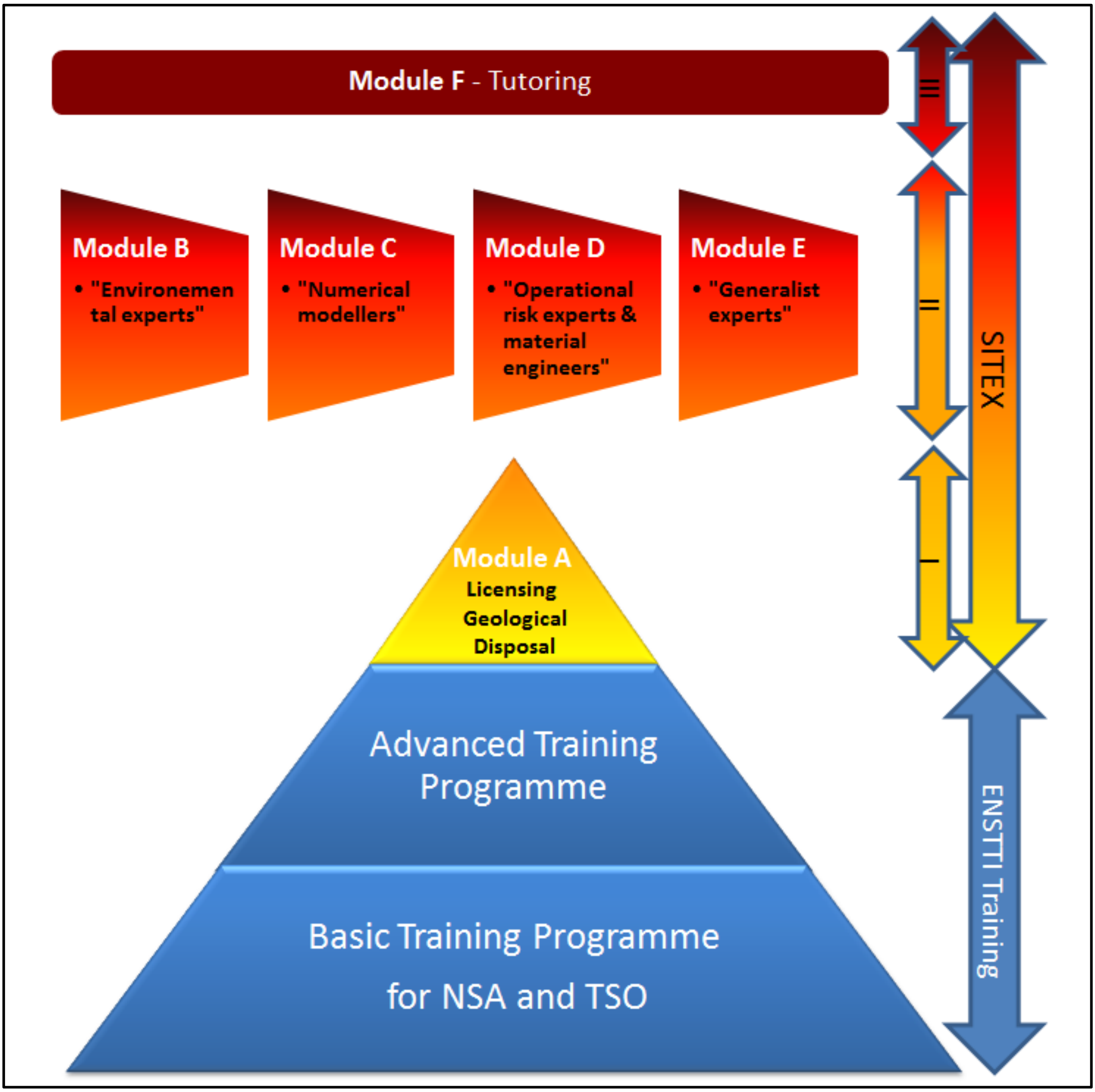

Figure 5: SITEX training programme

A preliminary draft of programme is presented in the SITEX report D4.2 for these different modules.

As an example, the module A for all experts engaged in the licensing review process of a geological disposal, may comprise 3 main sessions:

- The definition of the « expertise function », including developments on the notions of independence from WMOs, impartiality, transparency and openness to Civil Society, as well as competences and profiles of experts,
- The content of the Safety Case, with detail of each part and phases of development of the Safety Case,
- The different steps of the technical review, and the types of exchanges it may require, with various representatives such as implementer, safety authority or the public.

Each of the four specialization modules have common objectives, such as supporting exchanges of experience and best practices, but also include specific training sessions dedicated to the expert profile (specific R&D programme, how to use the results of this R&D programme in the technical review…).

7.3 Needs on competence and training within the SITEX network

SITEX project has identified competences to develop in fields of expertise, related to the six areas of expertise identified in section 4. These fields of expertise are the following:

- **Safety strategy**: The fields of knowledge needed to verify compliance with safety requirements associated with the area of expertise "safety strategy" are as follows:
  - **Generalist experts** with a good knowledge and understanding of the requirements / recommendations for the safety strategy,
  - Support of other expert's profiles in **specific fields** to verify that specific approaches (e.g., for host rock selection, concept and design development, reversibility and retrievability, etc.) are appropriate.
- **Management system**: It is essentially the fieldwork of "**non-specialist experts**". The specific fields of knowledge needed to verify compliance with safety requirements associated with the area of expertise "management" are as follows:
  - Expertise in management system and quality assurance (QA) (in general and specificities applying to nuclear facilities),
  - Control of the management system developed by WMOs.
- **Waste**: This topic is principally of concern for experts in construction and operational safety (specialists in hazards due to use of materials and presence of waste) and may also involve "**numerical modellers**" to assess extent and intensity of phenomena. The specific fields of knowledge needed to verify compliance with safety requirements associated to the "waste" are as follows:

- Waste characteristics (including waste types and quantities),
- Waste characterization methods,
- Waste processing and conditioning,
- Waste acceptance criteria (WAC),
- Waste form, package and container behaviour (physical, (bio)-chemical, radiolysis) and modelling of behaviour,
- Criticality,
- Waste handling.

