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Synthesis of existing practices for training and tutoring of experts in geological disposal safety

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RE	Restricted to a group specified by the partners of the SITEX-II project
CO	Confidential, only for partners of the SITEX-II project

SITEX-II OUTLINES

Sustainable network for Independent Technical Expertise of Radioactive Waste Disposal – Interactions and Implementation (SITEX-II)

The SITEX-II Project (Coordination and Support Action) was initiated in 2015 within the EC's Horizon 2020 programme to further develop the Sustainable Independent Expertise Function Network in the field of deep geological disposal safety. This Network is expected to ensure a sustainable capability for developing and coordinating, at the international level, joint and harmonized activities, related to the Expertise Function. SITEX-II brings together representatives from 18 organisations including regulatory authorities, technical support organisations, research organisations and specialists in risk governance and interaction with general public, including NGOs and an education institute. It is aimed at practical implementation of the activities defined by the former EURATOM FP7 SITEX project (2012–2013), using the interaction modes identified by that project. SITEX-II, coordinated by IRSN, is implemented through 6 Work Packages (WP).

WP1 - Programming R&D (lead by Bel V). The general objective of WP1 is to further define the Expertise Function's R&D programme necessary to ensure independent scientific and technical capabilities for reviewing a safety case for geological disposal. In this perspective WP1 will develop a Strategic Research Agenda (SRA) and define the Terms of Reference (ToR) for its implementation accounting for the preparatory work to be carried out in the framework of the JOPRAD project for construction of a Joint Programming of research for geological disposal.

WP2 - Developing a joint review framework (lead by FANC). The key objective of WP2 is to further develop and document in position papers and technical guides a common understanding of the interpretation and proper implementation of safety requirements in the safety case for the six phases of facility development (conceptualization, siting, reference design, construction, operational, post-closure).

WP3 - Training and tutoring for reviewing the safety case (lead by LEI). WP3 aims to provide a practical demonstration of training services that may be provided by the foreseen SITEX network. A pilot training module will focus on the development of training modules at a generalist level, with emphasis on the technical review of the safety case, based on national experiences, practices and prospective views. The training modules will integrate the outcomes from WP1, WP2 and WP4 and support harmonisation of the technical review processes across Europe.

WP4 - Interactions with Civil Society (lead by Mutadis). WP4 is devoted to the elaboration of the conditions and means for developing interactions with Civil Society (CS) in the framework of the foreseen SITEX network, in view of transparency of the decision-making process. The future SITEX network is expected to support development of these interactions at different levels of governance and at different steps of the decision-making process. Three thematic tasks, namely R&D, safety culture/review and governance will be addressed by institutional experts and representatives of CS within SITEX-II as well as externally through workshops with other CS organisations.

WP5 - Integration and dissemination of project results (lead by CV REZ). The overall objective of WP5 is to produce a synthesis of the results achieved within all the WPs of SITEX-II together with an Action Plan that will set out the content and practical modalities of the future Expertise Function network. WP5 will also foster the interactions of SITEX-II with external entities and projects, as well as the dissemination of SITEX-II results so as to allow possible considerations from outside the project in the process of developing the future SITEX network.

WP6 - Management and coordination (lead by IRSN).

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Further details on the SITEX-II project and its outcomes are available at www.sitexproject.eu

ABSTRACT

This report is the first deliverable prepared by the SITEX-II project group for Work Package 3 *Training and tutoring for reviewing the Safety Case*. The report provides an overview of existing training and tutoring practices used by twelve organisations located in Europe and Canada to build expertise to support the regulatory review of the Safety Case for deep geological disposal. The information was compiled from a survey of SITEX-II partners on the following topics: current national practices on topics that included existing training programs at national levels, strategies and management of human resources, career management, competence building, and existing initiatives on interacting with civil society. Common practices and points of view as well as the differences between the partners are identified. Recommendations for competence building of technical experts (Safety Case reviewers) in the future are provided.

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1 Introduction

For reviewing of a Safety Case for a deep geological repository, experts with wide ranges of competencies are required. During the SITEX 7FP project (2012-2013) five different types of experts being involved in the technical review process were identified (generalist experts, environmental experts, numerical modellers, risk experts, experts in long-term safety) and their necessary knowledge and skills were compiled into “experts’ profiles”. According to the Terms of Reference of the SITEX network [SITEX, 2014a], Training and Tutoring will be one of the services provided by the network. A plan for competence development in expertise of radioactive waste disposal safety has been developed [SITEX, 2014b] and includes setting up a training program.

The Work Package 3 (WP3) of SITEX-II aims at demonstrating the implementation of a training service, including both technical and management aspects, by developing and testing a training module devoted to generalist experts involved in the Safety Case review process.

The tasks under the activities in WP3 are being fulfilled by cooperation of technical safety organisations, research organisations, nuclear regulatory authorities, and the European Nuclear Safety Training and Tutoring Institute (ENSTTI).

A first task consisted of identifying the common practices and points of view as well as the differences between the partners. This required listing the current national practices on topics such as: existing training programs at national levels, strategies/ management of human resources, career management, competence building, and existing initiatives on interacting with civil society. A review of existing good practices and operational needs led to recommendations developed by WP3 for competence building of technical experts.

The current report documents this first task of WP3 with an overview of existing training and tutoring practices, experience on application of existing training schemes and networks in Europe and Canada, and recommendations for competence building of technical experts for reviewing Safety Case of geological disposal (Safety Case reviewers) in the future.

2 Method

A questionnaire was developed to collect information on existing strategies and practices on competence building of technical experts in different areas of expertise. The results of the questionnaire were compiled and analysed (Chapter 3), leading to recommendations (Chapter 4).

The questionnaire form (Annex No. 1) was compiled to cover the following topics:

1. General information on organisation
2. Career management of experts in general
3. Existing training programs at the national level
4. Competence building
5. Existing initiatives on interaction with Civil Society (CS)

6. Participation in training and tutoring activities in relation to geological disposal on the international level

3 Overview of common practices, experience on training and tutoring of technical experts for reviewing the Safety Case - Synthesis

3.1 GENERAL INFORMATION ON ORGANISATIONS

In total **12** organisations took part in the survey. The respondents to the survey consisted of: Bel V, FANC (Belgium), GI-BAS (Bulgaria), CNSC (Canada), CV Rez (Czech Republic), IRSN, ASN (France), GRS (Germany), LEI (Lithuania), NRG (the Netherlands), DECOM, a.s. (Slovakia), and PSI (Switzerland).

The distribution of the responding organisations by status, i.e. technical support organisation (TSO), regulatory institutions or research organisations, is presented in Fig. 1. In the current survey typically one organisation per country provided the information on its expert training for technical review of Safety Case of radioactive waste disposal, except for Belgium and France where two organisations contributed within the framework of this WP.

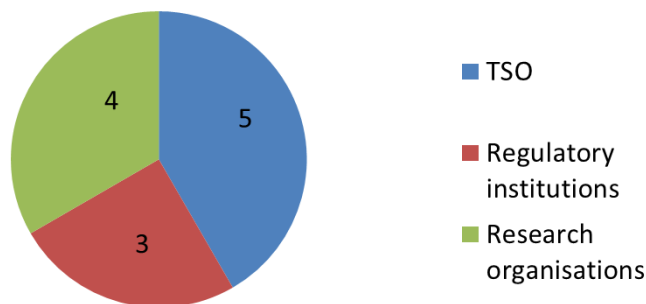


Fig. 1. Distribution of organisations by status

The description of each organisation that took part in the survey (respondents) is presented below.

Bel V (Belgium) is a technical subsidiary of the Federal Agency for Nuclear Control (FANC). Bel V performs certain regulatory functions legally delegated by the FANC. It is through the association of the FANC on one side, and Bel V on the other that the function of the Regulatory Body is ensured in Belgium.

FANC (Belgium) FANC/AFCN is the Belgian Federal Agency for Nuclear Control.

DECOM, a.s. (Slovakia) - DECOM, a.s. is the company with 21 years of history in nuclear energy branch, providing engineering and consultancy services for customers in Slovakia and abroad. Decom is TSO.

Institute for radiological protection and nuclear safety (IRSN, France) is the national public expert (TSO) in nuclear safety and radiation protection risks, and its activities cover all the related scientific and technical issues. Its areas of specialization include the environment and radiological emergency response, radiation protection of workers, population and environment, in both normal and post-accident situations, the prevention of major accidents, nuclear reactor safety, as well as safety in plants and laboratories, transport and waste treatment, and nuclear defense expertise.

Canadian Nuclear Safety Commission (CNSC, Canada) is the sole regulator of nuclear facilities and activities in Canada. The CNSC is responsible for licensing geological repositories intended to provide for long-term management of radioactive wastes. In Canada the technical and scientific support functions for the Canadian Nuclear Safety Commission (CNSC) are provided by in-house technical staff; there is no separate TSO.

Lithuanian Energy Institute (LEI, Lithuania) is a state research institute dealing with nuclear safety and radioactive waste management, structural integrity assessment of components and structures, thermal physics and fluid mechanics, and other energy related issues. There is no permanent agreement on the technical support for the regulatory body; usually the contracts are signed on a case by case basis.

CV Rez (Czech Republic) is a Czech TSO organisation founded in 2002 as daughter company of ÚJV Řež, a. s. (former Nuclear Research Institute, NRI), the oldest nuclear research organisation in the Czech Republic established in 1950's.

The Nuclear Safety Authority **ASN (France)** is an independent administrative authority set up by law 2006-686 of 13 June 2006 concerning nuclear transparency and safety.

Geological Institute – Bulgarian Academy of Sciences (GI-BAS, Bulgaria) is a research organisation, also in some cases supports regulatory body as TSO.

Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) gGmbH (GRS, Germany) is a non-profit and independent research and expert organisation. It refers to research organisation and TSO.

Paul Scherrer Institut (PSI, Switzerland) is the largest research centre for natural and engineering sciences within Switzerland.

NRG (The Netherlands) is the main research organisation in the Netherlands concerned with nuclear-related research and consultancy, TSO on contract basis.

Experience in review of the Safety Case of geological repository

Experience in reviewing of Safety Case for geologic disposal is dependent on the situation for geological disposal in each country and whether a Safety Case is either in development or has been submitted, as shown in Figure 2. Fifty percent of organisations report having some experience in the review of the Safety Case of geological disposal; all of those respondents are in countries that have either preliminary or well-developed Safety Cases for some type of geological disposal. The other fifty percent of organisations that have no experience are in countries where the Safety Case has not been developed. Some of those other organisations have gained experience in the review of other radioactive waste management and disposal facilities.

■ Yes ■ No/no SC developed yet

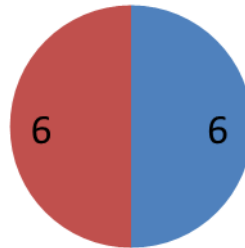


Fig. 2. Experience in reviewing the Safety Case of geological repository

The Safety Case for geological disposal has not been developed yet in Lithuania (LEI) and Slovakia (DECOM) but there is some experience gained from the review of surface disposal or radwaste management facilities in these countries. Similarly, the implementation of a geological disposal facility in Belgium is still pending. Nevertheless, if Belgium’s government approves the principle of a geological disposal, the next milestone for the high-level and/or long-lived waste disposal programme, proposed by ONDRAF/NIRAS, will be the development of a first “Safety and Feasibility Case” (SFC 1), planned in 2018 and Bel V will contribute to the review of the SFC 1.

Canada (CNSC) has experience in reviewing the Safety Case for a geological repository for low- and intermediate-level radioactive waste from the Bruce, Pickering and Darlington nuclear generating stations (2009-2014). In the case of a spent fuel repository, there is currently no licensing application and one is not expected for 7-10 years. At this time, it is not known where the repository will be located; therefore the applicant is developing conceptual designs for two hypothetical sites in representative rock formations. The CNSC is conducting a pre-project design review of the conceptual design and post-closure safety assessment for the two hypothetical sites.

Meanwhile France is in the final stage of site selection and at an intermediate stage for updating of the reference design (several reviews of a partial Safety Case). ASN, with its technical support organisation IRSN, reviewed preliminary files regarding the deep geological disposal: site characterisation, inventory, feasibility of the disposal concept, seals, operational safety. GRS also has experience and participates in planning phase, closure phase, licensing phase. GI-BAS has participated in the site selection process for geological repository of radioactive waste in Bulgaria.

Experts’ profiles

The required competences typical for “generalists”, “environmental scientists”, “numerical modellers”, “risk experts” and “experts in long-term safety” are employed in the responding organisations. However, not all organisations have the experts in all profiles. In one case (ASN), the experts match the “generalist expert” profile only. Meanwhile e.g. GI-BAS has experts of specialized profiles (environmental scientists, numerical modellers, risk experts) and did not report as having experts with generalist profile. Nevertheless, the answers indicate that the

majority of organisations foresee the need of the 4 profiles of experts (generalist + 3 specialist profiles) to review the proposed solutions for radioactive waste management.

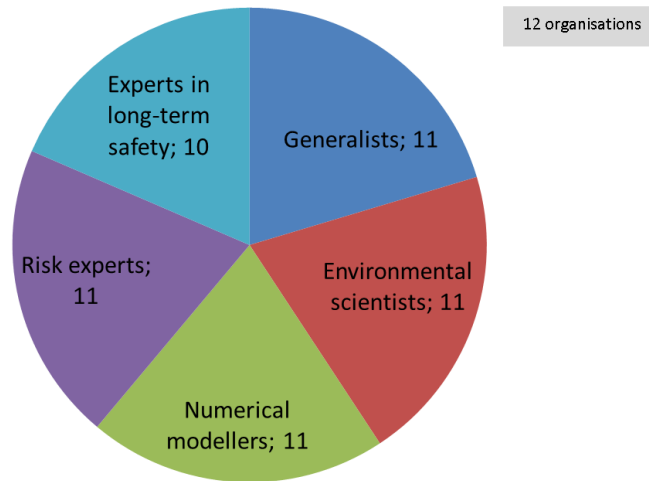


Fig. 3. Availability of experts of different profiles

Here,

- **Generalists** (nuclear facility experts, examining a Safety Case for DGR 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)
- **Environmental scientists** (experts with competences in biosphere, radioecology, meteorology, climatology, geochemistry, geology, hydrology, hydrogeology, seismology, geotechnics, geomechanics)
- **Numerical modellers** (experts with competences in numerical modelling, mathematics, computational methods)
- **Risk experts** (experts with competences in waste, civil & materials' engineering, radiochemistry, microbiology, nuclear physics, physical protection, radioprotection, human actions, earthquakes, flooding, environmental risks, fire & explosion, criticality, dynamic & static containment, radiolysis & thermal effects, ventilation, handling, power supply, underground hazard)
- **Experts in long-term safety** (experts with competences in scenario development, treatment of uncertainties)

For small organisations a single person might fill multiple expert profiles.

Main observation:

- ~42 % of answers were provided by TSO organisations (5 organisations), 25 % of answers came from regulatory institutions (3) and the rest part from research institutions (4 organisations).
- One organisation per country provided the information on its expert training for technical

review of Safety Case of radioactive waste disposal, except for Belgium and France where two organisations contributed per country.

