Building Confidence in the Face of Uncertainty

The Role of the Safety Case

Third Joint FSC-IGSC Workshop, Bern, Switzerland, 18 May 2022

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In May 2022, the Forum on Stakeholder Confidence (FSC) and the Integration Group for the Safety Case (IGSC) held a Joint Workshop with stakeholders from Germany, Sweden and Switzerland to assess the challenges in communicating scientific safety evidence to non-technical stakeholders and to find ways to effectively communicate such knowledge to increase confidence in the safety case. The workshop also provided an opportunity to learn from local stakeholders in Switzerland and abroad about fostering confidence among non-technical audiences and creating engagement in the waste repository development process. This summary report presents the results and general findings of the workshop.

Participants

Sixty individuals attended the workshop, representing sixteen countries. Participants included:

- members of the FSC (technical experts, policymakers and communication and stakeholder involvement specialists);
- members of the IGSC (technical specialists);
- representatives from the three Swiss regional conferences: Jura Ost, Nördlich Lägern and Zürich Nordost;
- a representative from Östhammar (Sweden); and
- members of the Citizens Working Group (AGBe) within the TRANSENS ("Transdisciplinary research on the disposal of high-level radioactive waste") project from Germany.

Programme

The workshop began with a pre-recorded opening statement from William D. Magwood, IV, (Director-General of the Nuclear Energy Agency) and an introduction from the chairs: Lucy Bailey (Former Chair and Member of the Core Group of the IGSC, Nuclear Waste Services, United Kingdom) and Pascale Künzi (Chair of the FSC, Swiss Federal Office of Energy). This was followed by presentations, divided into three sessions:

- Managing uncertainty, with Lucy Bailey;
- Communication of the Swedish safety case, with Annika Bratt (Swedish Radiation Safety Authority), Allan Hedin (Swedish Nuclear Fuel and Waste Management), and Jacob Spangenberg (host community Östhammar, Sweden); and
- Perspectives of Swiss stakeholders, with Ann-Kathrin Leuz, (Swiss Federal Nuclear Safety Inspectorate), Thomas Kaempfer, (National Cooperative for the Disposal of Radioactive Waste), and Marlène Koller (Jura Ost), Gabriela Winkler (Nördlich Lägern) and Thomas Feer (Zürich Nordost).

A World Café session allowed a structured dialogue between all participants, centred around seven key questions.

The workshop concluded with feedback from representatives from each siting region and closing remarks.

Objectives

FSC and IGSC:

- To gain an understanding of what local stakeholders need:
  - » To what extent do they want to understand the safety case themselves?
  - » To what extent can they have confidence in an independent assessment of the safety case by regulators or their appointed peer reviewers?
  - » What would help give them confidence in the safety case?
- To understand how the safety case (including the management of uncertainties) is perceived by local stakeholders and what role they can play in debate, participation, governance and decision making.

Swiss local stakeholders:

- To build knowledge and understanding of the safety case and the management of uncertainties.
- To gain insight into debates taking place on an international level regarding the safety case and its communication.

1. Managing uncertainty

1.1. Managing uncertainty

Lucy Bailey – Nuclear Waste Services, United Kingdom

Making decisions in the face of uncertainty

Uncertainty is not ignorance: it is incomplete knowledge that means it is not possible to describe exactly an existing state or future outcome. Provided the uncertainties are represented, managed and communicated appropriately, decisions can be made with confidence, even in the face of substantial uncertainty.

There are a lot of decisions that have to be made in the face of uncertainty. Understanding the uncertainty (and, where possible, quantifying it) can help the best decisions to be made. This is particularly true when dealing with the complex uncertainties around the geological disposal of nuclear waste.

There are a number of strategies for taking uncertainty into account in the safety case, including:

- demonstrating the uncertainty is irrelevant, i.e. uncertainty in a particular process is not important to safety because safety is controlled by other processes;
- addressing the uncertainty explicitly using probabilistic techniques;
- bounding the uncertainty and showing that even the bounding case is safe;
- ruling out the uncertain process or event, usually on the grounds of very low probability of occurrence, or because other consequences, were the uncertain event to happen, would far outweigh concerns over the facility's performance; and
- agreeing to a stylised approach for handling an uncertainty (e.g. internationally agreed reference biosphere models).

How to provide safety despite the large uncertainties involved in geological disposal

It is imperative to ensure the geological disposal facility is safe despite the large uncertainties involved and this should be demonstrated through the safety case approach. This involves:

1. capturing an understanding of the system in conceptual and mathematical models;
2. quantifying the uncertainty in the input parameters and using the models to propagate the uncertainty in input parameters into uncertainty in performance measures;
3. assessing the performance of the system under different scenarios representing potential evolutions of the system against relevant safety standards, informed by regulatory guidance and legislation, using both qualitative and quantitative lines of reasoning; and
4. exploring the results to improve safety by improving understanding of the system and/or improving the design.

How to ensure everything has been taken into account

Safe disposal performance is provided by safety functions (functions performed by a barrier or combination of barriers that contribute to the overall safety of the geological disposal facility). These can be affected by many different factors (called Features, Events and Processes [FEPs]). Disposal system performance, safety functions, and FEPs all evolve over time, and this is captured through scenarios which represent different potential evolutions of the system. Regulatory guidance helps establish safety standards, against which disposal system performance for each scenario can be assessed. Assessments draw on qualitative and quantitative lines of reasoning. To assess safety, this conceptual understanding needs to be represented.

Addressing uncertainty

Model uncertainty: There is uncertainty about the extent to which the models used in the safety case reflect the safety-relevant features of the repository system. This is due to uncertainties concerning the conceptual understanding as well as the way this understanding is propagated into models. For instance, making inappropriate assumptions may exclude possible outcomes and thereby make the determination of performance inaccurate or bias results such that they do not represent a good basis for decision making. It is important to think about uncertainty in a systemic way, considering the behaviour of the system as a whole.