- **Site**: This topic is mainly examined by "**environmental experts**" associated with "**numerical modellers**". The specific fields of knowledge needed to verify compliance with safety requirements associated with the "site" are as follows:
    - Geo(bio)chemistry, and radionuclides speciation and transport,
    - Geology, structural geology, tectonics
    - Hydrogeology,
    - Seismology, geophysics
    - Geomechanics / Geotechnics,
    - Climatology,
    - Biosphere (radioecology, etc.),
    - Geophysics.
- **Engineering**: This topic principally concerns **specialists in construction and operational safety** ("**Operational risk experts & material engineers")** and **specialists in scientific calculations** (**numerical modellers**"). The specific fields of knowledge needed to verify compliance with safety requirements associated with the area of expertise "engineering" are as follows:
    - Radiolysis,
    - Geochemistry + radionuclide speciation and transport,
    - Geomechanics / geotechnics,
    - Civil and mining engineering, geotechnics,
    - Material sciences (concrete, corrosion, mechanics, etc.),
    - Hydraulics + thermo-hydro-mechanics (THM),
    - Modelling,
    - Testing methods,

- Handling systems.

- **Operational Safety**: This topic is performed by the **specialists in hazards** possibly occurring due to **construction and operation** ("**Operational risk experts & material engineers")** and may also involve specialists in scientific calculation. The specific fields of knowledge needed to verify compliance with safety requirements associated with the area of expertise "operational safety" are as follows:
    - Radiation protection,
    - Conventional safety,
    - Fire protection / mine ventilation,
    - Work in (nuclear) underground facilities,
    - Decommissioning,
    - Human factors / risks,
    - Risk analysis (HAZOP,etc.).

In order to fulfil these identified needs of competences, the SITEX network could set up the future steps of the training programme presented in the sub-section 7.2 of this report. Regarding the Module A, the syllabus is under development. A pilot session could be organised at end 2014-beginning 2015. Modules B, C, D, E and F should be further developed.

8 Expertise function and Civil Society

Since the 1990s, in the field of hazardous activities in general and in the nuclear field in particular, a general trend of evolution has developed in Europe towards reinforced information and participation of the public to decision-making processes and towards more inclusive governance frameworks. Several research projects have been performed regarding the COWAM European Research Program (2000-2009), the RISCOM or the IPPA projects. This section presents the outcomes of practical experiences and case studies that have been reviewed within SITEX WP5 and also the conclusions of the SENEC SITEX workshop discussions on interaction between Civil Society and expertise function with regards to three areas of the expertise function: along the decision making process, along Safety Case review and R&D processes. In addition, some recommendations for the future SITEX network interactions with Civil Society on European level are presented in the last sub-section.

8.1 Outcomes of potential interventions of Civil Society along DMP

In the nuclear field, the relationships between expert organisations, in particular technical support organisations (TSOs), and Civil Society appears of key importance for developing access of the public to information and participation of the public to decision-making processes. Various processes of interaction between experts and Civil Society have thus developed in Europe since the mid-1990's, involving different types of experts: institutional experts (TSOs), Civil Society experts, independent experts (university, foreign experts not engaged in the national context…).

Several cases studies have been compiled by the SITEX project (see deliverable D5.1 of the SITEX Project) on the interactions between the Civil Society and the experts in the context of nuclear safety. Four different types of outcomes have been identified as a result of those interactions: the improvement of expertise, the improvement of decision-making, the competence building and the access of Civil Society actors to reliable and relevant information. This preliminary investigations will have to be further completed in the future in order to develop a more in depth understanding of the conditions and means of a common safety culture between the experts and the Civil Society and a more detailed characterisation of the (actual and potential) contribution of those interaction to the safety of radioactive waste management.

8.1.1 Improvement of expertise

As regards the improvement of expertise, the interaction processes have led in different cases to some kind of improvement of the quality of the expertise process and its results (e.g. better definition of reference groups of exposure scenario taking into account local ways of life). This includes development of new processes and methods for performing expertise with local actors and Civil Society taking on board the priority and concerns of the Civil Society. Interactions between experts and Civil Society also improved reliability of the results of the expertise process, in particular in the cases where experts with various backgrounds (and different views vis-à-vis the considered technologies) are involved in the expertise process.

8.1.2 Improvement of decision-making

As regards improvement of decision-making, the interaction between experts, decision-takers and Civil Society has led in different cases to improve the quality and reliability of the decision-making process. This includes identification of commonly agreed solution between Civil Society, local actors and decision-makers but also adaptation of the decision-making process to allow the different stakeholders to contribute to the quality of decisions. This also includes the development of mutual understanding between experts and decision-makers on the one hand and local actors and Civil Society actors on the other hand, notably the development of a common language between the different involved categories of stakeholders.

8.1.3 Competence building

The considered interactions between experts and Civil Society have also contributed to reinforce the skills of the considered actors. On the one hand, local actors and Civil Society actors have developed their capacity to address technical issues according to their priorities, in the perspective of a continuous involvement along the decision making process. On the other hand, TSOs and experts have developed their capacity to interact in a relevant and fruitful way with local actors and Civil Society and to take advantage of those interactions to improve the quality and relevance of their expertise (and for instance introduce new issues in the scope of the expertise or reframe certain issues according to the concerns of the Civil Society (e.g. for instance while implementing the concept of reversibility as a result of societal influence on the decision-making process). It is also noted that the Civil Society can contribute to maintain on the R&D agenda issues related to geological disposal safety that would not otherwise be addressed by the institutional players.