- Experience on the review of a Safety Case depends directly on the national context. Half of respondent reported as having some experience in review of Safety Case of geological disposal. The others have no experience in the review of deep geological disposal for spent fuel in particular, but have experience in the review of other radioactive waste management and disposal facilities.
- Most of the responding organisations employ the various identified expert profiles (generalists, environmental scientists, numerical modellers, risk experts and experts in long-term safety).

3.2 CAREER MANAGEMENT OF EXPERTS (IN GENERAL)

Practice of human resources management

Regarding the practices of human resources management in the organisations the majority of respondents indicated they have trained full-time employees, hire external contractors on demand (Decom, FANC,) or implement a specific internal strategy (GRS). Bel V indicated having the management of human resources (HR) fully integrated in the Quality System (QS). For instance, a series of tools and processes exists in Bel V QS to evaluate if HR (in terms of staff and competencies) is compatible with the current and future needs of Bel V and to take appropriate measures if gaps are identified (e.g. transfer knowledge, employ new co-workers...). CNSC, ASN, IRSN have full-time staff employed with the expertise required to carry out an evaluation for a licence application for radioactive waste disposal, while CV Rez, LEI, PSI, NRG are contracting out reviews for specific topics or will employ individuals based on demand. Specific mention of training initiatives specific to a country (i. e. national program of experts' trainings, etc.) was not mentioned and appears to be managed internally in the organisations.

Career management practise on the organisational level

For career management, 8 organisations (ASN, Bel V, CNSC, GI-BAS, IRSN, NRG, PSI) indicated having career management at the organisational level or under development (FANC), while in small organisations like DECOM careers are managed by experts individually or on the sub-level, by individuals and head of department (LEI). CV Rez reported as having no career management practise at the organisational level.

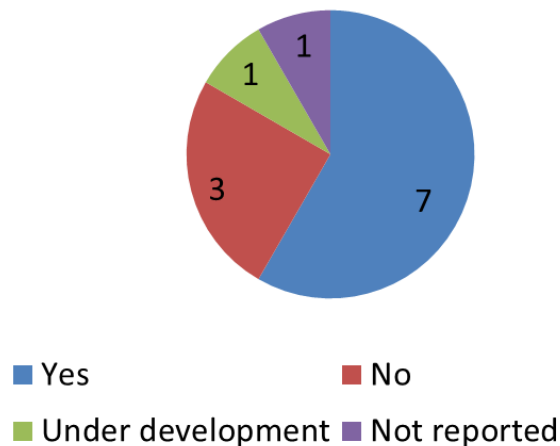


Fig. 4. Career management practise on the organisational level

Subject Matter Expert training and career progression

There is a common trend of employing young people or experts from other departments and providing them with training in research or regulatory review related to safety case to ensure competence development. Some organisations (GI-BAS, LEI, NRG) indicated progression in terms of position (e.g. junior researcher->researcher->senior researcher; junior scientist->medior consulting scientist -> senior consultant). In some organisations, the management of competence development is organized by a dedicated department (e.g. ASN, CNSC, IRSN) and documented by individual learning plans (e.g. Bel V, CNSC), or managed individually.

With the aim of maintaining and developing its own competency, ASN has implemented a comprehensive training program for its staff. This program intends, in particular, to give ASN inspectors sufficient competence to perform their activities. This program is based on technical courses augmented by general courses in the field of communication, legal affairs, quality, English language or management. Such training is taken into consideration in any decision to qualify staff as inspectors. The ASN human resources department aims to provide necessary skills and competences to each other ASN department. The human resources management includes: recruitment process, competency management and career development. There are permanent discussions between technical departments and department in charge of human resources on one hand and between all departments and ASN executive management on the other hand. These relations aim to identify the competencies required, to confirm the department concerned and to validate the recruitment process to undertake or, in some cases, to proceed to arbitrages. These relations and exchanges take into account actions to conduct and projects to manage by each department.

The CNSC has a strategic framework in place that defines the organisation's goals for the coming years and outlines key priorities and initiatives to achieve these goals. Workforce planning is carried out concurrently, looking at the CNSC's human resource requirements and how employee development can be supported to ensure there is flexibility to respond effectively to changing industry requirements such as regulatory reviews of a Safety Case. Specific operational plans and strategies for resources and the workforce may differ however among the various parts of the

organisation. (e.g. one division may have a larger number of people retiring sooner than others). The organisation has a program for learning and development which is headed by the Strategies, Programs and Learning Division. This program supports employees' professional development, innovation, leadership/management development and knowledge transfer. An important aspect of the program is the individual learning plan. Employees are required to fill out a learning plan that is a written strategy for developing and maintaining the competencies (knowledge, skills, behaviours and abilities) needed to perform in their current position and to develop their career in the future years. The learning plan incorporates a combination of in-house and external training courses, conferences, on the job training, and mentoring. This learning plan tool is used often to help employees gain exposure to training activities related to the Safety Case and international workshops on geologic repositories (e.g. attendance of the IAEA Underground Research Laboratories Network).

The definition of individual development plans and appropriate training programmes for Bel V co-workers is fully integrated in the quality system (QS) of the organisation. For instance, the QS foresees the development of general annual training programmes for Bel V experts, as well as the development of individual training programmes depending on the function(s) and skills of experts. The QS foresees the possibility for experts to evolve between different functions (e.g. newcomers, safety analyst, safety assessors) and between different departments (Inspection, Assessment, and Project).

Decom employs students and develops their competence step by step and by providing permanent contracts after graduation. Any expert is supported to participate on available training courses (especially IAEA training courses), but it is managed by the expert, without direction from management. Financial support is provided in line with available resources. Cooperation with Slovak Technical University (STU) in Bratislava is well established; a majority of DECOM experts completed PhD studies collaboratively with STU, and were employed by DECOM during or after their PhD studies. If DECOM has the capacity and suitable projects, students and PhDs from STU are contracted for project work.

IRSN recruits both young engineers and experts coming from other organisations. Competence building for new graduates comes from practice (with time and senior colleagues support) and from training. The harmonisation of career management at the level of the Institute is under implementation. IRSN has defined 8 families of profiles, nearly 30 profiles and about 150 sub-profiles, so as to facilitate internal transfers and homogenise the practices in terms of QS. Each position is affiliated to a profile. Each position needs specific competences and skills, but the experts of related profiles could use the same forms, procedures and have common retraining sessions if the profiles are relative (short overview of training options, schemes and networks at/including IRSN is provided in the Annex 2).

Usually master students begin to work in one of the LEI laboratory as engineers (introduction to laboratory researches); later they may start PhD studies to focus their research in particular area. During PhD studies, students work as young researchers and take courses on specific topics related to their PhD, as available. After obtaining PhD degrees, new experts can apply for researcher or senior researcher position. Researchers and senior researchers maintain their competence in particular areas through participation in courses, technical meetings, national and international projects.

Regarding the expert competence evolution, CV-Rez indicated that self-study, participation in international events, in training courses, and conducting literature surveys as the main forms of training activities being undertaken.

GI-BAS mostly employ PhDs students (seldom MSc) and develop their competence step by step, until they become senior researchers/experts.

Number of experts in the field of radioactive waste disposal

Based on the answers provided to the questionnaire, the average number of experts in the field of radioactive waste disposal per organisation is presented in Fig. 5.

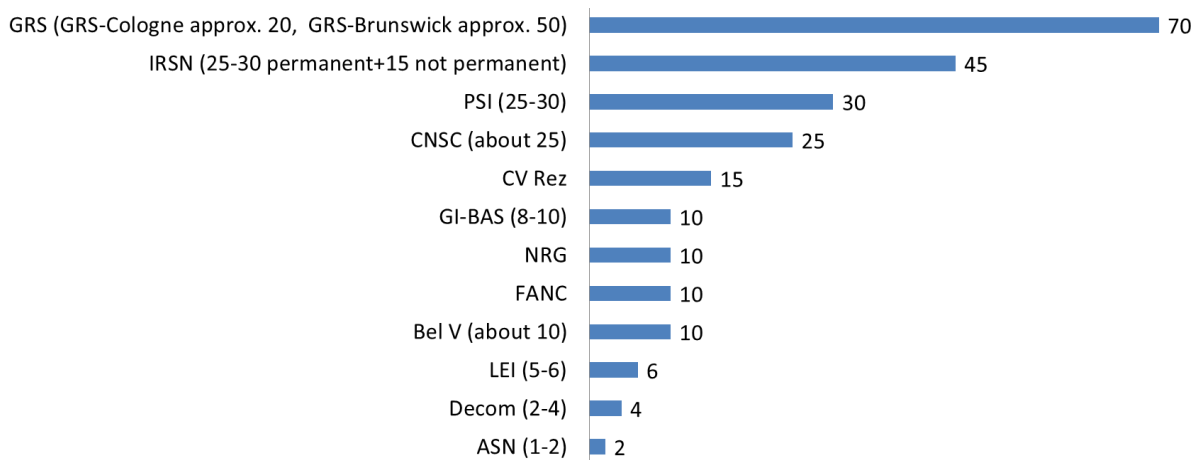


Fig. 5. Average number of experts in the field of radioactive waste disposal

As seen in the figure, more experts seem to be employed by the GRS (Germany)¹, IRSN (France), CSNC (Canada) with considerably fewer employed by DECOM (Slovakia) and LEI (Lithuania). This closely relates to the status of the country’s disposal program: organisations from countries with less experience and less advanced disposal program have different demands and thus fewer technical experts. ASN experts are supported by IRSN technical experts, thus should be considered together within the country context (France); similarly, FANC is supported by Bel V.

Number of experts focussed specifically on geological disposal

In reviewing the Safety Case for geological repositories, technical knowledge of geological environments, relevant geological processes, and the interactions between the natural environment and engineered materials on a large scale and over the long term is required. This requires experts with more specifically focus on geological disposal. The average number of experts in the surveyed organisations is presented in Fig. 6. The trend of having more experts in the organisations from countries with more advanced disposal program or long term experience is evident (GRS, IRSN, CNSC).

¹ It is worth noting that in Germany, all existing disposal facilities are underground ones).

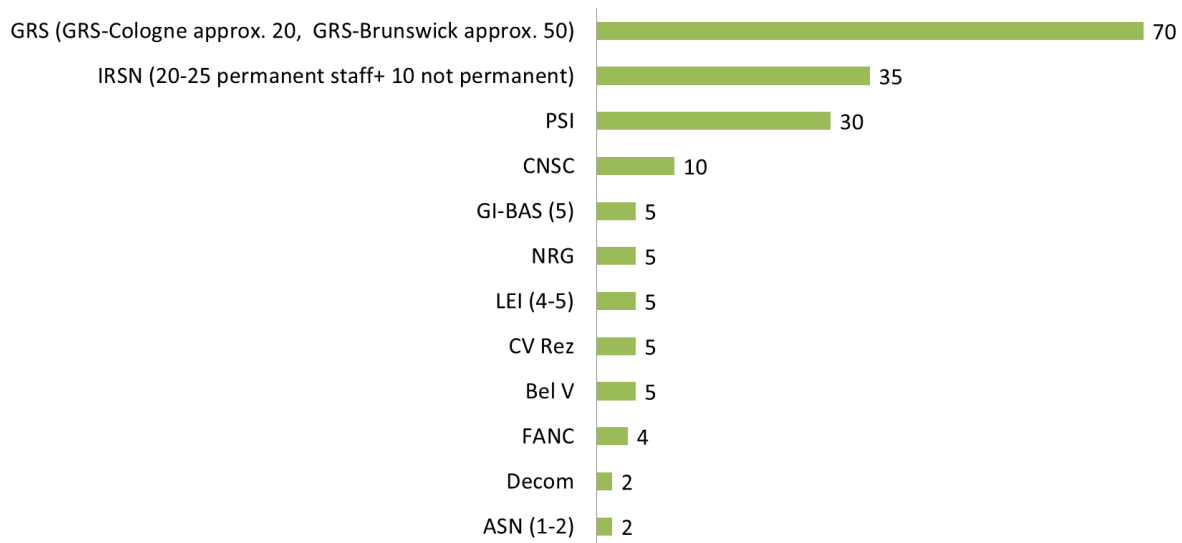


Fig. 6. Average number of experts focussed specifically on geological disposal

Longevity of experts in this field

Years of experience of experts currently working on geological disposal varied from 4 years on average (ASN) to 40 years (CV Rez). The other organisations indicated an average of ~10 years (IRSN, LEI), ~12 years (DECOM, GI-BAS), >10 years (NRG), and 10-20 years (CNSC). Longevity of experts in this field and a low fluctuation of employees in general were also reported by GRS. PSI reported having their experts until retirement.

This indicates that experts tend to stay in organisations for significant time periods. Thus, knowledge is being preserved and the competence is being developed continuously.

Background of newcomers

The answers revealed a variety of practises across organisations for newcomers: the newcomers are young engineers (Bel V, GRS, LEI); or professionals from other teams inside the organisations or from other institutions (ASN). The majority of organisations indicated that newcomers are young engineers and professionals from other teams or organisations (CNSC, CV Rez, DECOM, FANC, IRSN, NRG, PSI). The practice in each organisation could reflect the urgency of expertise needed, the availability of experts as well as long-term strategy of human resources within the organisation.

Preservation and transfer of knowledge

The organisations with human management departments indicated that knowledge management is integrated in the quality management system. This could take the form of internal training courses, with particular attention given to training program development and delivery (ASN, Bel V, CNSC, IRSN).

Even in the absence of a human resources department, knowledge preservation by educating newcomers and working under the supervision of experienced experts is a common practice (CV

Rez, DECOM, LEI). Some organisations (NRG, GI-BAS) reported not having a particular internal department, but indicated that experts are available to provide training and knowledge transfer activities (GI-BAS). This observation highlights the importance and necessity of knowledge management and learning processes such as training, learning from experience, and continual improvement. The knowledge management strategy is more formalized and documented in organisations with dedicated human resources or knowledge management departments, or where it is incorporated in the organisation's overall quality management system.

There is no specific department for education and training in the GRS. However, initial training for newcomers includes a wide spectrum of education modules in the nuclear field. This education program is performed under the umbrella of the GRS-Academy. Another option for newcomers is the participation in the ETSON²-Summer-Workshop. The workshop is aimed at young professionals and trainees of technical safety organisations (TSO). The participants should have basic knowledge of relevant technical nuclear fields. In general, members of GRS have the opportunity to participate in internal and external training courses.

It was also noted (ASN) that regarding the deep geological disposal subject, the step by step approach, with regularly discussions between implementer, TSO and regulatory body is also very important to allow growth of competences and knowledge keeping.