Data and parameter uncertainty: Uncertainty in input parameters of the models used might arise, for example from incomplete knowledge or from measurement inaccuracies. They need to be defined and, if possible, quantified. Probabilistic models are often used to do so. Uncertainties in some parameters can be sampled directly

by experiment but most uncertainties will require the use of some form of expert elicitation to enable an appropriate Probability Distribution Function (PDF) to be determined. When using expert elicitation, the effects of cognitive bias must be considered. People struggle to estimate probability without bias. Mental shortcuts are often taken to make quick estimates, leading to:

- Anchoring biases: making an initial judgement and then making insufficient adjustment to account for uncertainty;
- Availability biases: overestimating the probability of events experienced in the past compared to those not experienced;
- Combination biases: making mathematical errors when combining probabilities.

Usually, these lead to an over-confidence bias. Nuclear Waste Services (NWS) has developed methods and tools to elicit PDFs for parameter values. Training and uncertainty calibration questionnaires help people become aware of their own biases and better quantify uncertainties in their estimates. Experts provide initial estimates for a parameter, which are used to propose a scale. Using a structured approach to guard against bias, and considering extreme values first, experts are asked to distribute probability on the scale to produce the PDF.

Uncertainty over future states: Scenarios represent potential evolutions of the disposal system from a given initial state. The safety case will present assessments of a broad base scenario and a small set of variants which together aim to capture all potential evolutions of the disposal system. Assessments will draw on qualitative and quantitative lines of reasoning.

- The base scenario represents the set of likely or expected evolutions of the system. It incorporates the broadest set of evolutions that is reasonable. It is often assessed probabilistically (cf. above). As the design and assessment models are improved iteratively, it may become possible to incorporate many of the initial scenarios into the base and to group others into a small set of variants.
- Variant scenarios represent credible but less likely evolutions of the system triggered by FEPs that may or may not occur and cannot be incorporated into the base scenario either because the uncertainties involved are large and unquantifiable, necessitating a different sort of treatment, because assessment is against different safety standards (e.g. human intrusion), or because incorporation into the base scenario would introduce undue bias (e.g. if its probability cannot be confidently quantified, a highly unlikely scenario may be presented with a much higher risk than the base scenario in an independent assessment). Variant scenario assessments will be presented alongside the base scenario assessment in the safety case. Some may follow a probabilistic approach, while others may use stylised representations and rely more heavily on qualitative arguments. This approach is consistent with UK regulatory guidance, which requires uncertainties to be quantified and implies that probabilistic calculations of risk will form at least part of a post-closure performance assessment.

It is possible to identify an initial set of scenarios by:

- exploring the effects of FEPs with the potential to affect the performance of each safety function (comprehensive lists of FEPs relevant to post-closure safety help to consider all known relevant factors);
- exploring the effect of the loss (or partial loss) of each safety function on total system performance (this helps capture the effect of both known and unknown factors).

Demonstrating safety

The safety envelope is the set of input parameters under which Geological Disposal Facility (GDF) performance will comply with safety standards. Many of these parameters are beyond control. It is possible to demonstrate safety by quantifying all the contributing uncertainties through appropriate PDFs for input parameters and showing that performance assessments of the full set of scenarios representing GDF evolution are consistent with safety standards. If a performance assessment shows a scenario is not consistent with safety standards, it is possible to use sensitivity analysis to identify the key contributing parameters and take appropriate action.

The scenario performance can be brought into the safe performance space by setting design requirements or identifying information needs to:

- reduce the likelihood of particular outcomes or their consequence on system performance; or
- reduce uncertainties in input parameters that lead to uncertainties in system performance that take it outside the safe performance space.

Communicating uncertainty

Building a safety case is about understanding the performance of the system as a whole: the combined contribution of multiple barriers to each safety function, substantiated through multiple safety arguments. Uncertainties need to be managed in an open and honest way to inform good decision making and to build trust with stakeholders. The perception of risk is affected by the understanding of the systems and uncertainties involved and their representation, the amount of control over the outcomes, and the trust in those making decisions.

- Understanding: Involve people in the assessment of risk. Allow them to influence what scenarios are evaluated and how uncertainty is addressed.
- Trust: Be open and honest about uncertainty and explain how it is managed.
- Control: Don't just explain risk calculations to people, involve them. Listen to, understand, and address their issues and concerns.

2. Communication of the Swedish Safety Case

2.1. Communication of the Swedish Safety Case – a regulator's perspective

Annika Bratt – Swedish Radiation Safety Authority (SSM)

In Sweden, all spent nuclear fuel is currently under temporary storage at the interim storage facility (Clab) in Oskarshamn. The Swedish concept for disposal, KBS-3, is that spent fuel will be encapsulated in copper canisters with nodular cast iron inserts and embedded in bentonite clay in repository tunnels drilled at depth in crystalline rock. The Swedish Radiation Safety Authority (SSM) reviews final disposal applications from the Swedish Nuclear Fuel and Waste Management Company (SKB) under the Swedish Act on Nuclear Activities, and issues pronouncements to the Swedish government, which then makes licensing decisions. On 27 January 2022, the Swedish government formally decided to grant SKB a licence to construct, possess and operate a final repository for spent nuclear fuel in Forsmark in Östhammar Municipality, close to the Forsmark nuclear power plant, and an encapsulation plant in Oskarshamn, adjacent to the Clab central intermediate storage facility for nuclear fuel. The decision includes a licence condition that SSM conduct a continued stepwise review process prior to the facility being taken into routine operation. The government is now handing over the case to the Land and Environment Court, which issues formal judgments on licensing and prescribes conditions under the Swedish Environmental Code.

There are many stakeholders involved in the Swedish process. These include: the National Council, the Land and Environmental Court, the County Administrative Board, the Oskarshamn Municipality, the Östhammar Municipality, the SKB, the SSM, the public, the Swedish government and non-governmental organisations (NGOs). During the licensing process, there has been a lot of debate and engagement, much of it centred around the communication of uncertainties, and a number of key points of learning have been identified as a result.

Definition of roles

Transparency and public participation are key tenets behind Sweden's approach to geological disposal; however, geological disposal is a complex field with the many parties involved playing different roles; how they all interact with each other are important factors in making sure the process works.

Lesson learnt: It is important to clearly define and communicate the roles of the regulator, the implementer and local stakeholders, and to provide funding for local stakeholders to build competence and participate in the process.

Annika Bratt, Swedish Radiation Safety Authority (SSM).