8.1.4 Access of Civil Society actors to information

These interaction processes have most often resulted in a better access of local actors and Civil Society actors to relevant information according to their questions and needs. In particular, the work of "technical mediation" (mediation between Civil Society and institutional experts) carried out by non-institutional experts (from NGOs or other institutions having some proximity with the Civil Society) appears as a key factor for fostering effective access of Civil Society to information on issues involving a high degree of technicality, such as radioactive waste management.

8.1.5 Contribution to a longer-term evolution of governance: interaction processes as "change incubators"

Taking a step back and looking beyond the strict scope of the various complex interaction processes, we can see that they almost all fit in a longer-term process of evolution of the governance of radioactive waste management (and also of nuclear activities in general) towards a greater openness to different stakeholders, especially Civil Society[1]. This process is a long-term process of co-evolution between expert bodies and Civil Society.

[1] **Constructive democracy and governance of technology:** The conditions of democratic governance in a complex technical and social process: the example of the European project Cowam-in-Practice in the management of radioactive waste, S. Lavelle, G. Hériard-Dubreuil, S. Gadbois C. Mays and T. Schneider - Governance Review (Canada) - Winter 2010 (Vol.7, No. 2): http://www.revuegouvernance.ca/index.php?article_id=79&page_id=45&lang_id=2&PHPSESSID=4c02b1ecd8842974b82208371e5d7131&

In this process of co-evolution over a long time, the interaction processes between experts and Civil Society, limited in time, space and in the scope of considered issues, can be considered as "change incubators". Indeed, they open, usually off the usual system of governance, a bounded space where the different actors (especially Civil Society actors and TSO) can safely experiment with new types of interactions and enter in a process of collective learning. Should favourable conditions be met, the improved mutual understanding of actors, the experimentation of new roles and the new formulation of issues resulting from the interactions may contribute to changes in longer-term relationships and mutual positions of the actors. These contribute to a process of longer-term evolution of the radioactive waste management governance (and, more generally, nuclear activities).

The expertise function contributes to this process of co-evolution in different ways. This includes the support of the engagement of civil society actors and the strengthening of their skills in the framework of interaction processes (foreseen in the legal or regulatory framework), or initiating themselves such (pilot) processes:

- Adapting its culture and practices to accommodate the active contributions of Civil Society as an added value to the relevance of safety, expertise and decisions.
- Directly supporting an autonomous, continuous and long-term process in which Civil Society develops skills, capacity to engage in issues of public interest, networking capacities.

The following **Figure 6** summarizes the potential contribution of Civil Society to this process.

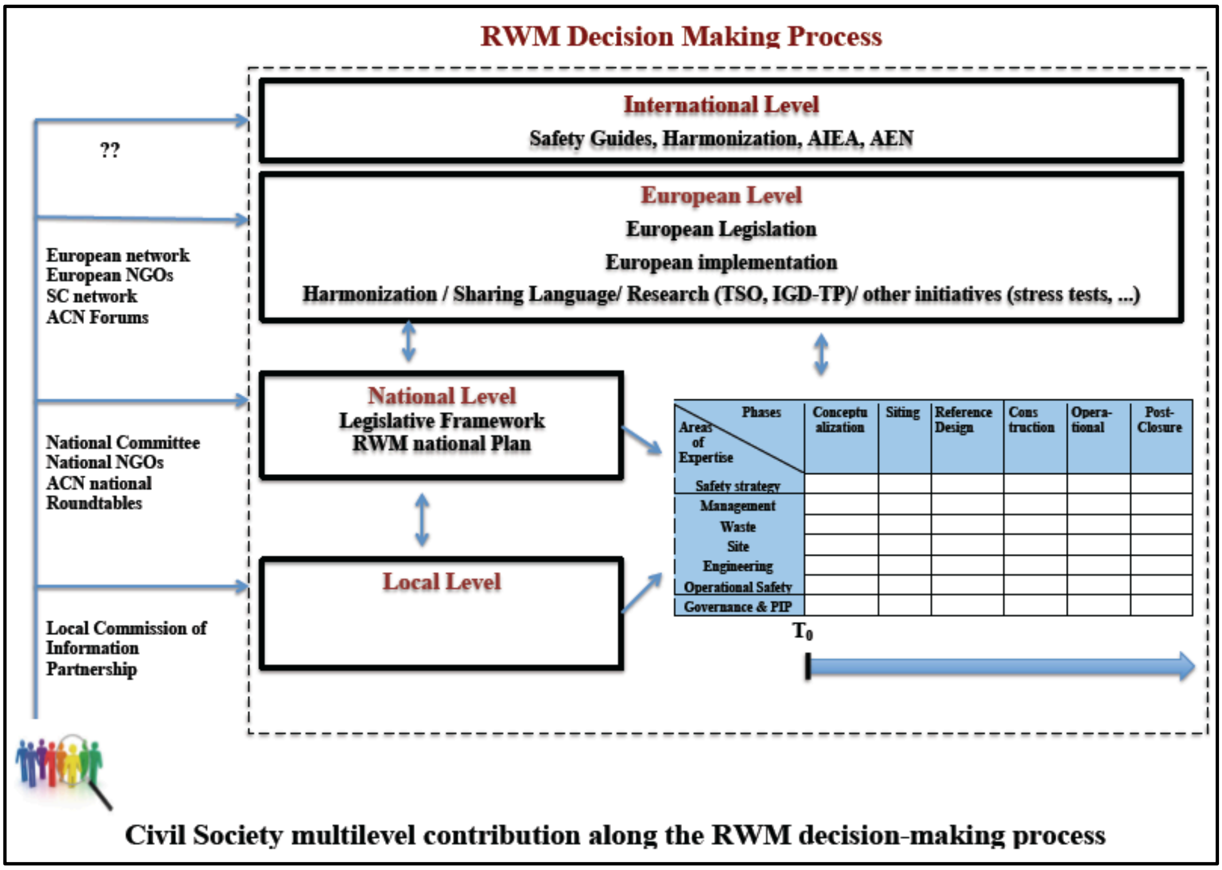

Figure 6: Civil Society multilevel contribution along the RWM decision-making process