Main observations:

- The majority of the organisations employ experts regularly and external contracting on demand.
- Several organisations (ASN, Bel V, CNSC, GI-BAS, IRSN, NRG, PSI) indicated having career management at the organisational level or under development (58 % responses), while in small organisations career management occurs at the individual level and/or the department-level.
- Half of the organisations indicated that their newcomers are young engineers **and** professionals from other teams or organisations. The organisations provide training of their experts to develop necessary competence and skills.
- The average number of experts in the field of radioactive waste disposal varies among the organisations from the largest team in GRS, PSI, IRSN, CNSC to lower ones such as DECOM. It is likely related to the status of country's disposal program: organisations from countries with less experience and less advanced disposal programs have different demands and thus less technical experts in this field.
- Several organisations (ASN, Bel V, CNSC, IRSN) having or implementing a human management department indicated that knowledge management is integrated in the quality management

² In 2006, the technical safety organizations of France (IRSN), Belgium (Bel V) and Germany (GRS) have founded the European TSO network (ETSON). The main objective of ETSON is to promote improved cooperation among the European TSOs in the field of nuclear safety. An important measure here is the maintenance of knowledge and expertise by establishing common education and training programmes, like the ETSON Summer Workshop.

system.

- Knowledge preservation by educating new comers and working under supervision of experienced experts was commonly mentioned.

3.3 EXISTING TRAINING PROGRAMS AT THE NATIONAL LEVEL

This section was intended to identify if there are some training schemes (programs, courses) available on national level for training of technical experts in the field of radioactive waste disposal (possibly linking to the universities if they offer a dedicated programs, or other institutions providing this type of training). The respondents were asked to consider only the aspects concerning training on how to **perform the review of Safety Case**, and not training of the basic technical knowledge (geology, radioactivity, modelling and so on), that should already been acquired . However, it is important to acknowledge that some training tools in the context of radioactive waste management and disposal mentioned by some organisations are not specifically dedicated for review of Safety Case. They are maintained within the following analysis as information of interest.

The answers from the respondents are summarized in Fig. 7. This comparison provides preliminary insights on the organisations' needs in terms of experts training.

The answer category "Not applicable" indicates experts with this profile are not available in the organisations.

Training for generalist experts:

For training of generalist experts 5 of 12 organisations indicated applying some tools available inside the organisations or at national level. For example, the training program applied by ASN is based on technical courses and also general courses in the field of communication, legal, quality, English language or management. Such training is taken into consideration in any decisions to qualify staff as inspectors. The initial training programs length is about six months. Different modules have been implemented in the field of nuclear safety, radiation protection, labour inspection, or radioactive substances transportation to give people sufficient competencies to deliver authorisations, conduct inspection or enforce regulatory requirements. IRSN mentioned IRSN's internal school (see Annex 2) of expertise (Internal training for IRSN engineers to prepare them for expertise work) as well as training modules offered by ENSTTI. There is no module on Safety Case review, but specific module to radioactive waste disposal exists, which includes Safety Case review to some extent.

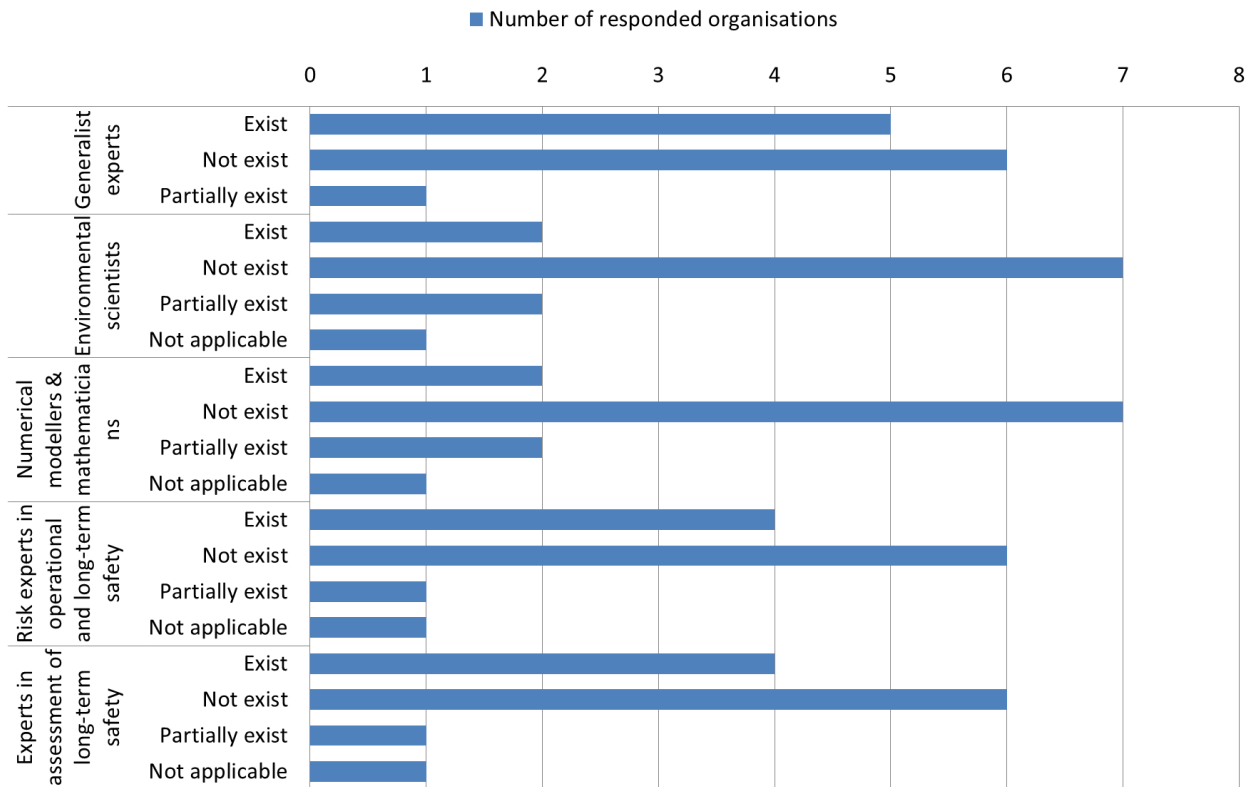


Fig. 7. Existing schemes within the organisations or national level for training of experts

In Belgium, there is no program focusing on how to perform the review of a Safety Case for waste disposal facilities; however several training tools were mentioned by FANC and Bel V (BNEN, SCK•CEN Academy). A more general program (BNEN) is developed for nuclear engineers and could be followed by generalist experts. BNEN (the Belgian Nuclear higher Education Network, see <http://bnen.sckcen.be/>) organises a one-year (60 ECTS) master-after-master programme in nuclear engineering. The primary objective of the BNEN programme is to educate young engineers in nuclear engineering and its applications and to develop and maintain high-level nuclear competences in Belgium and abroad. BNEN is organised through a consortium of six Belgian universities and the Belgian Nuclear Research Centre, SCK•CEN.

The SCK•CEN Academy provides tailored and modular training courses for workers from nuclear industry, the medical sector, non-nuclear industry, research and governmental institutions who are directly or indirectly faced with applications of radioactivity in their professional environment. The Academy is active in all nuclear research fields including:

- Nuclear engineering sciences
- Radiation protection
- Material sciences
- Waste management
- Dismantling and decontamination
- Nuclear emergency planning
- Radiobiology and radioecology
- Microbiology

Duration of training varies, depending on the programme it could last from 1 week to 1 year (e.g.: next initiative http://academy.sckcen.be/en/Customised_trainings/Calendar/Radioactive-waste--disposal-expert-20160601-20160610-24347c76287ee51180cbecf4bbc6e825?leftmainmenu=1).

Training of experts of GRS was reported as not mandatory. Each member can decide by themselves if he or she will participate in training courses in the context of Safety Case review. GRS supports the participation for specific training courses financially.

Furthermore, GRS hosts on a regular basis so called seminars for public authorities "Behördenseminar" in the entire nuclear field inclusive radioactive waste management. These seminars are aimed at members of German regulating authorities and licensing authorities. The tutors are experienced experts of the GRS and also from acknowledged external expert organisations.

The tools available for GRS for the experts (of different profiles) training was mentioned as follows:

- GRS academy
- Cooperation with following colleges and universities:
 - Ruhr-Universität (RUB) Bochum.
 - Rheinisch-Westfälischen Hochschule (RWTH) Aachen
 - Technische Universität Braunschweig
 - Technische Universität Clausthal-Zellerfeld
 - Technische Universität Dresden
 - Technische Universität München
 - Universität Magdeburg
 - FH Brandenburg
- Several national seminars provided by e.g. TÜV, AINT, KIT.

Meanwhile the other 6 organisations indicated the absence or limited training available (e.g. there is only one regular training on Decommissioning aspect of NPP organised by Slovak Technical University; Nuclear safety and environmental issues are included in general nuclear engineering studies, as reported by DECOM).

Training for environmental scientists, numerical modellers, risk experts, experts in assessment of long-term safety:

The availability of schemes/tools for training experts of environmental scientists, numerical modellers, risk experts, experts in assessment of long-term safety on reviewing the Safety Case, is different across the countries. 7 (out of 12) organisations indicated a lack of training scheme for environmental scientists, numerical modellers, 6 organisations reported the absence of training scheme for risk experts, experts in the assessment of long-term safety. Few organisations declared as having the needs of specialized trainings partially met by existing training schemes.

The Canadian regulatory body has trained CNSC staff to review the Safety Case using the following methods: training by CNSC senior staff by direct supervision (mentoring); participation (D-N°: 3.1)

Synthesis of existing practices for training and tutoring of experts in geological disposal safety

Dissemination level: **PU**

Date of issue of this report: **11/30/2016**

of CNSC staff in research projects joint with Canadian universities on aspects of radioactive waste disposal (barriers, natural tracers, etc.); hiring a third party contractor to carry out modelling and learn from the contractor about how the model works, calibration of the model, limitations etc. Training of risk experts occurs mainly through mentoring of junior staff by senior staff and by staff participation and involvement in site visits to and conferences. Training of experts in assessment of long-term safety occurs mainly through mentoring of junior staff by senior staff and through staff participation in research programs with Canadian universities and international projects.

IRSN reported IRSN's internal school of expertise (Internal training for IRSN engineers to prepare them for expertise work) and ENSTTI as a tool for the training of risk experts and for experts in the long-term safety (ENSTTI), however no existing scheme for numerical modellers and environmental scientists exists. These experts are hired as already efficient in their field after graduating from university for example and are mentored by senior staff the first years to learn about the assessment of long-term safety.

As it was indicated by FANC and Bel V, most of Belgium universities propose courses for training of environmental scientists, numerical modellers, risk experts and experts in long-term safety, however not specific to Safety Case.

Meanwhile, the majority of the organisations reported as having no already available tools for training on reviewing the Safety Case inside organisations or on the national level which would be dedicated for experts of more specific profiles.

Main observation:

Training for generalist experts:

- 5 (out of 12) organisations indicated applying some tools available inside the organisations or at national level. However not all of these tools are devoted to the Safety Case review specifically.
- One organisation reported partial availability/suitability of existing training schemes to provide training dedicated to generalist expert profile for Safety Case review.

Training for Environmental scientists, numerical modellers, risk experts, experts in assessment of long-term safety:

- 7 (58 %) organisations indicated a lack of training scheme for environmental scientists, numerical modellers in the context of reviewing the Safety Case.
- 6 (50 %) organisations reported the absence of training scheme for risk experts, the assessment of long-term safety.
- Few organisations declared as having the needs of specialized trainings partially met by existing training schemes.

3.4 COMPETENCE BUILDING

The overview of different forms used by the organisations for competence building of their experts is presented in Fig. 8.

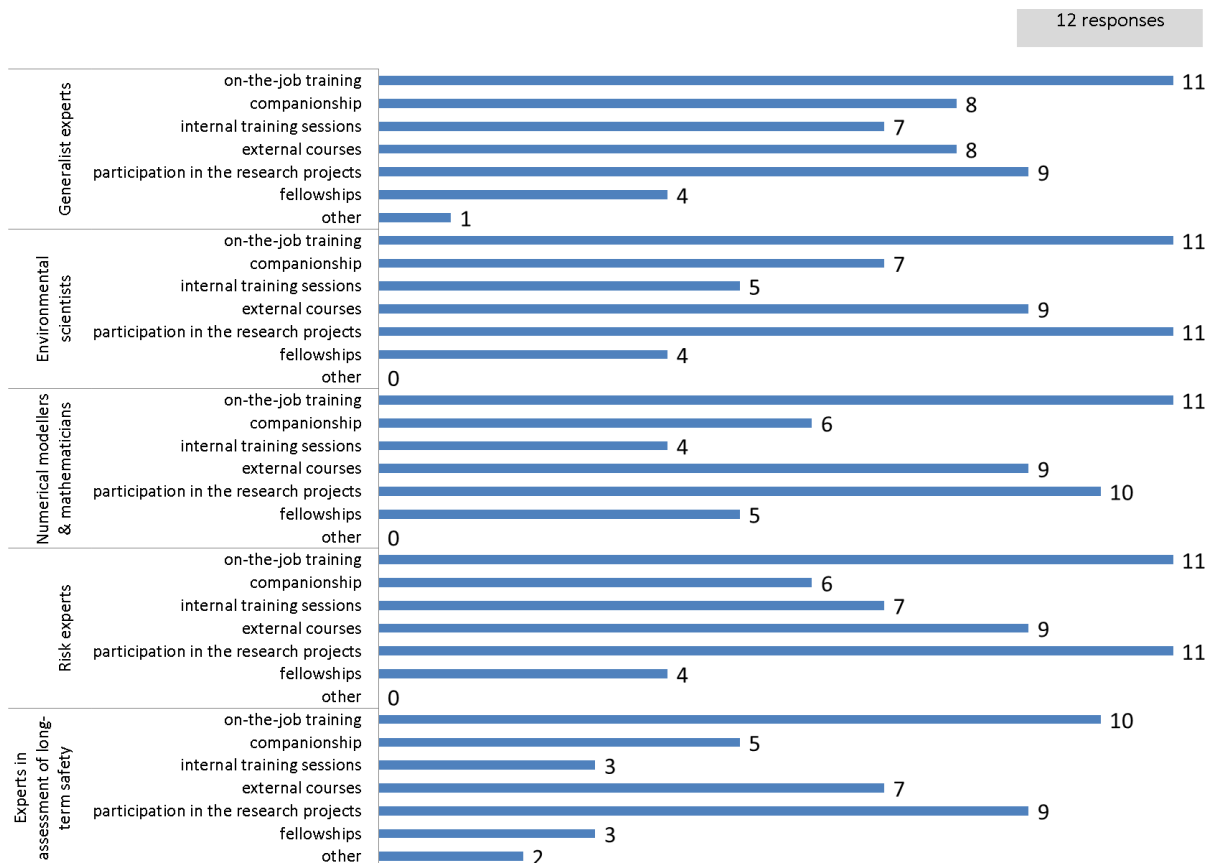


Fig. 8. Practices applied for increase of the competence of experts

Competence of generalist experts

As seen from the diagram (Fig. 8), competence of experts typically develops while working on dedicated tasks (on-the-job training), and reviewing documentation on safety and environmental impact of other nuclear facilities. Participation in research projects and external courses are other common ways for the competence development. Working in pairs with a more experienced expert (companionship) was also indicated as an effective way to increase the competence (e.g., for the newcomers). For training of generalist experts, the existing training courses are used if available (correlates with section “EXISTING TRAINING PROGRAMS AT NATIONAL LEVEL”).