Process for engagement

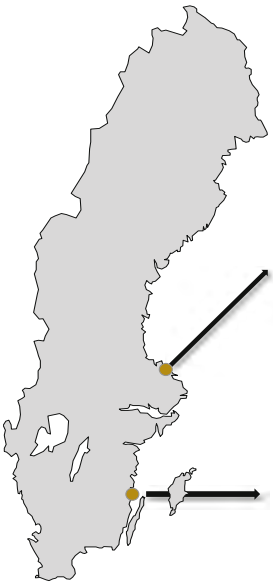
In Sweden, there is no formal process governing public involvement in the steps following the government decision. This can lead to uncertainty and a fear of exclusion.

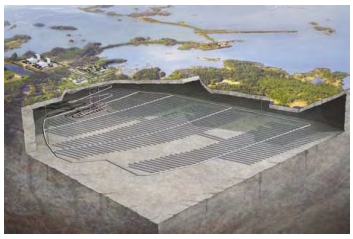
Lesson learnt: There should be a clear framework for how different stakeholders can be involved throughout each step of the licensing process.

System perspective

In Sweden, NGOs and critical researchers have raised many concerns and objections on specific topics, for example copper corrosion, site selection and alternative methods for the management of nuclear waste. These often come up repeatedly in different contexts; however, concerns and objections tend to consider specific topics in isolation; they are not usually presented in a wider safety case context.

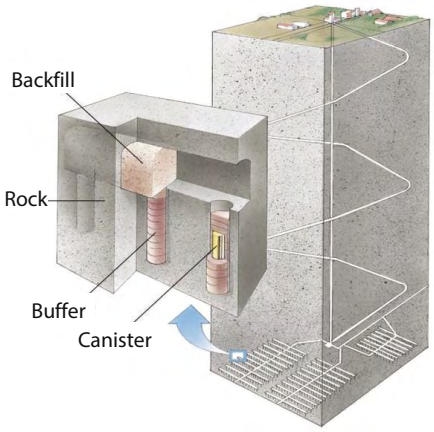
Lesson learnt: It can be difficult to plan communication: external critics tend to set the agenda. It is the role of the regulator and implementer to provide the safety case





Spent Fuel Repository in Östhammar

Encapsulation plant in Oskarshamn



Final repository for spent nuclear fuel near the Forsmark nuclear power plant, and the encapsulation plant next to the Clab central intermediate storage facility for nuclear fuel.

Source: SKB.

context for topical discussions. They should consider all aspects from a system perspective and provide stakeholders with the information to enable them to do the same. This includes making sure everyone has a basic understanding of the role of the safety case and ensuring topical discussions are presented in this context.

Communicating uncertainty

SSM received a request from the land and environmental court to present a list of all the uncertainties in the safety case, how they were being addressed and why the process could continue despite them. SSM complied with the request. Although this was a helpful way of demonstrating how each individual uncertainty had been managed, the sheer volume of contributing uncertainties discussed may have had the effect of magnifying the perceived amount of uncertainty around the decision to move forward.

There can be an impression among stakeholders that all uncertainties need to be resolved before a decision can be made, and different stakeholders may have different impressions of what resolution entails. In particular, they may expect that the goal is to remove all uncertainties, and may struggle with those uncertainties which are tolerated, either because of the stage which the programme is at, or the nature of the uncertainties themselves and their effect on the performance of the system. It will be necessary to communicate messages such as:

- "More research will be needed to support decisions at future stages, but we have enough information to make this decision at this stage."
- "Yes, there are uncertainties that remain, but they are appropriately represented in the safety case and it can be demonstrated that the system will be safe despite these uncertainties."

Lesson learnt: Stakeholders appreciate the importance of uncertainties in decision making and some of them have a desire to understand how specific areas of uncertainty have been addressed in the safety case. Both the overall approach to uncertainty management at each stage of decision making and a comprehensive view of how each of the contributing uncertainties have been addressed within this context needs to be presented in a way that is accessible to interested stakeholders.

2.2. Communication of the Swedish Safety Case – an implementer's perspective

Allan Hedin – Swedish Nuclear Fuel and Waste Management (SKB)

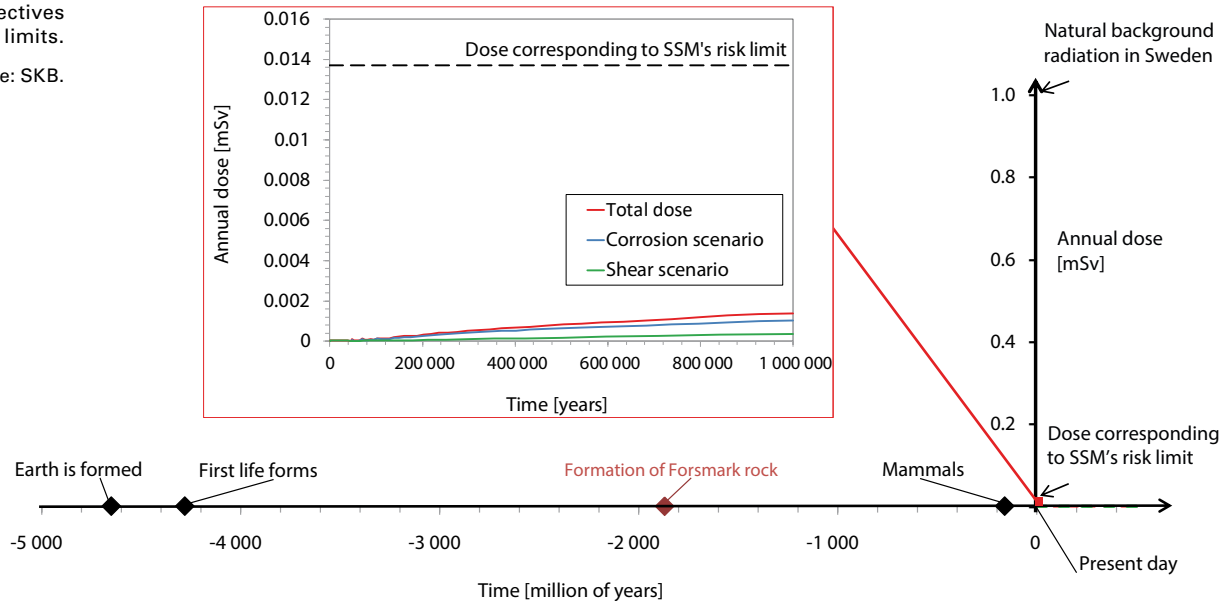
Building trust is a long-term effort

SKB has been active in the municipalities of Oskarshamn and Östhammar for decades. It has been planning for a repository in Östhammar for about ten years and has been engaging with the local communities for even longer. It has engaged on a broad range of different topics, including the safety case. Iterations of the safety case have been presented many times over the years, as each update is issued.