8.2 Necessary conditions and opportunities to develop interactions between the Civil Society and the expertise function along the decision-making processes

The development of the interactions between CS and the expertise function is linked with a wider institutional and legal evolution in the context of each country. Although this question is outside the scope and competence of SITEX, it is worth to have in mind that the interactions of the CS with the experts take place in actual decision-making contexts as well as within the opportunities that are offered to the public to access information and to intervene along its successive steps. The more the decision-making process is structured and made explicit, the more the public has a chance to intervene (and in this perspective to interact with experts) in order to bring its contributions to the quality of decisions. In this perspective, the quality of those interactions is partly linked with the benchmarking of inclusive decision making processes (notably through the channel of harmonisation). In addition, specific tools and methodologies regarding the involvement of the "concerned" public are to be developed by the expertise function, notably in the perspective of intergenerational aspects of the radioactive waste management.

8.2.1 Harmonization of legislation regarding the involvement of the public

Necessary conditions for entering a decision making process are to be recognised as an "affected" public. There is not one standard baseline for public participation across European countries, nor definition of concerned stakeholders, who could participate on official decision-making process, for various levels of decision-making processes as well as for various purposes. Therefore understanding of who is concerned stakeholder can vary country by country. None of one directive defines particularly the strategy of public involvement into the decision-making process and it is upon national regulator or implementer to decide what level of participation is adapted to particular processes. It is mentioned in the Directive 2011/70/EURATOM that participation of the public in decision-making should be effective. Standard format of public access to information along the decision-making process in Radioactive Waste Management (RWM) involves public consultation along the official licencing processes. Again, legislation can vary country by country, but in the case of RWM the licensing process generally entails the successive steps of Environmental Impact Assessment (EIA) process, siting and construction licensing and finally nuclear installation licensing by nuclear regulator.

At an international level, trend towards reinforced public information and participation has notably led to the signature in 1998 of the Aarhus Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters by the European Commission and 39 European and Eurasian countries including the EU Member States. It should be noted for instance that the Aarhus Convention clearly establishes the right of the public to access environmental information "Without an interest having to be stated" (article 4-1 a). At the European level, the provisions of the Aarhus convention for information and participation of the public have been incorporated into several European directives (although to a certain extent only) related to regulation of radioactive waste management or, more generally, of activities with potential impact on the environment.

Regarding the national legislation framework, important differences exist between countries in practices on consulting interested parties and the public. Harmonization of public or stakeholder involvement seems however to be difficult to propose, given it is very depending on the country laws and political systems. Nevertheless, experience from cases of involvement might be better shared. Another disharmony among countries is regarding the understanding of the "sensitivity" of information (that would justify a denial of public access). Some information may be considered as "safety sensitive" in one country, while not in another country. Anyhow, it is not simple to reach a common consensus. It would be worth to better define the appropriate condition to consider some information as "safety sensitive".

8.2.2 Specific Tools and methodologies

Developing a mutual understanding between CS & experts necessitates appropriate tools for enabling communication between the parties. The Civil Society must be provided with relevant and reliable information in due time, while the conditions for an actual dialogue should be established in order to avoid inefficient polarised discussions.

The regulatory body, and the expertise function, are expected to develop exchanges with the Civil Society on a regular basis:

- On the fundamental safety issues, like safety principles & requirements,
- For each steps of the decision-making process,
- On the successive outcomes of Safety Case Review (making explicit the position of the authorities on Safety Strategy, Safety Concept and R&D programme adopted by the implementer),
- The rationales and the outcomes of the R&D programmes that is developed by the expertise function.

A common understanding on the fundamental safety issues makes possible to discuss the specific aspects along the successive steps of the decision-making process. It is therefore not appropriate to initiate discussions with Civil Society only at a later stage, whereas many decisions have already been taken many years before. Therefore the Civil Society has to be involved quite early in the process of the development of a geological repository project.

It is not unambiguous, which is the most suitable tool for interaction with Civil Society in DMP. There are number of tested participative attitudes.

The formal options for achieving public participation in the decision making process depends on type of the process and national legislation. There are a number of available processes, as advisory group, citizens panel, expert or focus groups partnerships etc. The PIPNA survey (December 2012)[2] commissioned by DG ENER is proposing institutional and legal procedures tools in order to achieve public participation in the nuclear sector along the decision-making process. The IPPA FP7 project has also developed a mapping of public participation tools in various decision-making processes (not only

[2] **Public Information and Participation in Nuclear Activities (PIPNA): Assessment of good practices on the participation of Civil Society in the development of nuclear activities - Final report 5th December 2012 - Contract NO. ENER/D2/2011-539**

http://ec.europa.eu/energy/nuclear/studies/doc/20130128_pipna_final_report_05-12-2012.pdf

in waste management contexts) together with a toolbox to support decision makers in the selection of the proper tool for interacting with the public:

- Reference tools for public information and participation at national level: a way to facilitate interactions with Civil Society at national level is the creation of a permanent national reference committee involving institutional actors and local, regional and national concerned citizens and Civil Society organisations (CSOs) together with elected representatives. The reference committee is to participate in the initial preparation of the national framework, in the preparation and corresponding update of the different sections of the national programme, in the preparation of 3-year reports to the European Commission, in the self-assessments of the national framework, in the preparation of the siting process, in the implementation of the siting process, as a third party guaranteeing the practical conditions for public information and participation at the local and national level. Conditions should be also set up to provide national and local CS stakeholders with relevant expertise from diversified sources.
- Reference tools for public information and participation at local level: For all phases of the decision making-process, an engagement of local actors in the national reference committee could foster mutual understanding. Regarding the siting phase, approaches involving new roles for local communities & stakeholders (see e.g. Sweden, Belgium, Slovenia & the UK) should be developed with voluntary engagement of local communities and stepwise decision-making process for progressive engagement of local communities with right to withdraw at different steps according to defined procedures (so-called "veto right"). These approaches implies also organised forms of local democracy, knowledge building & clarification of issues between the various components of the local community, NGOs, RWM organisations, sometimes regulators; resources to support local engagement and local democracy, including access to various sources of expertise and clear separation between support to engagement of local actors and support for local development. For operating and post-closure phase, the creation of a permanent Local Committee of Dialogue and Information attached to the RWM site, gathering local stakeholders to follow-up the activity of the site and provide independent information to local population can be a reference. (See e.g. the Local Committees in France, the UK or Sweden). Il is also to consider of building an intergenerational 'contract' between the local and the national community including territorial development, a system of vigilance and monitoring including contributions of the national and the local levels, and a system of memory of the RWM sites shared between the national and the local level and possibly with the EU and/or international level (see e.g. UNESCO World Heritage system).
- Suitable ways to interact: Looking for opportunities for civil society and experts to interact three contexts have been identified:
    - Dialogue between implementer and Civil Society - oriented on information and action toward waste management strategies implementation;
    - Technical dialogue between Expertise function and Society with various level from clarifying of technical issues up to interaction with Civil Society on development of Safety Case;

- Particular dialogue with regulatory function focused on licensing process and regulatory decision, on nuclear safety issues.

In any case, expectation of Civil Society, as mentioned above (see 8.1.4), needs to be reflected and sufficient time has to be accommodated for discussion to satisfy all participants. An open/safe space has to be guaranteed to keep discussions neutral, not polarized.

8.2.3 Intergenerational management of the interactions with the Civil Society

As waste management and especially waste disposal are topics to be dealt with on many generations, these are issues that lead to consider the long-term decision-making process. A certain level of flexibility to come back on previous decision is needed. But there is lot of question concerning intergenerational management, which have to be answered, e.g.:

- How to achieve some consistency in the development of RWM long-term strategies across generations (to start with the foreseen operational phase of geological disposal that would last at least 100 years)?
- What in case of major change?
    - Implementer need to review the impact of the change on the Safety Case
    - According to the issues to be discussed and timing of the decision-making, what are the appropriate levels of interaction (local, regional, national) between the expertise function and the Civil Society?
    - Ensuring sustainability of any decisions, agreements or interaction in such a long/term process means to develop very good tools for keeping records and distributing proper information to all actors.

This is area, where historical experiences need to be researched and applied and surely new ideas will be evolved.

8.2.4 Expectations of the Civil Society

Implementing transparency in the context of RWM makes it necessary to create conditions for the public to have an effective access to relevant and reliable information as well as to have access to independent sources of expertise. It is in particular expected that Civil Society has access to the expertise function of the public authorities. As a matter of fact, representatives of Civil Society commonly do not have sufficient knowledge and resources to enter discussions on an equal footing with the proponents of the projects. The availability of supporting independent experts during the DMP, providing the public with independent review and explanations of the available documentation of the project, is therefore a necessary component of transparency.

The discussions during the SITEX Workshop in SENEC have also underlined the need for some kind of clarification regarding the principle of independence of the expertise function. There are specific institutional settings for expertise functions in the various considered countries. Some expertise functions are carried by public or private institution and independence can be understood in several ways. It is also understood that, in the reality, no expert or scientists can be absolutely independent because of the necessary cooperation in research areas, or as result of a lack of available scientists and specialists in safety in nuclear sector in each country. It is expected that clear guidelines should be drawn in this area in order to determine what the acceptable level of reliance is.

Resulting from SITEX workshop discussion in SENEC, development is needed on clear identification how and when should Civil Society enter the decision making process. Stakeholder's expectation is to take part to the decision-making process at the earliest stage, even before conceptual phase. To ask Civil Society to cooperate only at the final stage of the nuclear energy cycle without interaction in earlier stages of project development is not acceptable anymore.

In general it can be noted that early interaction with expertise function should forego any decision making process. It could be some kind of deliberative discussion on Energy Strategy SEA. A frequently observed bad practice in some European countries is to shorten the official observation process and subsequently there is not sufficient time to open real discussion with stakeholders.

In summary, the basic requirement of Civil Society regarding entering the decision-making process can be summarised as follows:

- Start participation processes even earlier than conceptual phase,
- Open discussion during preparation of Energy Strategy SEA, New build EIA as well as Plant Life Extension (PLEX) EIA (prescribed under ESPOO),
- Include in the interaction with the public any topic related to waste management, including decommissioning and legacy waste management,
- Introduce flexibility for enabling the public to interact with the decision-making process when he feels appropriate.