Other forms of the competence development of generalist were also mentioned, e.g., workshops and preparation of documents on elements of the Safety Case (CNSC); international collaborations are considered as a part of FANC training program: exchange of experience allows being informed about the state of the art and being aware of “good practices” (FANC).

Competence of the experts of specialized profiles

For the experts with specialized profile (non generalists), the on-job-training dominates among the most frequent practises. Besides, more rapid competence development is stimulated through the participation in research projects. All responding organisations (except ANS which has experts matching the generalist profile only) reported this among the other forms for their experts' competence development. For example, FANC noted that collaboration of FANC with Tournemire underground laboratory (IRSN) and Mont Terri underground laboratory is one of the ways to train their experts about development and implementation of in-situ experiments as well as about difficulties encountered and uncertainties of the results. International collaboration also occurs in terms of the participation in international workgroups such as HIDRA (CNSC). This confirms importance of cooperation in research activities, especially for organisations from countries with less advanced geological disposal programs.

Training courses or application of internal training sessions (to less extent) are also among the forms for competence development. The application of training courses or internal training sessions to less extent might be correlated with the availability/non-availability of training in dedicated topics, participation cost, lack of information about the event itself, etc.

The fellowships are among the practices being applied; however they are not very common. This might be related to training specifics (longer duration, requires more resources, etc.). The CNSC supervises and financially supports doctoral and post-doctoral students being trained as numerical modellers. DECOM employs PhD students as part-time workers. The LEI has some experience in competence development through fellowship at other organisations abroad.

In general, the organisations have several ways to increase the competence of their experts. Some organisations have developed more internal training inside the organisation in comparison to the other, e.g., GRS developed GRS academy, IRSN developed its own "internal school of expertise" to prepare engineers for expertise work. IRSN internal school contributes to diffusing homogeneous methods, references, etc. at the Institute. In addition, IRSN proposes to its experts to attend other trainings (catalogue of services provided by other institutes, private companies, universities..., with sometimes negotiated prices/topics for IRSN) in the following domains: sciences and technics, quality, management, informatics, foreign languages, economy, law, communication, etc.

The other organisations are more dependent on and look for the available training outside the organisation in terms of external training and international collaboration.

Main observation:

- In general, the organisations apply several ways to increase the competence of their experts.
- Some organisations (ASN, GRS, IRSN) have developed more internal training in comparison to the others.
- The other organisations are more dependent on and look for the available training outside the organisation in terms of external training and international collaboration.
- On-the-job training, participation in the research projects, and taking external courses were reported as the most common ways for the competence development.

3.5 EXISTING INITIATIVES ON INTERACTION WITH CIVIL SOCIETY (CS)

This section was devoted to collect information about practices existing in the organisations on the interaction with Civil Society (CS). The interaction of technical experts with CS will occur while reviewing the Safety Case, and the experts are expected to be introduced to the modes of interaction with CS. Besides, one of SITEX network services is foreseen to be training of technical experts, which might include non-institutional (CS) experts.

Interaction with Civil Society

In summary, the majority (67 percent) of the organisations have interaction with the CS in one or another way (Fig. 9).

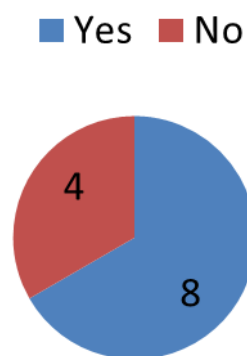


Fig. 9. Responding organisations interacting with CS

Bel V, GRS, NRG reported as not interacting with CS directly.

Forms of interaction with the CS

Forms of interaction with the CS and the public range from sessions with the CS and Municipalities' representatives within the 7FP project IPPA to the participation in Environmental Impact Assessment (EIA) process public hearings as members of the reporting team (DECOM); from discussions with concerned actors, provision of local communities with resources and data allowing them to learn more about radwaste disposal, the partnerships with associations of environmental protection and others to education at schools (IRSN). Spoken and/or written communication, presentations, organisation's website, round table were reported by FANC; a visitor centre, guided tours, presentations/discussions were declared by PSI as a means of interaction. The LEI indicated the interaction through the discussions of EIA reports.

As the Canadian regulatory body, the CNSC is committed to operating with a high level of transparency. The Commission has a mandate to disseminate objective scientific, technical and regulatory information to the public concerning nuclear activities. This obligation is defined in the Nuclear Safety and Control Act.

Different means by which the CNSC interacts with the public were reported:

- The Commission makes decisions on the licensing of major nuclear facilities through a public hearing process.

- Information is disseminated to the public through the CNSC website, information sessions, outreach activities and other types of social media (Twitter, Facebook, etc.).
- CNSC administers a participant funding program that aims to enhance Aboriginal, public and stakeholder participation in nuclear review processes while bringing value-added information to the CNSC.

Information exchange with stakeholders was mentioned as essential for ASN. This makes it possible to avoid getting isolated and to become aware of and appreciate the positions of all players. It enables ASN to enrich and develop doctrine and to promote its positions. The involvement of stakeholders is essential to enable a truly several-sided debate. It can help ASN to make decisions and arbitrate (e.g., through public inquiry) or discussions between environmental associations and waste producers. In that objective, ASN manages press relations, public affairs, professional events, exchanges with Local Information Committees (CLIs), working groups, etc. (formal mechanisms) and by informal mechanisms (through Information Centre). The brand new Information Centre at ASN headquarters performs its public service duties notably through the following specific functions:

- “Organisation of pedagogical exhibitions and conferences” concerning nuclear safety and radiation protection.
- “Documentation and access to administrative documents”. It offers more than 3,000 documents concerning nuclear safety and radiation protection for consultation.
- “Answering the public’s questions” (with IRSN’s help) from a variety of audiences: private individuals, professionals, students, associations, etc. In 2012, the ASN’s Public information centre answered more than 1,600 queries from the various parties, requests for administrative documents, for environmental information, for transmission of publications, for documentary searches and for position statements on subjects with significant implications.

Purpose of the interaction

The purpose of the interaction with the CS and the public is predefined for the organisations with regulatory function (CNSC, ASN, FANC). The support of the public to RAW site selection and environmental impact assessments is a purpose of the interaction as indicated by Gi-BAS. PSI reported the demonstration and discussion of research at the institute as the purpose of interaction with CS.

The interaction with the CS and the public was also recognized by organisations supporting the regulatory bodies (TSO, research organisations). For example, in France the purpose is defined in the charter on openness to society since 2009. In this charter, IRSN commits to improve risk assessment through a better interaction with society. For this IRSN pledges to:

- Enhance transparency in presenting its work;
- Share its knowledge;

- Help stakeholders acquiring the skills necessary to actively participate and build risk assessment along with them.

The CNSC is committed to operating with a high level of transparency. The CNSC has a mandate to disseminate objective scientific, technical and regulatory information to the public concerning nuclear activities. This obligation is defined in the Nuclear Safety and Control Act.

Communication with the CS

A part of the organisations has a special department devoted for the communication and interaction with the CS (IRSN, CNSC, ASN) or intend to establish it (FANC, CV Rez). The others have no special department (DECOM, LEI, GI-BAS) or reported as not interacting (Bel V, GRS) (Fig. 10). None of mentioned options were reported by NRG.

■ Yes ■ No ■ Not yet ■ Not interacting

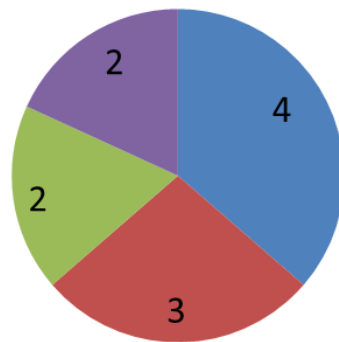


Fig. 10. Specific department for communication and interaction with the CS

Relations with the CS

The organisations, which indicated previously as interacting with CS in one or other way (IRSN, CNSC, ASN, FANC, CV Rez, DECOM, LEI, GI-BAS, PSI), reported their relation with the CS as constructive and neutral mainly (Fig. 11). Some organisations chose more than one term for the description of the relationship.

■ Neutral ■ Constructive ■ Conflicting

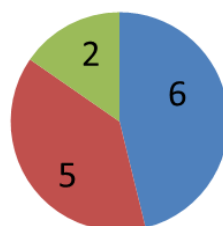


Fig. 11. Relations of the interacting organisations with the CS

Forms of interaction with the CS

A summary of the forms of interaction with the CS is presented in Fig. 12.

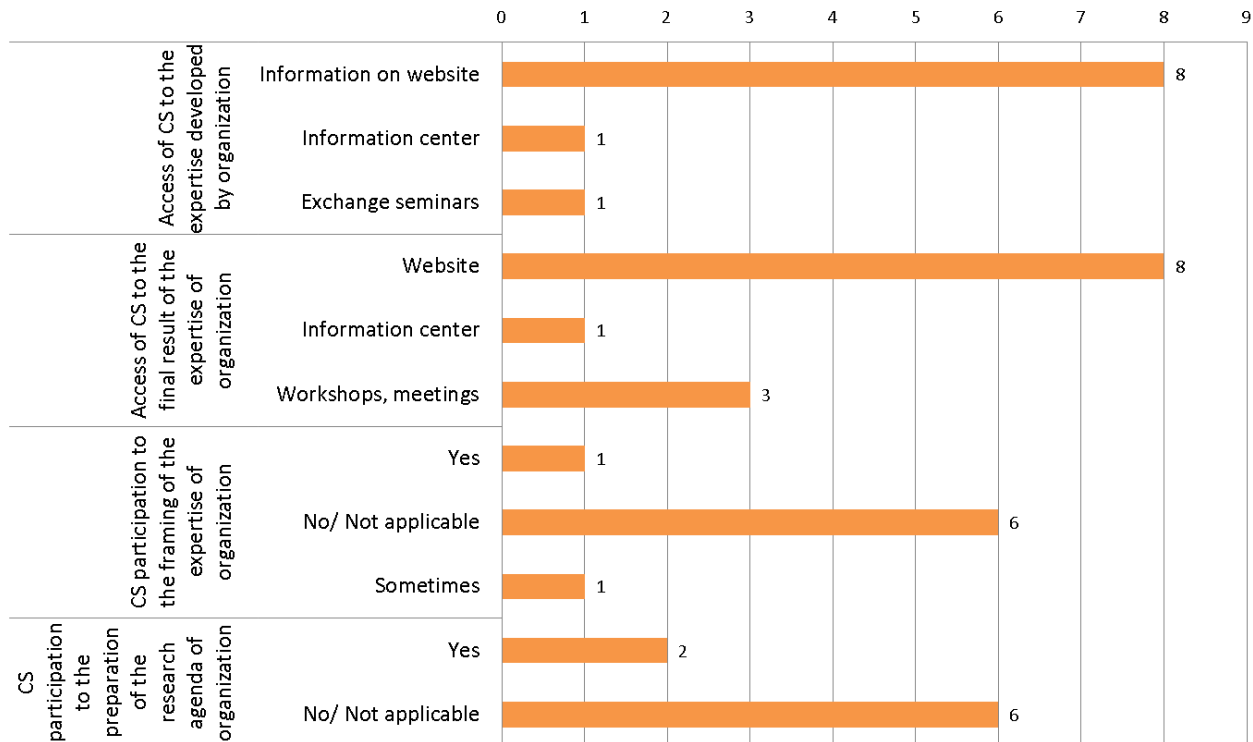


Fig. 12. Interaction with the CS experienced by the organisations

As it is clearly seen from the Figure, the organisations have reported that the CS has access to the expertise developed by an organisation and access to the final result of the expertise of their organisation though the websites. Besides that, the other examples of the organisation presenting its expertise results are the exchange seminars being organized by IRSN or the brand new Information Centre at ASN headquarters performing its public service duties.

Regarding the access to the final result of the expertise of the organisation, IRSN reported their practice that in agreement with ASN, IRSN publishes technical expertise that it has established at the request of this authority since 2009. The law about energetic transition (2015) makes this publication compulsory. These final results of expertise are also presented to the CS (during seminars, association meetings, etc.). Meanwhile the CNSC reported that it makes decisions on the licensing of major nuclear facilities through a public hearing process (meaning that the public has access to their expertise results).

Regarding the participation of the CS in the framing of the expertise, FANC reported about this contribution of CS through public debates/workshops. Meanwhile IRSN explained that some experiences have been developed to enhance the participation of the CS to the framing of the expertise but it has to be improved. For example, in the field of environmental expertise, the work methods and the choice of places for sampling have been discussed in the monitoring groups involving the CS. The remaining organisations did not report about the participation of the CS in framing the organisation’s expertise.

Responding to the CS participation in the preparation of the research agenda of the organisation, only IRSN indicated experience in such type of interaction. IRSN has a Research Policy Committee which is a consultative body assisting the Board of Directors. It develops an overall approach to the orientation of the Institute’s research, including social and political aspects. It is made up of members of public authorities, companies, professional bodies, and employees in the nuclear sector, elected representatives, associations, research bodies, advisory members and persons from other countries. This committee has created a workshop including the CS (2 environmental associations, one labour union) to elaborate on the recommendations about a Strategic Research Agenda on radioecology, published in 2014. FANC indicated that the CS still do not participate in setting the research agenda, but it could be done in the future.

Impact of interactions

The interactions were reported as contributing to the improved quality of organisation’s expertise, nuclear safety by the majority of the organisations interacting with the CS and the public (eight organisations) Fig. 13. As an illustration, one organisation indicated having no contribution to the improved quality of expertise, nuclear safety due to interaction with the CS.

IRSN pointed out that it has deepened the topic of geothermal resources in the waste disposal Cigéo project because it appeared as a very important topic for the CS within the technical dialogue.

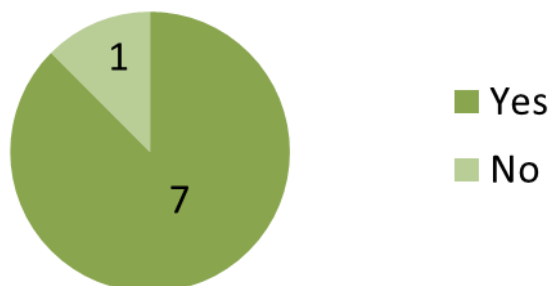


Fig. 13. Contribution of interaction to improve the quality of expertise, quality of nuclear safety

Development of citizen training

Two organisations indicated developed/developing citizen training in order to raise the competence and to enable them to participate in the decision-making process. The remaining organisations are not developing a dedicated training or are not committed to this („not applicable“) Fig. 14.