Stakeholder perspectives

Stakeholders have different backgrounds, interests and ways of engaging with the safety case:

- The local general public includes members who are interested in a broad sense and others who have a desire for an in-depth understanding, particularly in areas where they are themselves knowledgeable. Östhammar, for



Time perspectives and risk limits.

Source: SKB.

example, with a nuclear power plant in the municipality, has a large number of people who know a lot about spent fuel, and there have been many detailed discussions on matters relating to spent fuel.

- Focus groups organised by the municipality often spend considerable time studying SKB reports and generally see SSM as the authority responsible for the more in-depth, critical review of SKB's safety case.
- NGO representatives are often unconvinced about the safety of a final repository and will frequently challenge SKB to respond to opinions expressed by critical experts.

Formats for communicating the safety case

Communication of the safety case occurs over a number of different formats:

- Written information is presented at different levels: the full, technical report (main report, approximately 1 000 pages) and a technical summary of the full report (approx. 50 pages) are published in printed and digital formats in Swedish and English, while less technical descriptions (approx. 10 pages) are generally published online and in Swedish only, although printed formats may also be available.
- Oral presentations at meetings organised by the municipality, SKB, SSM and NGOs make it possible to convey not only the technical content at a level tailored to the occasion and audience in attendance but also an impression of the presenter and the organisation they represent. This is important for establishing trust: people wonder "who is behind this?" "what kind of person are they?" and "are they someone I can trust?"
- Social media (Facebook, Twitter, Instagram and YouTube) also have a role in public engagement.

Challenges

Communication of the safety case can be challenging because of the complex nature of the underpinning analyses, the very long timescales and the high levels of uncertainty involved. People ask how it is possible to say anything at all over a million-year timescale and to know the safety case is complete. They ask what happens if something is missed, how the high doses that result from drilling scenarios that penetrate the canister can be addressed and, given how much we focus is given to uncertainties, what certainties there are.

These are probably familiar communication challenges for most waste management organisations and SKB's ways of addressing them are similar to those of most other organisations. One example of how SKB has addressed the unfamiliar timescales and risks is to put timescales and risk limits into perspective by using comparisons, verbal and graphical, to values people are more familiar with from other contexts or have direct experience with, such as geological and evolutionary timescales and levels of natural background radiation in Sweden. This makes it possible to show the relative time period over which the dose is assessed and how low it is compared to natural radiation.

The roles of the implementer and regulator

Distinguishing the roles of SKB as the implementer and SSM as the regulator has been essential for building public confidence.

Transparency is key in communicating nuclear safety to stakeholders. SKB has involved its own experts in dialogues with the public and other stakeholders and has striven to be inclusive by involving and taking on board opposing views in discussions. SSM is an important actor in informing the public about the laws and regulations that help provide confidence in the decision-making process, and in critically reviewing SKB's safety cases and explaining its findings to the public.

2.3. Communication of the Swedish Safety Case – A host community's perspective

Jacob Spangenberg - Mayor of Östhammar municipality, Sweden

Nuclear facilities in Östhammar municipality

It takes time to build trust, particularly when discussing such a complex issue: it is important to be persistent and prepared to invest time engaging with the local community over a long period. Östhammar has a long and broad-ranging involvement with the nuclear energy industry.

- The Forsmark Nuclear Power Plant was commissioned there in 1980 and continues to operate today.
- The final repository for short-lived radioactive waste is also located at Forsmark. It has been operational since 1988. In 2014, an application was made for its extension, which was approved in 2021.
- The final repository for spent nuclear fuel is to be located at Forsmark. Pre-feasibility studies started in 1992, the site was selected in 2009, a licence application was made in 2011, and approval from the municipal council of Östhammar was received in 2022, with the final licence conditions still under deliberation.

The long presence of the nuclear power plant and the engagement of the community with each of the decisions relating to the repositories mean that they have a strong awareness of nuclear energy issues.

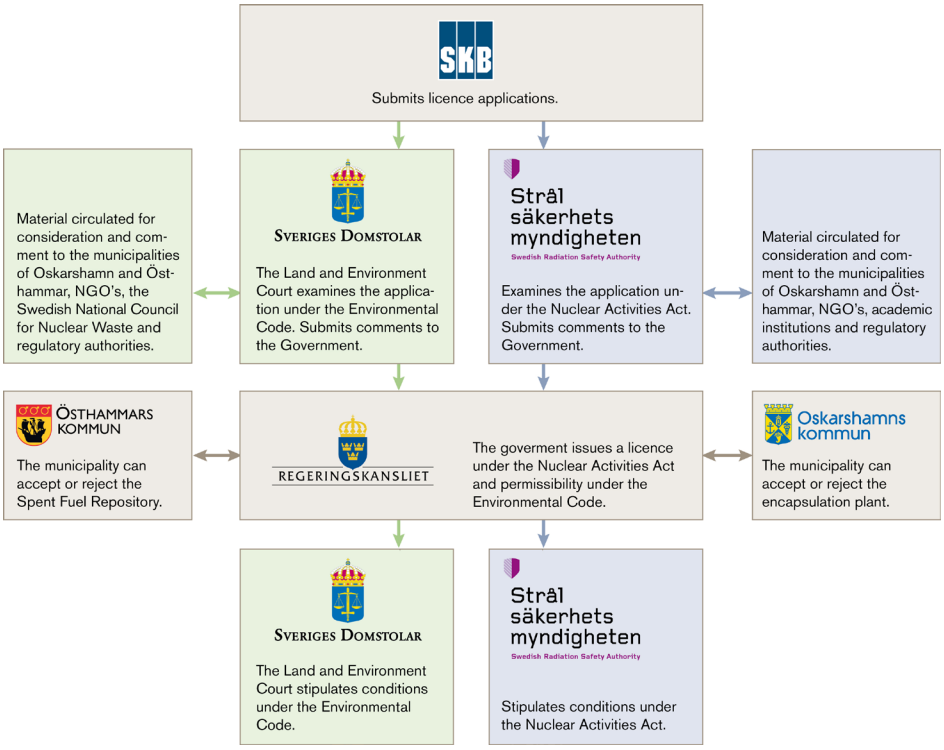
The legal process in Sweden

Swedish counties (*län*) are not involved in the decision-making process: communication is directly between the municipality and national government. This simple two-layer system is an important feature for success in Sweden.