Stakeholders have identified the following topics as topics where particular interaction is needed:

- Fundamental aspects of waste management background in each national context,
    - Decision process, history and rationale of already done decisions, subsequent strategic decisions,
    - Norms and standards determining certain decisions and waste management itself,
    - Safety principles & requirements.
- Position of regulator and regulatory body's experts,
    - Periodic update on the R&D agenda of the expertise function,
    - Safety Case review progress (i.e. Safety concept; Safety strategy adopted by the implementer) and periodic review of the evolution of the concept.

Mutual understanding is required to guarantee a continuous dialogue between the Civil Society and the expertise function. If there is no common understanding of fundamental issues, it is not possible to discuss more detailed aspects of each stage of the decision-making.

8.2.5 Opportunity to interact with the expertise function along the review process

In complement to the legal participation of the public in the decision making process when it exists, specific interactions are therefore needed between the Civil Society and the expertise function along the Safety Case Review process.

During the SITEX workshop in SENEC, several questions rose up during discussion with stakeholders that would deserve a common understanding and answers from the expertise function.

What is the aim of interaction?

Interactions between experts and Civil Society along the review are expected to entail a strong technical dimension. Goals, expected outputs, mutually agreed, quality criteria for managing the process & rules of the participatory process should be discussed and approved by the participants prior to the beginning of the process. Improvement based on feedback experience is expected.

On the one hand, a first purpose is to provide the public with relevant information on the most problematic issues identified by the expertise function regarding the Safety Case, and the corresponding options implemented as a result of the review. On the other hand, it is also an opportunity for the expertise function to identify the priorities and particular concerns of the public vis-à-vis the safety of Geological Disposal or particular issues regarding the decision making process. This exchange may contribute to enhance the expertise function by considering added value provided by experts from the Civil Society. In the case where some issues of particular concern for the public are not considered as key safety issues by the expertise function, closer dialogue contributes to clarify the judgment of experts and makes more robust the safety analysis and the common understanding between stakeholders. Finally, the interaction process is expected to contribute to mutual confidence and mutual respect (as an outcome of a credible and understandable dialogue).

In addition, interacting with the Civil Society will represent an opportunity to address the intergenerational dimension of safety and the problem of continuity of institutions and memory in the context of the Geological Disposal successive steps of implementation.

Who should be included?

Experiences with interaction with Civil Society in review are very limited; therefore there is no definite answer to this question. Certain categories of the Civil Society have specific knowledge to share with the experts (regarding e.g. locality, particular technologies etc.) and representatives of the affected communities are worth to be included into the process. However as the Aarhus Convention states it, any person claiming to have an interest in the issue should be welcome. It should however be understood from the beginning that this kind of interactions is representing a significant amount of resources from both sides. In some cases (e.g. the case of French Pluralistic Expertise process in France, or the engagement of CSOs in the review in Sweden) specific resources are foreseen in order to make it possible for Civil Society to engage in the review. Sufficient funding has to be made available to keep the same level of interaction along the process.

When is it worthy to begin interaction?

The answer to this question is very similar to the answer of the question regarding the participation requirements in the decision-making process. This means, that participative process should start as early as possible, at the stage of conceptualization phase. Discussion needs to continue on periodic basis, as Safety Case is a living document.

8.2.6 Opportunities of Interactions with the SITEX strategic research agenda

This purpose of this sub-section is to review the public expectations & the conditions for ensuring sustainable interactions between the expertise function and the Civil Society, along the implementation of research by expertise function.

Expectations of Civil Society regarding the role of the expertise function in assessing R&D needs

The SENEC's workshop raised different expectations from Civil Society regarding exchange with expertise functions on scientific issues:

- To make explicit "what is known and what is unknown" and what issues R&D programmes should in priority address;
- To quantify hazards and describe associated uncertainties and how to manage them;
- To translate and explain the difficult technical topics in a simple form but with sufficient details;
- To take on board the concerns of CS regarding technical and societal issues on RWM (e.g. the development of "RWM PLAN B" as potential alternatives in the case of a potential Safety Case failure of the "reference RWM solution")
- To foster international cooperation and resources sharing as a mean for enhancing the reliability of the expertise function and its capacity to develop internal R&D agenda, and to improve national capabilities for reviewing the Safety Case;

Governance of R&D and public participation

Several research program have been developed in the past addressing the need for appropriate patterns of governance in order to make it possible for the public to engage in the decision-making of RWM. Some knowledge is now available on the practical application of various tools and methodologies supporting the involvement of the Civil Society in the context of RWM. The R&D is an important dimension of the expertise function and the Civil Society is expecting some kind of interactions at the different stages of the R&D process as described above. But a particular concern is regarding the potential interactions with WMOs as a result of joint programming actions along the research agendas of WMOs and expertise function: in that context, maintaining the principle of independence of the expertise function vis-à-vis the WMOs is a key challenge.

This question is also linked with setting of an appropriate framework for the governance of European research, as the existing European Technological Platform in the RWM area (IGD-TP) is more specifically initiated and governed by operators. A particular attention here should be given to Horizon 2020 potential developments in this area and more specifically on the future development regarding the development of social sciences in the context of nuclear activities (e.g. for instance the PLATENSO project or the future development of Insotec).