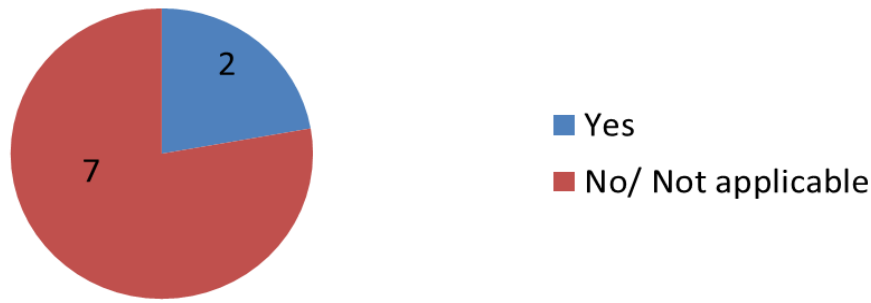


Fig. 14. Development of citizen training by the organisation so that the CS could participate in the decision-making process

To facilitate their involvement in nuclear safety and radiation protection issues, IRSN organizes specific actions in tandem with these actors, some with around 100 participants, others with a few people willing to know more about very technical topics. IRSN can also propose training courses to meet their needs. It can be mentioned that some participants of the technical dialogue about radioactive waste disposal wrote contributions during the public debate on this issue in 2013.

Response to the CS questions and needs

Seven organisations indicated having implemented a process to answer the CS questions and needs, e.g., through website, information centres (FANC, CNSC, ASN). Besides that, IRSN pointed out that the activities on interactions with the CS carried out for several years allowed IRSN to identify some questions and needs of the CS, e.g., by inviting seminar participants to submit their questions in advance so that they could be answered during the meetings.

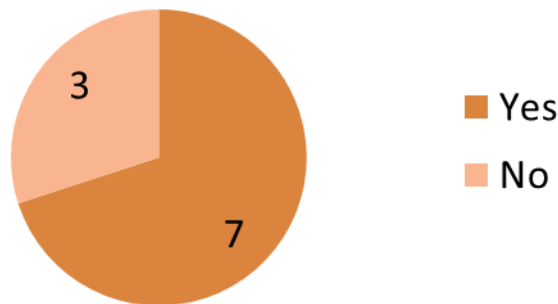


Fig. 15. Implementation a process in the organisations to answer the CS questions and needs

Training of experts in interacting with the CS

Five organisations reported they were offered a possibility to get trainings in the interaction with the CS. One organisation expressed that training in interaction with the CS is highly desirable by their experts.

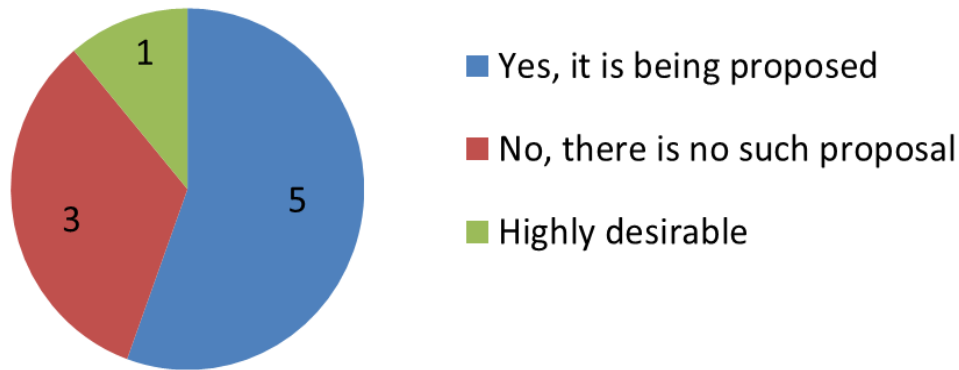


Fig. 16. Training of technical experts in interaction with the CS

As IRSN wants to enhance the ability of its staff to interact with stakeholders, internal meetings and sensitizations about that are being organized. For instance, sharing feedback on these activities is organized in-house to spread the culture of openness to the society throughout the Institute.

Demand for specific competences or skills for interaction with the CS

Five organisations reported that their experts feel the need for specific competences or skills regarding interaction with non-technical stakeholders (the public, the CSOs, etc.). Two organisations did not indicate such a demand of their experts.

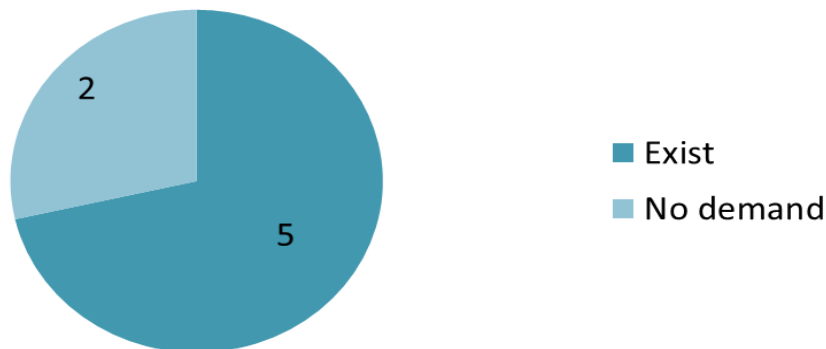


Fig. 17. Demand of organisation's experts for specific competences or skills for interaction with non-technical stakeholders

Availability of tools/measures/schemes to improve knowledge of the non-technical stakeholders

Three organisations reported that the tools/measures/schemes exist in place (within or outside of their organisations) to improve knowledge of the non-technical stakeholders involved in the disposal project.

FANC indicated the option for non-technical stakeholders to increase their knowledge through the participation in international activities such as IGSC Communication Group, SITEX project, IAEA coordinated events. In the case of IRSN, the technical dialogue has begun several years ago. Various organisations make presentations during the seminars and these presentations are then available on the IRSN and ANCCLI Web sites. Assessments of the realized actions are made to know whether they have fulfilled their purpose and to improve what needs to be.

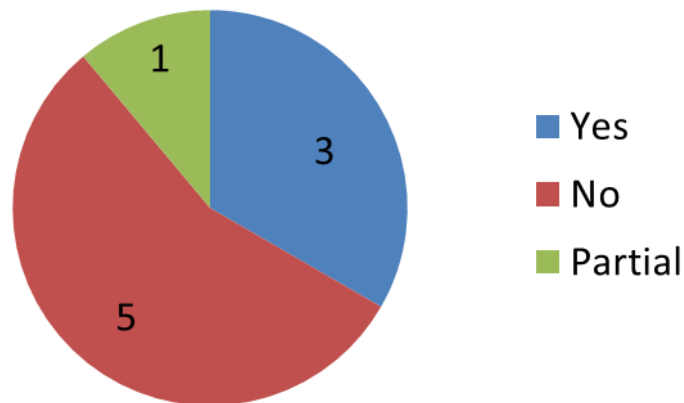


Fig. 18. Availability of tools/measures/schemes to improve knowledge of the non-technical stakeholders

One organisation indicated the existence of some training options available (“partial”). The CNSC engages affected communities to provide factual and unbiased information about how it regulates the nuclear sector to protect the health, safety and security of Canadians and the environment, and how it respects Canada’s international commitments on the peaceful use of nuclear energy.

Main observations:

Diversity of situation regarding interactions with the Civil Society

- There is a diversity of situations amongst the SITEX experts’ organisations regarding the interaction with the Civil Society. Some organisations have no dedicated department to promote this function of interaction (or have a department currently under development), some have a department limited to communication only, some have a department with a broader perspective (regular exchanges, etc.)
- A diversity of tools also exists: communications of information on Internet websites or information centres, implementation of regular seminars and workshops to present the experts’ work, share knowledge and help stakeholders developing competencies to participate to the review process.
- The main part of the existing interaction of experts with the Civil Society is reported as neutral or positive yet some experiences are reported as conflicting. Globally, the impact of these interactions on the quality of the expertise is assessed as positive by the SITEX partners

Needs for training in interaction with the Civil Society

- According to the questionnaire, several processes have been implemented to develop training of experts regarding interaction with the Civil Society (focused on answering questions of citizen). But there is still a need for development of such training for some organisations that do not currently have one or for enhancing the existing one.
- There are also few organisations that include the CS participation in the training of experts.

Observations on the basis of the WP4.2 results

A link should be made here with the work of task 4.2 on safety culture, which indicates the need for a cultural shift towards a better integration of the CS into the expertise process (see below). WP4.2 of SITEX-II investigated conditions and means of a safety culture shared by experts and the civil society.

- **Why a common safety culture?** As indicated in the INSAG4 definition³, all the actors need to have a common goal: ensuring safety as an overriding priority. In the context of geological disposal, the various actors are involved (institutional experts and civil society). These actors will interact all along the different stages (intergenerational perspective) and they have to keep in mind this idea of safety as an overriding issue. It is the reason why it is important to develop a common safety culture between experts and society, without questioning or jeopardizing the roles of each actor in this area.
- **Who could contribute?** The experts have a key role by developing an inclusive safety culture that is not limited to the operational safety but extended to a set of conditions of means needed to establish a common language and mutual understanding around safety. Connecting expertise function and the civil society is a function for the future SITEX network identified by the SITEX and SITEX-II projects.
- **What kind of training could be developed by the SITEX network?** The network could develop training in these issues:
 - Examine the conditions and means for ensuring that nuclear safety of Geological Disposal is given proper attention along the foreseen intergenerational long-term stakeholders interaction (internal and external to safety operation), along its lifecycle

³ "The discussion extends to Safety Culture in all concerned, because the highest level of safety is achieved only when everyone is dedicated to the **common goal**." (...) "Safety Culture is that assembly of characteristics and attitudes in organizations and individuals which establishes that, **as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance**.", International Nuclear Safety Advisory Group, safety series, n°75-INSAG-4, IAEA, Vienna, 1991, P3-P4

- Engage experimental stakeholder interaction on complex boundary issues that entail actual geological disposal safety dimensions (like e.g. the question of reversibility).
- **SITEX network could be a place to promote openness to society inside the expert organisations by facilitating exchanges of practices amongst experts’ organisations and also exchanges with civil society representatives in order to improve a mutual understanding.**

3.6 NEED FOR EXPERT TRAINING

The overview of the need for expert training among the organisations is presented in Fig. 19. The largest demands were declared by GRS, IRSN. The demands reported might be reasonably correlated to the status of a country’s geological disposal program. For example, as having a more advanced disposal program, the French regulatory body is expecting the licence application for repository construction in the near future, and the Safety Case review will be soon initiated with support of IRSN. The demands declared by other organisations are similar or somewhat less.

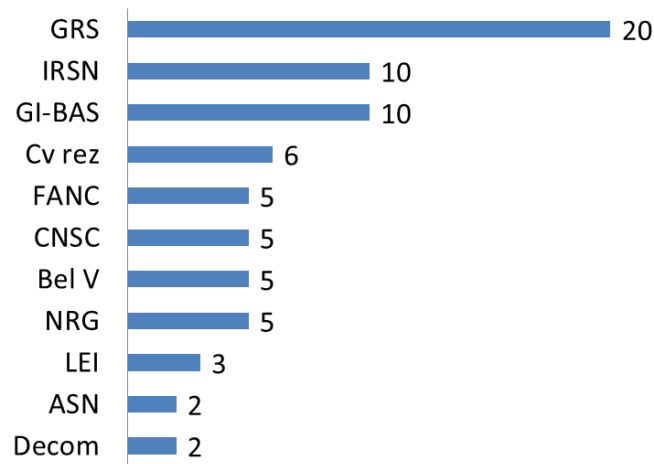


Fig. 19. Need for expert training in the next 5 years (2016–2020)

All compiled profiles of the experts are needed with slightly lower demand of risk experts as seen from Fig. 20. This relates to the experts working within the organisations (e.g., ASN has generalists experts only) and needing training.

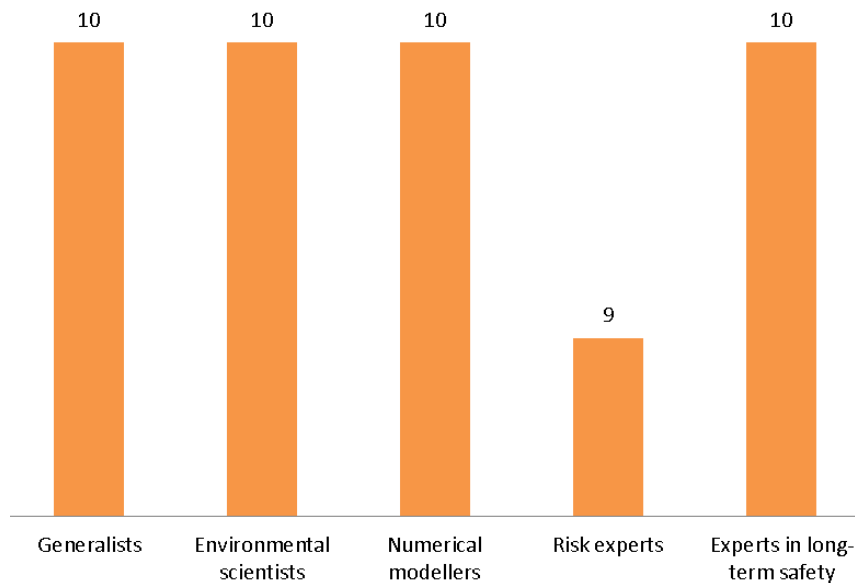


Fig. 20. Distribution of the experts' profiles needed among the organisations (each profile mentioned by X organisations)

Training types (outside organisation) which can be interesting

Among several different types of activities being listed, the organisations were interested mostly in the annual training course on general issues related to the review of Safety Case dedicated to radioactive waste geological disposal (Fig. 21). Annual training courses on specific issues or specific training courses and/or workshops on request were also identified as a key interest by most organisations.

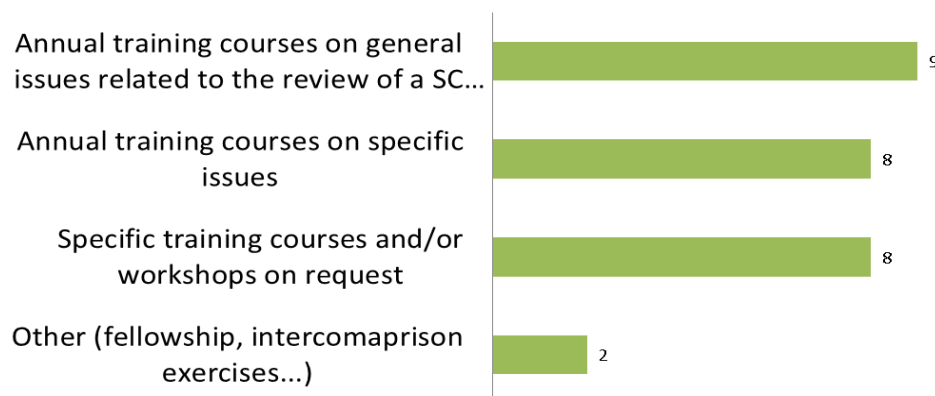


Fig. 21. Intercomparison of training types mainly desirable for the next 5 years (2016–2021)

Among the topics in which the organisations showed interest, the following were indicated:

- Annual training courses on general issues related to the review of the Safety Case dedicated to radioactive waste geological disposal:
 - Processes governing radionuclide transfer in the geosphere; site characterization; site acceptance criteria;
 - Radioactive waste management in general in the context of the State-of-the-Art;

- Annual training courses on specific issues:
 - E.g., understanding of phenomenological processes important to safety, management of uncertainties, use and limitations of codes for performance assessment, characterization of waste, materials and host rocks, modelling, etc.;
 - Safety functions fulfilled by clayey host rock;
- Specific training courses and/or workshops on request:
 - Interaction with the civil society: effective engagement;
 - Inspection of the WMO;
 - Safety functions fulfilled by bentonite based EBS;
 - Technical exchange for evaluating specific processes like earthquakes, gas transport, multi-phase flow.