Learning from the siting process in Sweden

Alongside the relative simplicity of the legal structure, there are factors that make Sweden particularly well-adapted to siting a geological disposal facility: it is sparsely populated with a high degree of self-governance, a high degree of openness and transparency, and a high level of trust in the authorities. However, in order to make the siting process successful, work in the local municipality must be transparent, well-planned and predictable.

- Voluntarism: The siting process in 100% voluntary, which gives people ownership over the process and makes them more willing to engage. It encourages the implementer and regulator to engage with the community.
- Role definition: The roles of the regulator and implementer have been clearly defined and communicated. Additionally, the host community is sure of its own role in the process: there are areas in which it will take a firm stand and others where it will defer to other parties whose expertise may be important. The role of NGOs is particularly important – their questions have shaped many of the discussions.
- Financing: Financing is necessary, both for waste management and to support public engagement. Clarity about where the money comes from is important: money is drawn from the nuclear waste fund, which is controlled by government, so it is made clear that money is not being taken from other areas.
- Knowledge and awareness: Complicated technical issues must be described in layperson's terms.
- Openness and transparency: At all stages, it is important to be open and transparent with all the involved parties.



The legal process in Sweden

Source: SKB.

3. Perspectives of Swiss Stakeholders

3.1. The systematic evaluation of uncertainties – Examples from the Swiss programme

Ann-Kathrin Leuz – Swiss Federal Nuclear Safety Inspectorate (ENSI)

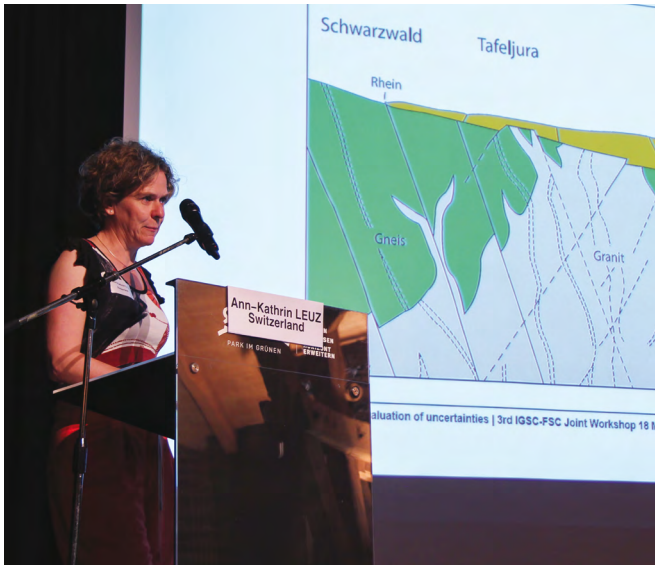
Example 1: Potential host rocks (1979-2006)

Crystalline bedrock: Between 1979 and 1988, the Swiss implementer explored the option of locating a repository in crystalline bedrock. They had initially expected a relatively level, homogeneous host rock; however, field investigations presented a more complex picture, including faults disturbing the bedrock and the presence of water-conducting features. The regulators took the view that the uncertainties associated with locating a repository in these rocks were too high: the geological environment would be difficult to characterise, there was a chance a suitable site might not be found, and drilling during site characterisation might damage the rock, impacting its potential to host a GDF. They recommended investigating sedimentary host rocks instead.

Opalinus clay: Between 1988 and 2006, the Swiss implementer investigated the feasibility of hosting a GDF in the Opalinus clay. The Opalinus clay was much simpler to characterise due to the rock's homogeneity; however, the creep behaviour exhibited by the clay might introduce complexity during construction by making it difficult to keep excavations open. The case for the feasibility of a GDF in an Opalinus clay was approved by the regulators after review. The regulator identified key topics where knowledge needed to improve and open issues to resolve. For example, the short distance to the Alps made understanding erosion and its impacts important and the characteristics of the clay increased the potential for high gas pressures to build up, making it important to understand gas generation mechanisms such as corrosion. This systematic assessment of uncertainties also helps to structure research programmes and improve the system.

Example 2: The site selection process (2008 to ~2029)

In Switzerland, site-selection does not follow a volunteer approach: a suitable site is selected based primarily on safety: geology and operational safety, rather than political factors, are the only important considerations; socio-economic and spatial-planning aspects play a secondary role. The site selection process started in 2008, with a "blank map" of Switzerland, meaning all of Switzerland's potentially suitable regions and rock formations were considered. Safety-relevant and geological criteria were defined to help identify potentially suitable regions. Using these, six potential siting regions were initially identified for further investigation. A safety-based comparison of all regions reduced these to three: Jura Ost, Nördlich Lägern, and Zürich Nordost. The Swiss programme is now in its final stage of site selection, during which a single site will be selected from these three[1].



Ann-Kathrin Leuz, Swiss Federal Nuclear Safety Inspectorate (ENSI).

Whenever a region was excluded, the data underpinning this decision were presented. Before excluding a region, questions like "Could we obtain a different result with more data?" and "Could we reduce uncertainty to make a sound decision?" were considered. Still, some regions were excluded on the basis of too many uncertainties that could not easily be reduced.

1. Nagra announced Nördlich Lägern as its proposed site of the deep geological repository on 12 September 2022, https://nagra.ch/en/nagra-proposes-nordlich-lagern-as-the-site-for-a-repository.