8.3 Expected interactions between Civil Society and SITEX network

The SITEX project identified several main topics to deepen in order to develop interactions between the SITEX network and Civil Society actors:

- Public engagement brings an effective contribution to the quality of the decision-making process and SITEX provides a clear framework of the regulatory review process that is operated in the decision-making. The Civil Society is expecting from experts to adopt a broader vision and not to limit their scope to a narrow perspective (e.g. linkage between RW and energy strategy, to question the so-called need for transmutation reactors as a solution for RWM). The SITEX network interactions with Civil Society can be a forum in the future to bring this broader vision under the light of various structures on national as well as European level.
- The expertise is not the monopole of technical experts and Civil Society representatives are prepared to bring elements of expertise in the DMP. Experts from the society are not bound to one area of rationality. In this perspective they are more inclined to grasp the complexity of decision-making processes. This specific Civil Society multidimensional approach is a key factor of quality improvement of the expertise.
- The SITEX workshop in SENEC was perceived as an appropriate forum supporting the development of future cooperation and interactions with the Civil Society. SITEX should continue on providing such area for structured and equitable discussions between experts and the public and also according to the needs with other categories of stakeholders engaged into RWM. As suggested improvements, professional facilitators could be involved to achieve purpose-driven discussion.
- SITEX should cooperate in the future with existing Civil Society networks and CSOs operating at EU level, such as Nuclear Transparency Watch (NTW), REC, Greenpeace, Friend of the Earth, etc.

  From the SENEC discussions, it can be stated that SITEX network and its potential future interactions with the Civil Society are expected to bring under the light the particular dimensions and steps of the Geological Disposal development (decision making process, Safety Case review and R&D) and to contribute to clarify the very specific needs (knowledge, expertise, interactions with the public) at each level and stage, bringing a platform for sharing experience and preparing common ground for harmonizing review practices at European level.

EURATOM

9 Expertise function and WMOs

This section presents the issue of interactions between expertise function and WMOs in the context of geological disposal and the identified expectations, needs and limits regarding the development of these interactions.

9.1 Requirements on the interactions between expertise function and WMOs

This sub-section presents the requirements, elements of guidance and national practices that frame the interactions between the expertise function and the implementers.

9.1.1 Requirements of international guidance

Regarding the Technical exchanges between the expertise function and implementers, some requirements are presented in the international guidance. For example, the requirement 21 in **IAEA GSR Part 1- section 4** (Responsibilities of the regulatory body) is dedicated to the link between the regulatory body and implementer(s):

- *"The regulatory body shall establish formal and informal mechanisms of communication with authorized parties on all safety related issues, conducting a professional and constructive liaison".*

The requirements 23, 24 and 25 of this section 4 are also relevant on this issue:

- *"4.23. As its primary purpose, the regulatory body shall carry out oversight of facilities and activities. The regulatory body, while maintaining its independence, shall liaise with authorized parties to achieve their common objectives in ensuring safety. Meetings shall be held as necessary to fully understand and discuss the arguments of each party on safety related issues.*
- *The regulatory body shall foster mutual understanding and respect on the part of authorized parties through frank, open and yet formal relationships, providing constructive liaison on safety related issues.*
- *The decisions of the regulatory body shall be justified as appropriate, and the basis for the decisions shall be explained".*

The EPG report 2011-Draft also specifies that:

- *"In addition to develop the regulation and guidance related to geological disposal the regulator will have a continuing role to review the Safety Case and provide feedback to the implementer throughout the whole process of developing and implementing a geological disposal facility* […]. *Aspects of the work supporting the Safety Case will be subject to audit and inspection by the regulator. Such audits and inspections will be conducted according to a formal programme and established procedures. In the event of serious concerns or non-compliance, the regulator will take formal action. Other, less significant issues or concerns may be discussed with the implementer, or may be formally identified in writing, in order to* *move to the next phase in the development, on the understanding that they are addressed to the satisfaction of the regulator in a timely manner".*

However, such requirements remain general and no specific guidance is provided on exchanges between expertise function and implementers, corresponding to the "technical dialog". Only the GEOSAF final report comments the exchanges between implementers and reviewers:

- *"The reviewers should be careful of not being involved into the choices that are of the responsibility of the implementer and to avoid co-development of the Safety Case"*.

9.1.2 Elements of national guidance and practices

The SITEX participating organisations having regulatory functions work in conformity with these international requirements. More particularly, they favour frequent exchanges with the implementers in the following cases:

- To explain the regulation & guides to avoid ambiguities in the interpretation, to allow the implementer to discuss aspects on their practical implementation and sometime to elaborate some practical guidance in collaboration with the implementer;
- To discuss the methodological instruments (i.e. the approach of the implementer's safety strategy, safety assessment and management system…) before their implementation;
- To organize and define the successive steps of the license application;

For participating organisations developing expertise functions, frequent exchanges with WMOs ("technical dialog") are also considered as necessary for the following reasons:

- **Outside of the stage of reviewing the Safety Case**:
  - To ensure a correct understanding of the regulation and of the ways to meet the regulatory expectations,
  - To keep informed about the implementer's R&D program outcomes in order to know the conditions in which results were obtained (to avoid any misunderstanding of the results…), to be aware of the encountered difficulties, etc.; to be efficient, such kind of exchange requires to be periodic and can correspond to meetings, to the communication of implementer's periodic technical report, to visits in the implementer's surface laboratories or URL,
  - To undertake technical exchanges on concept evolution or safety approaches which are still under development and deserve mutual information.
- **During the formal review process**, exchanges are organized according to agreed procedure and focused on specific topics that are decided to be included in the framework of the review. Questions may be asked to the implementer & answers can be used for the technical review;

An increasingly controversy question is the opportunity to implement joint research programs with implementers in national or European frameworks.

Generally, implementers are mandated for developing their own R&D agenda aiming at supporting the development of concept and demonstration of safety. They receive funds for that purpose and must report periodically progress of research to the legal authorities.

In countries where expertise function is not formally identified, R&D organisations can play a role in supporting regulatory body but also implementer. Such situations make very confusing the boundary between scientific knowledge afforded to the regulatory body and that knowledge used to develop the Safety Case when supporting implementers. As a consequence, independence of expertise supporting the regulatory body is questioned.