The reflection to these needs will be considered while developing the training program for the generalist as foreseen within the SITEX-II project.

Evolution of need of technical experts (period 2021 - 2025)

The identification of the need of expert training over the next five-year period (2021–2025) appeared to be a difficult task. The comments from the organisations were as follows:

- Increased requirements on number of experts in Slovakia is expected after 2020 (DECOM);
- Constant training is highly desirable at all times. Whether the needs will significantly be changed depends on the situation around the geological disposal and on the retirement of some of the employees with the most experience in radioactive waste management (FANC, IRSN);
- Highly depends on the progress in the geological disposal program in Lithuania (LEI);
- Depends on the future statute of the organisation, not able to answer (CV Rez).

GRS reported as not expecting significant increase in the needs for experts during the 2021–2025 period. NRG only answered that they are expecting a slight decrease of the required expertise.

Nevertheless, the all compiled profiles of experts were foreseen as being needed in the future. Among the training types for the expert training over the next period (2021–2025), the organisations were mostly interested in the annual training courses on specific issues (22).

Slightly less intense interest was observed for the training in the Safety Case review process. Increased interest was observed in training through fellowships, inter-comparison exercises, and workshops. This could be related to the prognosis that the experts will get trained on the Safety Case (SC) review during the period 2016-2021 and the organizations could look forward to the training in specific issues while continuing the competence development on the review aspects. Not all organizations reported their interest due to the reasons mentioned in the paragraph above.

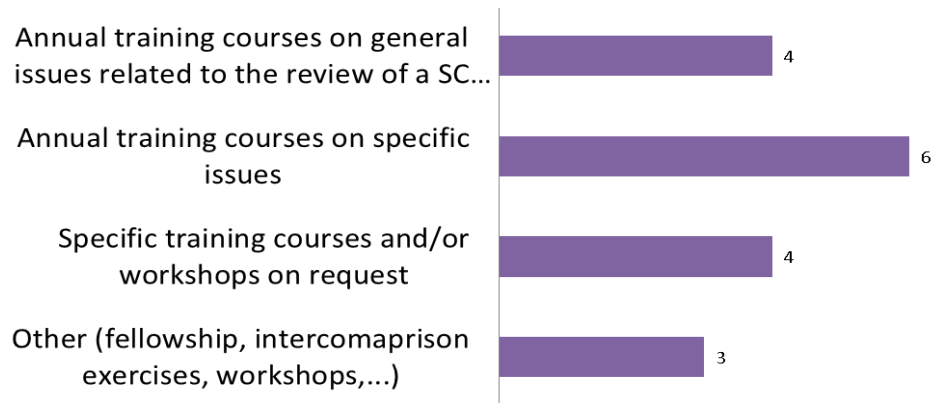


Fig. 22. Training types mainly desirable for another 5 years (2021–2025)

Main observations:

Need for experts over the next 5 years (2016–2021)

- The largest demands were declared by GRS, IRSN, GI-BAS. This tends to correlate with the status of the countries' geological disposal program.
- All compiled profiles of the experts are needed with slightly lower demand for risk experts. This is related to the different demand for different experts at different repository development phases.

Types of training mostly desired (2016–2021)

- The organizations were mostly interested in the annual training course on general issues related to the review of the Safety Case dedicated to radioactive waste geological disposal.

Need for experts over the next 5 years (2021–2025)

- The identification of the need for expert training over the next five-year period (2021–2025) appeared to be a difficult task due to uncertainties in the progress of the geological disposal program on the national level.
- Nevertheless, all compiled profiles of the experts were foreseen as being needed in the future.
- The organizations were mostly interested in the annual training courses on specific issues.
- Slightly less intense interest was observed in training in the Safety Case review process, but increased interest in training through fellowships, inter-comparison exercises, and workshops was expressed.

3.7 PARTICIPATION IN TRAINING AND TUTORING ACTIVITIES IN RELATION TO GEOLOGICAL DISPOSAL ON THE INTERNATIONAL LEVEL

The organizations were asked to describe the experience of the experts in training and tutoring courses taken through the available educational schemes:

1. European Nuclear Safety Training and Tutoring Institute (ENSTTI)
2. European Credit System for Vocational Education and Training (ECVET)
3. European Nuclear Education Network (ENEN)
4. Training activities provided by International Atomic Energy Agency (IAEA)
5. Training activities offered outside the Europe (North and South America, Asia, other)
6. Training and education in geological disposal under EC projects (7FP Petrus III project, etc.)
7. Other.

Participation in training and tutoring activities in relation to geological disposal through the available educational schemes is summarized in Fig. 23.

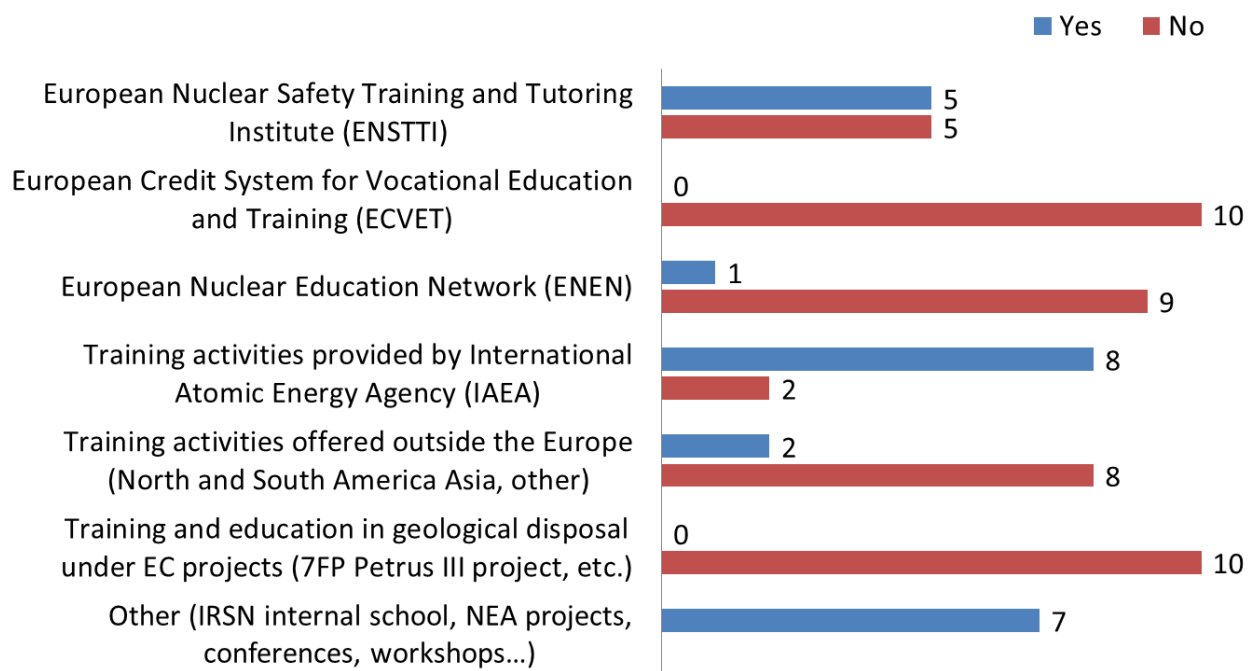


Fig. 23. Participation in training and tutoring activities in relation to geological disposal at the international level

The synthesis of the responses showed that the events organized and coordinated by the IAEA are highly acknowledged and attended most frequently. In the case of ENSTTI and IRSN internal school, it should be noted that the offered training was not focused specifically on geological disposal. Nevertheless, the training provided by ENSTTI addressed radioactive waste disposal

topics to some extent. The experts from some organizations (such as IRSN, Bel V, FANC, GRS) are being invited as trainers among others to the ENSTTI training courses.

Limited participation in training and tutoring activities through other schemes (ECVET, ENEN, Petrus, etc.) could be a result of the lack of the information on these possibilities, or the training may not be targeting the technical experts of the organizations under the survey. Outlines of available nuclear experts training considered in Petrus project is provided in Annex 3.

On a case-by-case basis, the organizations also indicated other ways of training their experts in international schemes. These were, for example, internal school/internal training (IRSN, ASN), NEA projects (CNSC), workshops, technical meetings, conferences (FANC, LEI, etc.), training at the IAEA Underground Research Facilities (URF) network (CNSC), training through participation in EU research projects (GI-BAS, LEI).

The experts of different profiles were trained using the available schemes (Fig. 24) but the generalists and numerical modellers were mentioned most frequently, while the environmental scientists and risk experts were mentioned less times as being trained through these schemes. This could be related to the training topics more oriented to the generalist experts rather than to specialized ones.

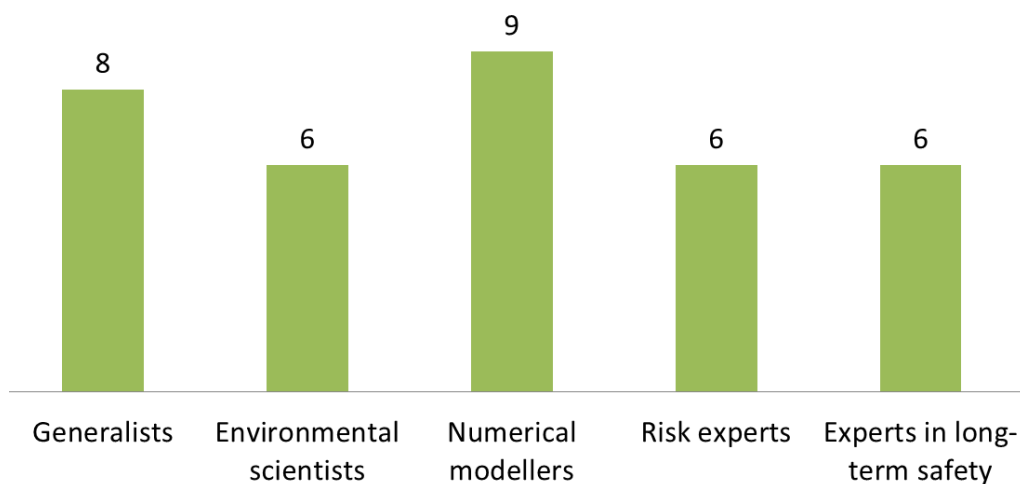


Fig. 24. Distribution (by profile) of the experts get trained through available educational schemes

Competences developed, regularity

The competences developed ranged from the introduction into the problem to the management of uncertainties, monitoring, and long term safety assessment. Some comments on the competence development and the regularity of training viewed by the organisations as trainees are given below:

- Depends on available topics, occasionally (DECOM);

- Mainly theoretical skills notably about the development of scenarios and models for assessing the long term safety of disposal facilities (Bel V);
- Applications of international standards, planning and performing R&D, assessment of safety, treatment of uncertainties, process modelling to support safety and performance assessment, etc. (LEI);
- Increased knowledge about underground research laboratories to support the Safety Case for deep geological disposal (CNSC);
- International regulation, work between specialist experts, how to deal with emergency situations, how to integrate main risks in nuclear facilities into safety evaluations, etc.;
- A training, which lasted for nearly three weeks, about general safety including few days on waste management, waste disposal in general (including geological disposal) (IRSN through ENSTTI);
- ENSTTI provided training course increased technical competence, knowledge of processes and competence on review process. The regularity of the course is one-shot training on demand (FANC).
- European Nuclear Education Network (ENEN) course taken by generalist experts and numerical modellers. The following competences have been developed: neutronics, thermo-hydraulics (usually the following study is taken during the master thesis of the future employee). The training increases technical competence, knowledge of processes and competence on review process (FANC).
- IAEA training activities taken by generalist experts and environmental scientists. The following competences have been developed: management of uncertainties, monitoring, long term safety assessment. It is usually a one-shot training on demand. The course is usually organized by workshops. Unexpectedly, the training faced some difficulties: the background and the knowledge base were different from the one given during the course. Nevertheless, the training increased technical competence, knowledge of processes and competence on review process (FANC).
- Competence in host rock characterization, safety modelling aspects. Not regular training (GI-BAS);
- Wide range of competences regarding the review of Safety Cases e.g., scenario development, long-term safety, operational safety. Regularity depends on the concerned member since the participation is on a voluntary basis (GRS).
- Expert judgement on geochemistry, transport processes, long term safety, and risk assessment (PSI).

- The focus is on long-term safety assessments (generic to performance assessments) (NRG).

Among the several types of training activities (course, fellowship, workshop, other), the courses and workshops were mentioned as the most popular training format.

Effectiveness of the training, difficulties

In general, the organizations confirmed the usefulness of the expert training pointing out difficulties regarding the general nature of topics presented, different background, and one-shot event type. The following comments were made:

- Generally, courses are theoretical and focus on the basic concepts of waste disposal safety. It seems difficult to find more detailed and practical courses about e.g., how and to what extent some phenomenological processes influence the safety of disposal facilities, the use and limitations of existing codes for long-term safety assessments, how to manage uncertainties, how to perform the review of a Safety Case, etc.(Bel V).
- The training focused on very general aspects, too institutional (i.e., IAEA institutional standards), with not enough exercises, presentation of field cases, feedback, site visits, etc. (IRSN on ENSTTI course).
- The main difficulty was that since experts attending the course had different backgrounds and that some of them were new to IRSN (and some others knew already IRSN very well), some courses were not adapted to all trainees' level of knowledge (IRSN on internal school).
- Hands-on tours provided by experts was reported as effective mean for competence development by CNSC.
- In general, it is effective. Usually, training courses are limited in time and are not dedicated to one very specific topic (LEI).
- DECOM, CV Rez reported that available and attended training was useful and effective.
- The training was very effective but not regular due to the funding difficulties in general (GI-BAS).
- Difficulties to find the right-focussed trainings (PSI).

Based on the responses from the organizations taken training lead to increased technical competence (8 organizations), knowledge of processes and to increased competence on review process (Fig. 25).

- Increased technical competence, knowledge of processes
- Increased competence on review process

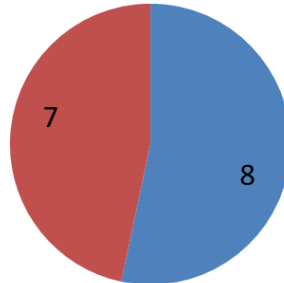


Fig. 25. The results of taken training through existing schemes

Main observations:

Training on geological disposal through the available educational schemes

- Events organized and coordinated by the IAEA are highly acknowledged and attended most frequently.
- Trainings organized by ENSTTI or IRSN internal schools are not focused specifically on geological disposal; nevertheless, to some extent these trainings address radioactive waste disposal topics. The experts from some organizations are being invited as trainers among the others to the ENSTTI training courses.
- Limited participation in training and tutoring activities through other schemes (ECVET, ENEN, Petrus,.....) could be a result of the lack of the information on these possibilities, and/or these trainings do not target the technical experts of the organizations taking the survey.