ENSI guidelines with respect to uncertainties

Uncertainties in data, models, processes or future developments are inevitable. It is important to systematically evaluate and manage them. Any decision, be it related to site selection, safety case development or optimisation, should be robust in the face of uncertainty. ENSI has developed guidelines to support the handling of uncertainties. ENSI requires that:

- a sufficient level of knowledge about the safety-relevant properties, events and processes be developed;
- uncertainties be systematically identified and their influence on safety be assessed;
- uncertainties be reduced as far as possible and necessary by research and data collection; and
- site selection and the safety case be robust despite existing uncertainties.

3.2. Nagra's next Safety Case – Dealing adequately with uncertainty

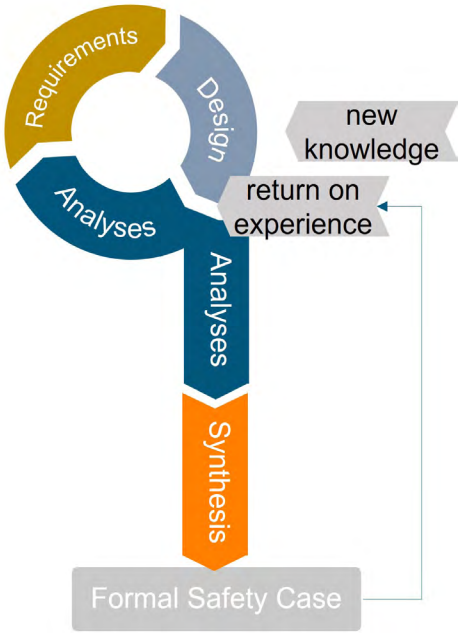
Thomas Kaempfer – Swiss implementer (Nagra)

The evolution of the safety case and disposal programme

Repository development follows a transparent, iterative process: requirements are formulated and translated into design choices, analyses are carried out to check requirements are met, and the results of these analyses inform further iterations of the requirements set.

For important milestones, formal safety analyses are performed, and a safety case is compiled. Whether optimising for safety or engineering, learning from experience is key.

In Switzerland, disposal feasibility for high-level waste was demonstrated more than a decade ago. The last formal safety case compiled was for this milestone. By the end of 2024, Nagra plans to submit the general licence application for a deep geological repository. This will need to be supported by a safety case. This can be seen as an update of the 2006 safety case, taking into account project progress and knowledge acquired. The increase in knowledge since the last formal safety case has been substantial, including a large volume of new information from extensive site characterisation programmes. With each iteration of the safety case, uncertainty is expected to decrease, but some level of uncertainty will always remain. Thus, adequate, sound management of uncertainty is another very important aspect.



Role and evolution of the safety case during the disposal programme

Source: Nagra.

Uncertainty management and decision making

In this iterative, step-wise process, the way Nagra deals with uncertainty is adapted to the decision or milestone ahead. It is imperative to demonstrate that safety is provided and decisions are robust, despite remaining uncertainties, which include new uncertainties that may be identified in the future. This requires adequate management of uncertainty, but it must be acknowledged that the elimination of all uncertainty is neither required nor feasible. The question is "How do we best deal with an uncertainty now?" With respect to the safety case, this question is linked to the safety relevance of remaining uncertainties. Nagra considers questions like: "How can this uncertainty be characterised now?", "Must it (and can it in practice) be reduced, mitigated or avoided now?" and "For future milestones, can it (and must it) be better characterised, reduced, mitigated or avoided?"

The elements of Nagra's safety case

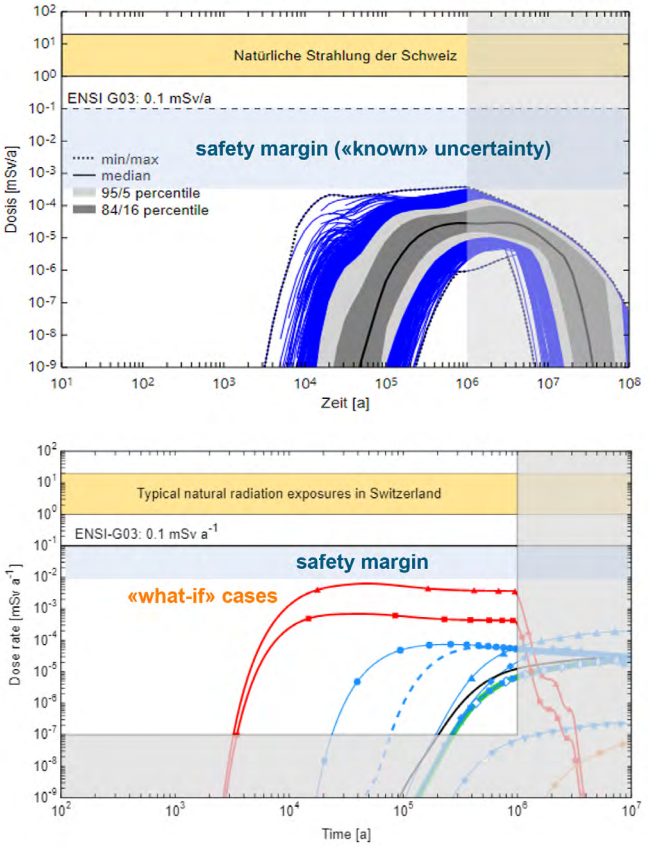
The elements of Nagra's safety case include:

- a system with properties that are favourable to safety, and which is feasible to implement;
- safety assessments that demonstrate adherence to safety criteria, using analyses that are complete and error-free; and
- a programme that follows and is embedded in a well-defined, transparent process.

The identification and treatment of uncertainties in safety assessments

Nagra's approach to the identification and treatment of uncertainties in safety assessments involves:

- Identifying uncertainties: Systematic approaches linked to system understanding and Features, Events and Processes (FEPs) relevant to disposal system safety are used to identify all uncertainties in the system.
- Assessing safety relevance: Nagra assesses safety relevance and, if appropriate and feasible, takes appropriate measures to reduce or mitigate against uncertainty.
- Representing uncertainties in safety assessments: Remaining uncertainties are characterised and adequately represented in safety assessments, making it possible to determine the full range of consequences due to remaining uncertainty, and assess their safety impact, e.g. by demonstrating that for all realisations, not only does the dose level or risk fall below a threshold safety level, but there is a significant safety margin providing a buffer before that threshold is reached.
- Carrying out "what if" assessments: It may be desirable to postulate so-called "what-if" cases that make it possible to explore system behaviour and consequences for either very improbable or even impossible evolutions of the system. It is important that there still be a safety margin for these "what if" cases, even if it is smaller. The goal is to demonstrate that there are always significant safety margins, allowing for appropriate responses should new uncertainty appear in the future.