In countries where expertise function is explicitly developed and implements strategic research agenda to enhance skills and independence vis-à-vis the knowledge of the implementer, it can be questioned whether research can be jointly carried out, in which conditions and for which purpose. Generally, as far as the research is focused on scientific gaps, and on acquisition of basic science that allows better understanding processes involved in the evolution of the disposal, there is a benefit to share as far as possible research programmes. This avoids undue duplication of resources and provides access to all stakeholders to the best level of knowledge. Then, it is of crucial importance that implementers and reviewers use separately the results obtained, for respectively developing the Safety Case and implementing the review process.

9.2 opportunities of interactions between SITEX network and WMOs

During the SITEX project, it was proposed to IGD-TP members, at the 3rd exchange forum of IGD-TP held on the 29th of November 2012 in Paris, to answer a questionnaire on the needs of WMOs further developing technical dialogue and possible additional guidance at the European level. Examples of questions of the questionnaire for each safety issue (from WENRA safety reference level) were:

- Do you think it is necessary to develop or further develop guidance on this issue?
- What are the topics that should be covered in particular by the guidance?
- What are the requirement(s) that should be addressed by the guidance?
- What is the level of priority of this development?
- Should the guidance address specific programme phase(s)?

Only one member (ONDRAF/NIRAS) completed the questionnaire and it was specified during the 4th IGD-TP exchange forum held in Prague 29-30 October 2013 that the answers should not be considered as representative of all IGD-TP members.

In order to foster exchange between WMOs and the experts, a special session was organised during this exchange forum with representatives of WMOs and SITEX, aiming at debating the assets and drawbacks of undertaking joint activities. Regarding the R&D activities, it was agreed that as mentioned above, as far as the cooperation is focused on acquisition of **basic science** there is no opposition to share joint research tools or programs. It was therefore remained that it is of crucial importance that implementers and reviewers **use separately the results obtained**, for respectively developing the safety case and implementing the review process. **Other strategic issues** (not exhaustive) were identified: the possibility for potential cooperation on topics like reversibility / retrievability, passive safety, long term safety, stability of geological system, impact on future generations, P&T. The idea was raised about possible **common positions** from IGD-TP and SITEX on such kind of issues **as far as these positions illustrate harmonization of view regarding key safety aspects and is worth to be communicated to various stakeholders.**

Because no representative opinion was made available through the questionnaire, SITEX checked needs and priorities on the basis of the IGD-TP's Strategic Research Agenda 2011[3] & Deployment Plan 2011-2016[4]. It appeared that several topics identified are directly related to requirements and "safety topic" addressed in the SITEX project:

- Increase confidence in, and testing and further refinement of the tools (concepts, definition of scenarios and computer codes) used in safety assessment;
- Technical feasibility and long-term performance of repository components;
- Methodologies for adaptation and optimisation during the operational phase and
- Monitoring.

It was concluded from this analysis that the list of topics identified by the SITEX participants (see SITEX D2.1), that would deserve more exchange, are similar to the needs identified by the WMOs in the two documents mentioned above.

[3] IGD-TP. (2011). IGD-TP Strategic Research Agenda (SRA): July 2011. Stockholm, Sweden; Retrieved from http://www.igdtp.eu/index.php/documents/doc_download/14-strategic-research-agenda

[4] IGDT-TP (2012). IGD-TP Implementing Geological Disposal of Radioactive Waste Technology Platform Deployment Plan 2011–2016. IGD-TP. Retrieved from http://www.igdtp.eu/index.php/key-documents/doc_download/143-master-deployment-plan-2013

ANNEX 1: Glossary of acronyms

ASAM: Application of Safety Assessment Methodologies for Near Surface Disposal Facilities

CS, CSO: Civil Society, Civil Society Organisation

DMP: Decision-Making process

GD: Geological Disposal

EBS: Engineered Barrier System

EC: European Commission

ENSTTI: European Nuclear Safety Training and Tutoring Institute

EPG: European Pilot Group

FEP: Features, events and processes

GEOSAF: The International Intercomparison and Harmonisation Project on Demonstrating the safety of geological disposal

HAZOP : Hazard and Operability Analysis (structured and systematic technique for system examination and risk management)

IAEA: International Atomic Energy Agency

IAEA TECDOCs: IAEA Technical Documents - http://www-pub.iaea.org/mtcd/publications/tecdocs.asp

ICRP: International Commission on Radiological Protection

IGD-TP: Implementing Geological Disposal of Radioactive Waste Technology Platform

MESA: Methods for Safety Assessment of Geological Disposal Facilities for Radioactive Waste

MELODIE: Model for long-term assessment of radioactive waste repositories (software developed by IRSN)

NEA: Nuclear Energy Agency

NTW: Nuclear Transparency Watch (European network of CSOs)

ONDRAF/NIRAS: the Belgian National Agency for Radioactive Waste and enriched Fissile Material

PAMINA: Performance Assessment Methodologies in Application to Guide the Development of the Safety Case

PRISM: Practical Illustration and Use of the Safety Case Concept in the Management of Near-Surface Disposal

R&D: Research and Development

REC: Regional Environmental Center

RW & SF-Management: Radioactive Waste and Spent Fuel Management

RWD: Radioactive Waste Disposal

RWM: Radioactive Waste Management

SARCON: Systematic Assessment of Regulatory Competence and Needs for Regulatory Bodies of Nuclear Facilities

SITEX: Sustainable network of Independent Technical Expertise for Radioactive Waste Disposal

SSG: Specific Safety Guide (IAEA Safety Standards)

SRA: Strategic Research Agenda

SRL: Safety Reference Level

THM: Thermo-Hydro-Mechanics

WAC: Waste acceptance criteria

WENRA: Western European Nuclear Regulator Association

WMO: Waste Management Organisations