Training type, experts trained

- Among the several types of training activities (course, fellowship, workshop, other), the course and workshops were mentioned most frequently.
- The experts of different profiles were trained using the available schemes but the numerical modellers and generalists were mentioned most frequently, while the other experts were mentioned less times as being trained through available schemes. This could be related to the training topics more oriented to the generalist experts and numerical modellers rather than to specialized ones.

Effectiveness, difficulties

- In general the organizations confirmed the usefulness of the expert training pointing out the difficulties regarding the general nature of topics presented, e.g., not enough exercises, different background of participants, one-shot event type and Safety Case review not

addressed.

4 Conclusions and recommendations

The analysis of the contributions from the respondents leads to the following key conclusions and recommendations to be taken into account while developing the training module for the pilot training session (Task 3.2):

1. Importance and necessity of knowledge management and learning processes such as training, learning from experience and continual improvement is acknowledged. The strategy for knowledge management is more formalized and documented in the organisations having dedicated human resources or knowledge management departments or is incorporated in overall organisation's quality management system.
2. Different means of knowledge management and expert training are used: while some have dedicated departments, internal procedures or schools for expert training, others rely more on co-working of younger and senior experts, participation in research programs on the national and international level. Usually, organizations have several parallel ways for knowledge management and experts training in parallel.
3. Development of training modules for the experts of all compiled profiles, i.e. generalists, environmental scientists, numerical modellers, risk experts and experts in the assessment of long-term safety, was acknowledged; however the training module for generalist experts has a priority to be developed firstly based on the higher interest expressed for the training for the next 5 years (2016–2021).
4. On-the-job training, participation in research projects and taking external courses were reported as the common ways for the competence development. Considering this observation, the form of SITEX training could be recommended to be defined as a package of activities on a several year cycle (lectures accompanied with practical exercises, visits, partial review of existing Safety Case, etc.)
5. To ensure effective competence building in the specialized areas for technical review of Safety Case, the means to equalize the background of the participants need to be considered.
6. There is a lack of available training schemes dedicated to the review of the Safety Case of geological disposal on the international level, thus the development of a scheme of sustainability and availability of such training could expect the acknowledgment on the international level.



5 References

SITEX, 2014a. Terms of Reference (TOR) of the SITEX network. *7FP Euratom SITEX project deliverable D-N°: 6.2*

SITEX, 2014b. A plan for competence development in expertise of radwaste disposal safety. *7FP Euratom SITEX project deliverable D-N°: 4.2.*

6 Annexes

6.1 ANNEX 1. QUESTIONNAIRE FORM

Training and Tutoring will be one of the services provided by SITEX network. Different types of experts being involved in the technical review process were identified (generalist expert, environmental expert, risk expert, etc.) and their necessary knowledge and skills were compiled within the framework of SITEX project (2012-2013).

Backing up on these development as well as on national and international experiences in the field of training and tutoring, the SITEX-II Work package 3 is dedicated to demonstrate in practice the implementation of this service, including both technical and management aspects, by developing and testing a training module devoted to generalist experts involved in the Safety Case review process.

This questionnaire is dedicated to collect information about current practises for technical experts training and competence development and the identification of training needs in near future. Information collected will allow identifying the commonalities in practises, good experience and to draw recommendations for competence building of technical experts.

The questionnaire is compiled to cover the following topics:

1. General information on organisation
2. Carrier management of experts (in general)
3. Existing training programs at national level used for training of experts
4. Competence building of experts
5. Existing initiatives on interaction with Civil Society (CS)
6. Needs of expert training
7. Participation in training and tutoring activities in relation to geological disposal at the international level

1. General information on organisation

No	Questions	Answers	
1.	Country of organisation:		
2.	Name of organisation:		
3.	Type of organisation (Regulatory body, Technical support organisation (TSO) (<i>organisation mandated to perform review or to support regulatory in review process</i>), Research organisation, other)		
4.	Have your organisation reviewed (participated in review of) the Safety Case of geological repository? If yes, to which part(s) of the Safety Case and at what phase of its development?		
5.	What experts work in your organisation?	Indicate as X	Comments, detailed explanation
	<i>Generalists</i> ⁴		
	<i>Environmental scientists</i> ⁵		
	<i>Numerical modellers</i> ⁶		
	<i>Risk experts</i> ⁷		
	<i>Experts in long-term safety</i> ⁸		
	If you answered “no” to some of these questions on experts’ profile, is it because you haven’t needed them yet or is it because you have used subcontractors for some of these specialties?		

⁴ Generalists (nuclear facility experts, examining a safety case for DGR 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)

⁵ Environmental scientists (experts with competences in biosphere, radioecology, meteorology, climatology, geochemistry, geology, hydrology, hydrogeology, seismology, geotechnics, geomechanics)

⁶ Numerical modellers (experts with competences in numerical modelling, mathematics, computational methods)

⁷ Risk experts (experts with competences in waste, civil & materials’ engineering, radiochemistry, microbiology, nuclear physics, physical protection, radioprotection, human actions, earthquakes, flooding, environmental risks, fire & explosion, criticality, dynamic & static containment, radiolysis & thermal effects, ventilation, handling, power supply, underground hazard)

⁸ Experts in long-term safety (experts with competences in scenario development, treatment of uncertainties)

2. Carrier management of experts (in general)

No	Questions	Yes/No	Comments, detailed explanation
1.	What is the practice of human resources management (regularly employing/retiring experts, employing new people on demand (to perform some tasks))?		<i>If yes, maybe there is strategy in organisation related to some external aspects (for example national strategy to have certain number of experts in regulatory authorities, while for research organisations this could be decided internally), the period of revision of such a strategy, etc.</i>
2.	Is there the carrier management practise on the organisational level?		<i>If yes, provide some details (for example, it is a common strategy for whole organisation to follow the same concept such as employ PhDs or students, to provide them same general training on particular topics, or it differs in each department without pre-definition of human resources department), etc.</i>
3.	How the carrier of experts evolves on organisational level?		<i>Describe it briefly (for example, employing students and developing their competence step by step, employing only experts in particular area and keep their competence, employing both students and experts), etc.</i>
4.	In average, how many people in your organisation work in the field of radioactive waste disposal?		
5.	In average, how many people in your organisation work more specifically on geological disposal?		
6.	In average, how long do people last in this field?		
7.	Are the newcomers usually young engineers or are they more often coming from other teams within in your organisation (who thus already have some knowledge about nuclear safety...)?		
8.	Are there dispositions in place within the human resources management to guarantee a knowledge keeping or a proper transfer of it in the field of radioactive waste disposal?		<i>For example, is there any internal department responsible for training and knowledge tranfer, etc. if yes, describe it briefly</i>
9.	Other important aspects to be mentioned		

3. Existing training programs at national level used for training of experts

This section is intended to identify if there are some training schemes (programs, courses,) available on national level for training of technical experts in the field of radioactive waste disposal (possibly linking to the universities if they offer a dedicated programs, or other institutions providing this type of training).

Please consider only the aspects concerning training on how to **perform review of Safety Case**, and not training of the basic technical knowledge (geology, radioactivity, modelling and so on), that should already been acquired through the initial formation on experts.

No.	Questions	Exists/ Not exists	Describe program (name, location, duration, etc.)
1.	Training of generalist experts		
2.	Training of environmental scientists		
3.	Training of numerical modellers & mathematicians		
4.	Training of risk experts in operational and long-term safety, including material & civil engineers as well as conventional underground experts		
5.	Training of experts in assessment of long-term safety (scenario development & uncertainties)		

4. Competence building of experts

No.	Questions	Answers		Comments, detailed explanation if needed
		Variants	Please mark as X	
1.	What practises are applied for increasing the competence of experts in your organisation?			
	generalist experts	<i>on-the-job training</i>		
		<i>companionship</i>		
		<i>internal training sessions</i>		
		<i>external courses</i>		
		<i>participation in the research projects</i>		
		<i>fellowships</i>		
		<i>other</i>		
	environmental scientists	<i>on-the-job training</i>		
		<i>companionship</i>		
		<i>internal training sessions</i>		
		<i>external courses</i>		
		<i>participation in research projects</i>		
		<i>fellowships</i>		
		<i>other</i>		
	numerical modellers & mathematicians	<i>on-the-job training</i>		
		<i>companionship</i>		
		<i>internal training sessions</i>		
		<i>external courses</i>		
		<i>participation in the research projects</i>		
		<i>fellowships</i>		
		<i>other</i>		
	risk experts in operational and long-term safety, including material & civil engineers as well as conventional underground experts	<i>on-the-job training</i>		
		<i>companionship</i>		
		<i>internal training sessions</i>		
		<i>external courses</i>		
		<i>participation in research projects</i>		
		<i>fellowships</i>		

No.	Questions	Answers		Comments, detailed explanation if needed
		<i>other</i>		
	experts in assessment of long-term safety (scenario development & uncertainties)	<i>on-the-job training</i>		
		<i>companionship</i>		
		<i>internal training sessions</i>		
		<i>external courses</i>		
		<i>participation in research projects</i>		
		<i>fellowships</i>		
		<i>other</i>		
2.	Describe the competence building strategy in your organisation (regular, not regular, main driving forces (such as national plans, strategies to have a certain number of experts in particular field), initiated/managed on organisational or personal level, funding sources, other important aspects)			

5. Existing initiatives on interaction with Civil Society (CS)

The following questions are devoted to collect information on practise existing in your organisation on interaction with CS. If there are no such practices and this type of activities in your organisation, after answering first question move to the questions related to the next topic (next section).

No.	Questions	Answers	Comments, detailed explanation
1.	Does your organisation interact with Civil Society? If not, you can go to the next section § 7	Yes/ No	
2.	What kinds of interaction with CS and public have your organisation developed?		
3.	What is the purpose of the interactions of our organization with the Civil society?		
4.	Does your organization have a specific department with a specific mandate to facilitate the interactions of your experts with the Civil society?	Yes/No	
5.	Would you characterize the relations of your organisations with Civil Society as neutral, constructive or conflicting? Why? Can you give examples?	Please mark as X	
	Neutral?		
	Constructive?		
	Conflicting?		
6.	Can-you describe the kinds of interactions with the CS experienced by your organization:	Answers	Comments, detailed explanation if appropriate
	<i>To what extent does the CS have access to the expertise developed by your organization?</i>	Yes/No	
	<i>Does CS have access to the final result of the expertise of your organization? How?</i>	Yes/No	
	<i>Does CS participate to the framing of the expertise of your organization? How?</i>	Yes/No	
	<i>Does CS participate to the preparation of the research agenda of your organization? How?</i>	Yes/No	
7.	Along the Safety Case reviews in your country, does CS have access to the exchanges between the TSO and the regulator? Between the expert and the WMO? Between the regulator and the WMO?	Yes/No	
8.	Do the interactions of your organization contribute to improve the quality of expertise? to improve the quality of nuclear safety?	Yes/No	
9.	Does your organisation develop citizen training in order to raise the competence in order to enable them to participate to the decision-making process?	Yes/No	
10.	Has your organisation implement a process to answer CS	Yes/No	

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Synthesis of existing practices for training and tutoring of experts in geological disposal safety

Dissemination level: PU

Date of issue of this report: 11/30/2016

No.	Questions	Answers	Comments, detailed explanation
	questions and needs?		
11.	Does your organisation propose to its members (experts) training on interacting with CS?	Yes/No	
12.	Does the members of your organisation feel the need for specific competences or skills regarding interaction with non-technical stakeholders (the public, the CSOs, etc.)?	Yes/No	
13.	Are there tools/measures/schemes in place (within or outside of your institute) to improve knowledge of the non-technical stakeholders involved in the disposal project	Yes/No	<i>If so, please provide some details</i>

6. Needs of expert training

The questions of this section are devoted to collect information on the needs of technical experts training to be involved/support the review of Safety Case and not on the needs of training on the technical issues (geology, modelling, etc.). These knowledge should already been acquired through the initial formation on experts.

No.	Questions	Please mark as X	Comments, detailed explanation
1.	For how many experts would you need training in the next 5 years (2016-2020)?		
	<i>Generalists</i>		
	<i>Environmental scientists</i>		
	<i>Numerical modellers</i>		
	<i>Risk experts</i>		
	<i>Experts in long-term safety</i>		
2.	For the training of these experts, in which training types (outside your organisation) your organisation would be mainly interested?	Please mark as X	<i>Please give example of specific issues for which you would need training</i>
	<i>Annual training courses on general issues related to the review of a SC dedicated to radioactive waste geological disposal</i>		
	<i>Annual training courses on specific issues</i>		
	<i>Specific training courses and/or workshops on request</i>		
	<i>Other</i>		
3.	Do you expect that your needs will significantly change after the next 5 years? If yes, for how many experts would you need training between 2021 and 2025?	Please mark as X	
	<i>Generalists</i>		
	<i>Environmental scientists</i>		
	<i>Numerical modellers</i>		
	<i>Risk experts</i>		
	<i>Experts in long-term safety</i>		
4.	For the training of these experts, in which training forms (outside your organisation) your organisation would be mainly interested?	Please mark as X	
	<i>Annual training courses</i>		
	<i>Training courses and specialized workshops organized alternately</i>		
	<i>Training course on request</i>		
	<i>Other</i>		

7. Participation in training and tutoring activities in relation to geological disposal at the international level

Describe your practise/experience of training and tutoring the experts through the available educational schemes:

- European Nuclear Safety Training and Tutoring Institute (ENSTTI)
- European Credit System for Vocational Education and Training (ECVET)
- European Nuclear Education Network (ENEN)
- Training activities provided by International Atomic Energy Agency (IAEA)
- Training activities offered outside the Europe (North and South America Asia, other)
- Training and education in geological disposal under EC projects (7FP Petrus III project, etc.)
- Other?