Uncertainty management: Identification and treatment

Source: Nagra.

Robustness, completeness and unknown uncertainty

There is also the question of robustness, completeness, and the treatment of unknown uncertainties: have all uncertainties been identified, has anything been ignored? Nagra's approach to managing these so-called "unknown unknowns" includes:

- Safety-oriented processes and principles and an appropriate safety culture, which help avoid "unknown/ignored unknowns";
- Regular stakeholder dialogue, which enhances awareness and contributes to a good, transparent process; and
- Robustness and safety margins together with an iterative approach, which provides assurance Nagra can react to new uncertainties appearing in the future, as well as making optimisation possible.

"Considering these few aspects and representing them well within our safety case gives us confidence that we will not only adhere to the requirements of our regulator, but foster confidence among all stakeholders," concluded Thomas Kämpfer.

3.3. Perspectives from the Swiss Regional Conferences – Jura Ost

Marlène Koller – Jura Ost Regional Conference

Trust: The working group on safety is a lay persons' group: input from experts is needed, but we have engaged with experts and carried out detailed analysis and learned a lot about safety and geology. There are several nuclear facilities in the region already, providing a lot of experience with these facilities as everything is in close proximity. People trust the laws governing the operation of these facilities and they trust the operators of the facilities. Everyone knows someone who works there, and experts from other areas come to the region for training. Members of the public in the region have access to experts and can go and visit to see what their jobs involve day-to-day. As mayor, I was directly informed by operators and could disseminate information to the municipality. This creates trust and acceptance. It is impossible to have 100% acceptance, but to get a high acceptance rate it is vital to ensure people are kept informed. People will have different expectations: experts will want more detailed technical content that they can interrogate in detail, whereas for lay people, information needs to be clear and easy to understand.

Process: It is important that questions be taken seriously and all inputs considered, no matter where they come from. It must be possible to understand decisions and see that they are well founded and well grounded. The sectoral plan for deep geological repositories (sectoral plan) is not very well known by the general public, which made achieving co-operation at a local level difficult. The regional conferences were created to address this. Initially, there was a concern that the input from the regional conferences would not be taken seriously, but now it is clear that they are. There are many challenges remaining to be addressed, however: several generations will be involved in the process; over time, a lot of the knowledge developed through the regional conferences can get lost, and not many people from the younger generations are represented, even though they will be involved in the building and operation of a facility. All three regions under consideration are close to Germany. There are quite a few cultural differences, but German participants join the regional conference.

Acceptance: At the time of the meeting, the Jura Ost community explained they were waiting with anticipation to hear what Nagra's site decision would be. Across all the regions, a lot of time has been invested in understanding the philosophical nature of the problem and built years of experience and knowledge about geological disposal.

3.4. Perspectives from the Swiss Regional Conferences – Nördlich Lägern

Gabriela Winkler, dipl. sc. nat. ETH, Vice-President regional conference, Co-President practice group safety

How safe is safe enough? This was the question that the members of the working group on safety in Nördlich Lägern were tasked with as representatives of the local community. Today this question has evolved into "Do we know enough to continue the journey for the geological disposal of radioactive waste?" The answer is "yes". What the working group has learnt in the past 10 years is to understand and accept that in a field as complex as geological disposal, every question has a specific moment to be addressed.

How was this conclusion reached? First, the working group on safety defined its role. The task was not to become specialists in radioactive waste handling or geology, but to ask questions to all involved institutions and expert scientists. And of course, the group tried to understand, but it limited itself to checking whether the answers from the different stakeholders were compatible and comprehensible. If answers differed, the group listened objectively to the facts and took time to understand all sides of the argument. In one specific case concerning the interpretation of the federal law about the protection of groundwater, the group was instrumental in concluding an agreement between the confederation and the canton of Zurich. It should not be the group's task to decide who was right or wrong. Finally, Nagra presented a technical solution to this important safety issue.

Does the group trust the institutions? It is vital to trust the process of participation. The group also believes that nobody has bad intentions. It took quite a bit of time to convince all the responsible people and representative institutions to not only communicate the findings of their underground investigations, but also identify areas that require greater investigation. In other words, "what questions remain unanswered?" This will make it possible to further trust Nagra to address such questions openly and continue the broad discussions that have promoted trust to date.

The working group also doubts whether the technologies of today are the ultimate solution. Therefore, it asks for openness. Innovation does not stop today. Trust needs to be placed in people the group knows and who establish their credibility and honesty with due diligence. Honesty requires providing information regularly and openly, admitting to the unknown, answering questions and being open-minded about future evolutions, never making disagreements with other stakeholders personal, never assuming superiority because they are academics. If someone cannot convince the public, they lose, even if they know much more about the subject than the audience.

Gabriela Winkler, Vice-President of the Nördlich Lägern regional conference, takes part in the debate.

The current and future generations who use nuclear energy are responsible for the waste's safe long-term disposal. Not only because they are consumers of nuclear energy, but because future societies should not be burdened with the waste of previous generations. For long-term geological disposal, trust must be placed in geology and engineering, even though there are inevitable uncertainties. This is the basis for the safety report. The requirements for this report are the same as mentioned above. The working group on safety has posed questions to various stakeholders (ENSI, Nagra, etc.). It has found that the explanations are comprehensible, honest and open. It is looking forward, hoping that all the work and knowledge acquired may endure for the next steps in this journey.

3.5. Perspectives from the Swiss Regional Conferences – Zürich Nordost

Thomas Feer – Zürich Nordost Regional Conference

The Safety Case – Today and tomorrow

Fifty years ago, the first nuclear plant in Switzerland started to produce energy – and high-level radioactive waste. Now, a sectoral plan is underway to select a suitable location for a final repository for this waste. It entails looking ahead many decades and taking a long-term perspective as decisions taken now will affect generations to come.