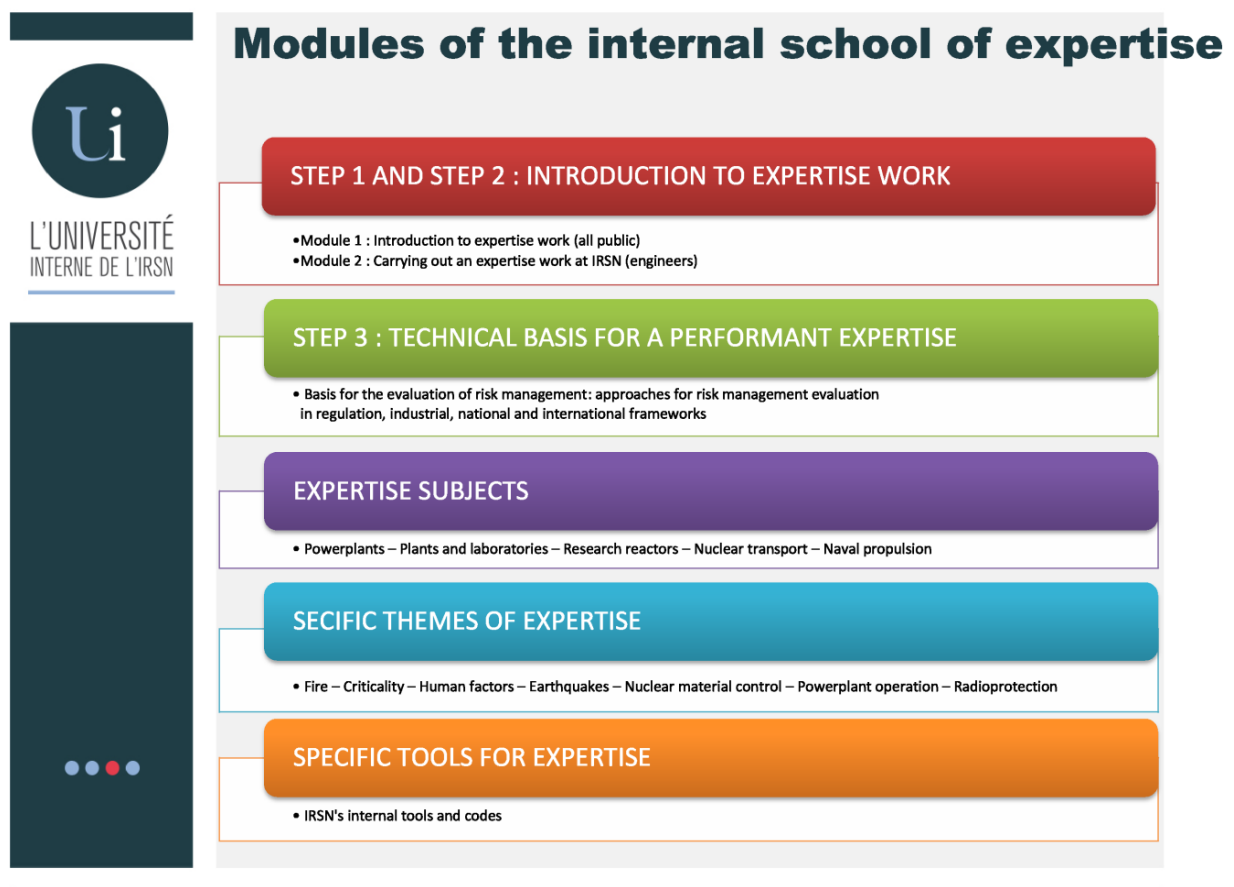
For each of the scheme you use, please answer:

No.	Questions
1.	<i>Do your experts develop competences through this scheme/initiative? If not, what are the reasons?</i>
2.	<i>What type of experts get training through this scheme a) generalist experts, b) environmental scientists, c) numerical modellers & mathematicians, d) risk experts in operational and long-term safety, e) experts in assessment of long-term safety)?</i>
3.	<i>What competences were developed? How regularly?</i>
4.	<i>Which courses are taken by a) generalist experts, b) environmental scientists, c) numerical modellers & mathematicians, d) risk experts in operational and long-term safety, e) experts in assessment of long-term safety?</i>
5.	<i>What was the type of training activities (course, fellowship, workshop, other)?</i>
6.	<i>Was the training effective through this scheme? What were the difficulties?</i>
7.	<i>Taken training lead to:</i> <ul style="list-style-type: none"> • <i>Increased technical competence, knowledge of processes?</i> • <i>Increased competence on review process?</i>
8.	<i>Do the same experts take several courses? How regularly?</i>
9.	<i>Other important issues to be mentioned</i>

6.2 ANNEX 2. SHORT OVERVIEW OF TRAINING OPTIONS, SCHEMES AND NETWORKS AT/INCLUDING IRSN

6.2.1 IRSN's internal school of expertise

Internal training for IRSN engineers to prepare them for expertise work. Composed the following modules (about one week each):



6.2.2 ENSTTI



ENSTTI offers short applied training courses and tutoring sessions for international junior professionals or new comers and for those with professional experience in the nuclear sector. Examples of trainings related to radwaste disposal facilities are:

- **Training ENSTTI – Introduction course**

General training about nuclear safety including the following courses/working groups:

- Radioactive waste management (1h30)
- Safety of radioactive waste disposal (1h30)
- Working group on waste management and disposal (1h30)

- **Training DEVCO ENSTTI June 2014 - Module “final disposal safety”**

1 week-long training specifically dedicated to the safety of radioactive waste disposal:

TYPE	DESCRIPTION	LENGTH
Day 1: General waste management		
Class courses	A1. Introduction A2. General overview A3. Pre-disposal stages overview A4. Practices in radioactive waste management in Belgium A5. Specific case of mining waste	1 day
Day 2: Near-surface disposal		
Class courses	B1. Safety assessment B2. Site evaluation B3. From CSM to CSA : French feedback B4. Interim storage vs. near-surface disposal facilities B5. Exercise (case study): disposal of radioactive spent sources	1 day
Day 3: Geological disposal		
Class courses	C1. Safety assessment overview C2. Main outcomes from IRSN's evaluation of Cigéo C3. Feedback from existing geological facilities in Germany	1 day
Day 4: Geological disposal (cont.)		
Class courses	C4. Experimental studies – Overview C5. Experimental studies – Example of IRSN's URL C6. Modeling tools as support of safety evaluation C7. Uncertainty management and its implications for the safety case	1 day
Day 5: Stakeholder involvement		
Class courses	D1. Overview D2. French experience with public debate	1 day
Assessment	Test to assess the knowledge acquired during the training course	
Closure	Discussion and debriefing of the week	

Safety assessment overview (IRSN)

- Rationales for implementing a deep geological repository
- Planning a deep geological repository
- Development, operation (closure) and post-closure
- Example of safety design criteria
- Advanced national programs
- Experience gained from international co-operations

Main outcomes from IRSN's evaluation of Cigéo (IRSN)

- The Cigeo French Project
- The Dossier 2005 and 2009 in the Cigeo Project
- Main Findings - Operational safety
- Main findings - Long term safety
- Key issues towards the Licensing phase

Feedback from existing geological facilities in Germany (GRS)

- Repository projects in the closure / retrieval phase (Morsleben / Asse)
- The Konrad repository for low and intermediate level waste
- Disposal of high level waste:
 - a) The Gorleben Exploration Site
 - b) Future site selection procedure

Experimental studies for geological disposal - General overview (IRSN)

- Rationale for experimental researches for RW deep repository
- Research and experimental programs for a Waste Management Organisation (WMO) and a Technical safety Organisation (TSO)
- Researches in URLs

Experimental studies for geological disposal - Example of IRSN's Tournemire

URL (IRSN)

- Detection and characterization of natural heterogeneities (faults)
- Detection and characterization of Excavation Damaged Zone in the host-rock
- Characterization of transfer mechanisms in the host-rock
- Exogenous materials: behavior and impact on the disposal safety
- Repository sealing at closure

Modelling tools as support of safety evaluation (IRSN)

- Mechanistic level modeling tools for reactive transport and 2-phase-flow simulations
- Integrated level modeling tool for radionuclide transport
- Illustration of applications in the context of safety assessment

Uncertainty management and its implications for the Safety Case (Bel V)

- The role of uncertainty management in the decision-making process
- Types of uncertainties
- Approaches to managing uncertainties
- Uncertainty management and the safety case
- Practical examples of uncertainty management

- **Course on "Management of spent fuel and radioactive waste"**

Upcoming 5-day training course including one day specific to radwaste disposal:

**Training, Management of spent fuel and radioactive waste
September 28 - October 02, 2015– Fontenay-aux-Roses, France**

Type	Description	Lenght
Day 1: Regulatory framework, waste management policy		
Class courses	<ul style="list-style-type: none"> ■ A01 - Introduction ■ A02 - Overview of the international standards ■ A03 - Presentation of the French national policy ■ A04 - Classification of radioactive waste (GSG-1) ■ A05 - Example of the French waste classification 	1 day
Day 2: : Pre-disposal		
Class courses	<ul style="list-style-type: none"> ■ B01 - Pre-disposal steps ■ B02 - Waste characterization ■ B03 - Waste acceptance criteria ■ B04 - Waste conditioning 	1 day
Day 3: : Storage		
Class courses	<ul style="list-style-type: none"> ■ C01 - Disused Radioactive Sources Storage – Safety Assessment ■ C02 - Exercise on disused sources storage ■ C03 - Spent fuel storage - Safety assessment ■ C04 - Comparison between interim storage and near-surface disposal facilities in terms of safety requirements 	1 day
Day 4: Disposal		
Class courses	<ul style="list-style-type: none"> ■ D01 - Safety case/safety assessment for disposal ■ D02 - Uncertainty management and its implications for the safety case ■ D03 - Practices in RW management and (pre-) licensing of near-surface disposal repository - The Belgian case ■ D04 - Exercise on disposal of radioactive spent sources 	1 day
Day 5: Stakeholder involvement – Final test		
Class courses	<ul style="list-style-type: none"> ■ E01 - Overview ■ E02 - French experience of public debate 	1 day
Assessment	■ E03 - Test to assess knowledge acquired during the Training course	
Close	Discussion and debriefing of the week's training	

(D-N°: 3.1)

Synthesis of existing practices for training and tutoring of experts in geological disposal safety

Dissemination level: [PU](#)

Date of issue of this report: **11/30/2016**

6.2.3 IAEA

Training course given by IRSN on “Safety Case on Geological Disposal - IRSN Safety Evaluation and Research”. RSA, October 2011 – 1 presentation with the following contents:

Contents

■ IRSN and radioactive waste management

- Who we are
- What we do
- Radioactive waste safety



■ The French Geological Disposal safety case

- French GD and regulation : a timeline
- Andra and the Cigeo project



■ IRSN involvement

- Safety evaluation of the GD safety case : a timeline
- Towards the creation of a GD : the years ahead
- Stakes and challenges for IRSN : the paramount role of research

■ Integration of safety evaluation and research : Project 211

- Project management & Resources
- Scientific programme
- External openings



6.2.4 Trainings developed specifically for foreign delegacies

About one-week long trainings carried out by IRSN’s safety assessment department for radwaste disposal facilities. These trainings usually focus on all types of disposal facilities with presentations such as:

- Licensing process in France
- Types of disposal facilities in France
- Modelling of radionuclide migration through geological formations: application to the Cigéo project (Cigéo = project of geological disposal for radioactive waste in France)
- IRSN’s safety assessments on the Cigéo project
- Safety principles for LL-ILW and HLW disposal systems (based on the French safety rules and ASN guidelines)

6.2.5 Trainings in French universities

Courses in the framework of masters degrees related to applied geology or nuclear safety, such as:

- Safety evaluation of a radwaste geological disposal – The Cigéo project (3h)
- Safety evaluation of a radwaste geological disposal – The role of geologists (3h).

6.3 ANNEX 3. PETRUS III - IMPLEMENTING SUSTAINABLE E&T PROGRAMMES IN THE FIELD OF RADIOACTIVE WASTES DISPOSAL

In line with the Lisbon strategy and 2020 perspective “Petrus” initiative coordinates since 2005 universities, WMOs, training organisations and research institutes efforts to develop cooperative approach to education and training (E&T) in the geological disposal with the purpose of expanding this cooperation under PETRUS III. PETRUS III project aims at the continuation of the European Cooperation in this area including:

- Practical implementation of PETRUS training programme following ECVET principles: Starting from the outcomes of the previous project, we will experiment the elaboration and the implementation of training modules defined in term of learning outcomes in a “Competency-Based Curriculum”. The objective is to set up accredited and recognised qualification in geological disposal that can be achieved in parallel both through formal and PD training programmes.
- Elaboration of multidisciplinary training and research framework for PhD student: The objectives are i) to fast-track the research activities in geological disposal by proposing customised training programmes, ii) to organize periodic PhD workshops and iii) to enhance the emergence of multidisciplinary research.
- Development of strategies and frameworks for maintaining PETRUS initiative over the long-term: Following the recommendations of the PETRUS End-users Council, the PETRUS3 project will establish strategic plan for sustainability of the PETRUS initiative through i) establishing a steering board for coordination and follow-up of the PETRUS educational programme, ii) collaboration with the IGD-TP's CMET Working Group iii) creation of an integration framework to the ENEN structure for the overall management of the radioactive waste disposal E&T activities under the association umbrella and iv) linking with the radiation protection platform EUTERP and related EFTS.

Within PETRUS III development of “competence-based” curriculum for the elaboration of the radioactive waste disposal Professional Development (PD) training programme that will be accredited using the “European Credit system for Vocational Education and Training” (ECVET) principles is underway. Also possibilities for ECVET integration by applying existing instruments such as European CV, diploma supplement, Europass training, etc. into a single framework in order to secure staff career pathways is studied. A core element of the project is the establishment and further, consolidation of an ECVET partnership in this sector in order to create a framework for credit transfer and mobility.

The focus is on profile of safety engineer for radioactive waste disposal. Two profiles are identified:

1. A Performance and Safety analysis engineer who is in charge of integrating a variety of geochemical and hydrogeological data on a specific site using simulation tools to predict a dose to the Public due to radionuclides migration through the geosphere.
2. A Safety engineer who is responsible for the preparation of regulatory filings and the analysis of industrial hazards applied to the nuclear sector. He is responsible for analysing, drafting and checking of documents constituting the safety standards used by designers and nuclear operators to obtain the necessary permissions.

The courses identified following topics to be addressed:

General

- Introduction to radioactivity (radioactive decay, radioactive isotopes, radioactive period, activity, decay chains, energy and matter;

- Fuel cycle (front end, back end, spent fuel, waste forms, disposal);
- Basis of solution chemistry (speciation, partition, solubility, radiolysis);
- Basis of geohydrology and (bio)geochemistry (Porosity, permeability, transport, dissolution/precipitation, adsorption, microbial effect...);
- Basis of safety, reliability and risk management.

Overview on radioactive waste management issues

- The management of radioactive waste: History, legal framework, waste inventory, chronic of volume production, industrial operations, ongoing projects, future developments, etc.;
- Repository designs: requirements, constraints, status: Geological site characterization, the various repository components, reversibility issue and impact on the repository design and operation;
- Main areas of current scientific and technological research.

Radionuclides behaviour in geological repository conditions

- Radionuclides release, mobilization phenomena, transport and absorption processes;
- Practical applications in different geochemical environments: Design and implementation of a water / rock geochemical model; Applications on transfer/chemistry models.

From the phenomenological understanding to a repository safety analysis

- Description of the phenomenological evolution (in time and space) of the various elements of a geological disposal (HL/IL LL waste); Performance evaluation of the various disposal components and safety analysis;
- Treatment of practical examples (numerical simulations): Release and transfer of radionuclides from waste packages to the geosphere; Modeling of the alteration processes of concrete and alkaline plume spread, including radionuclide migration....

PETRUS III project is still underway, so no final deliverables are available.