The safety case is developed by experts and is assessed by experts and lay people. But whose judgement is valid and capable of building confidence? The Swiss regional conferences can provide a forum for lay people to engage with and assess the safety case themselves, but experts will have far more insight into the process and the technical issues than people living in the local area. Significant public discussion of the safety case and uncertainties relating to geological disposal has probably been happening for two to three years. It is yet unclear whose judgements will be trusted, those of the experts or the regional conferences, or how conflicts will be resolved.

There will be new scientific findings and insights from discussions and reviews of the safety case. How is it possible to be sure the safety case is updated in light of these new findings and insights? It must be shared openly and transparently to enable review and discussion, and it must be modifiable at regular intervals.

At present, demonstrating safety is a legal requirement, but to what extent does this (minimal) legal requirement compromise scientific research aiming for the best possible level of safety? What processes enable the safety case to be developed to meet higher standards for long term safety as opposed to simply meeting the basic standards defined in law? The greatest level of safety would result if there was no waste to dispose of. Given this cannot be achieved it is still possible to aim for the best possible level of safety in the long term, taking into consideration, of course, cost and operational implications but with safety as the priority.

FSC-IGSC joint workshop participants.

Thomas Feer, Zürick Nordost regional conference.

Process, uncertainty and trust

It is important to think about how experts and lay people communicate and co-operate with each other. People in the region are part of the process. Co-operation between them and experts may be combative, complementary, contradictory, productive or inspiring – but the people in the region must be involved.

It should be considered whether the current level of public participation is sufficient in the sectoral plan, or whether greater participation via consultation and co-creation of products would be beneficial: increased co-operation may both improve public perception and strengthen the safety case.

Uncertainty is one of the issues we asked to be addressed. It raises a lot of questions, some of which have not yet been answered and some of which will never be answered. Uncertainty can be perceived as a sign of ignorance or being unable to provide answers, but it can also be a positive element of the process in terms of building trust and understanding of risk: a balance must be struck between risks to people at the site now and the risks to future generations.

How can trust be built?

People in the region must be given a platform to engage with experts on areas of mutual interest, to express differing opinions, etc. Scientific results and knowledge are important to people in the region, but scientific work is valuable only if it is open, transparent, honest and explained to the lay person such that it can be understood, including with regard to uncertainties and insecurities. It requires openness towards differing views and opinions, collaboration and generosity in sharing knowledge, lack of knowledge and contacts.

The future is uncertain but, when it comes to radioactivity, the local communities ask for certainty.

4. World Café

A World Café session provided the format for a structured dialogue between all participants. Discussion was centred around seven key questions. Each question was allocated a table at which a designated facilitator led three rounds of discussion, each round building on the results of the last. Participants rotated around the tables according to their interest so that each had the opportunity to discuss three of the questions. At the end, facilitators presented the results of the discussion to the entire conference.

Table 1 "Information" – Ulrich Noseck (Germany)

What do you consider the most important technical and non-technical information that you would like to receive?

Technical information

- **Barriers**: There was a lot of interest in the container and its characteristics, both as the first barrier to the waste itself, and because members of the public were more familiar with the processes and timescales.
- **Natural analogues**: The use of natural analogues was seen as useful, particularly for the geological barrier.
- **Site visits**: There was a strong feeling that experience may be more important than information: those who had visited Mont Terri expressed how impressive it was to drive into the tunnel, passing the calcite interface and moving from wet to very dry regions where no water flow had been observed over very long timescales. A lot of information can be communicated through experience.
- **Worst-case scenarios**: Discussions did not tend to focus on the use of models and modelling; however, the presentation of worst-case scenarios and their use in bounding assessments was encouraged.

Non-technical information

- **Methodologies**: People wanted to understand, not only the results, but the path from:

  research › data › results.

- **Changes**: There was a desire that changes to the safety case should be documented and communicated openly and transparently.
- **Decisions**: It was seen as important that decisions and the reasons behind them be documented, at least for big decisions.
- **Processes**: Particularly in areas requiring collaboration, e.g. between implementer, regulator and stakeholders, people wanted to understand the processes by which this would occur. Using roadmaps, and following a stepwise process was encouraged. Learning from the siting process was that "after the process had been established and all roles defined, progress was much smoother".

- **International experience**: Experience from other countries and other programmes was seen as important, both in a technical and non-technical context.

Round table 1 on the technical and non-technical information deemed most important.

Table 2 "Concerns" – Manuel Capouet (Belgium)

What are your concerns? What do you not believe? What characteristics or behaviour do you not find trustworthy?

Many of the concerns expressed related to uncertainties and their representation:

> ***"Demonstrations of safety over a million years are difficult to grasp", "It is impossible to capture the real world in a mathematical model", "The project will cost more and take longer than we expect."***

The absence of uncertainty, or the absence of the recognition of uncertainty is a red flag:

> ***"An arrogant expert that has complete confidence they have the solution is not trustworthy."***

Building trust in the integrity of experts and transparent application of the scientific process can help address this.

Trust, at a personal level

- People do not want a corporate message, they want authenticity: people are trusted on a personal level.
- Community representatives recalled a barrage of different slogans during the early stages of the siting process and representatives from the implementer arriving at public events wearing suits. This created a divide between the implementer and the public, making engagement with experts more difficult.
- People want to see the person behind the expert. They want to see them at work, to engage with them and see their enthusiasm for their subject, what they are confident about and what they are not, the uncertainties they face and how they handle them.

The scientific process

- Stakeholders discussed experiences of experts contradicting each other or disagreeing at public events.
- There was concern the public might not be able to follow complex scientific arguments and see only disagreement, leading to a lack of trust; however, stakeholders clearly expressed their desire to see scientists disagree: they saw opposition as an important part of the process, giving conclusions greater credibility and wanted to see science in action, not hidden behind closed doors.
- There was recognition that natural disagreement in science could be misrepresented in the media, as exemplified during the COVID-19 pandemic and discussions about climate change.

Challenges

Experts and members of the public have different levels of understanding and areas of interest. In stakeholder discussions, the same concepts come up again and again. It is vital to show these can be addressed suitably, but also to address those things that are more difficult but less obvious, and which more often come out of expert discussions.

Table 3 "Trust" – David Brazier (UK)

What information sources do you find trustworthy…and why?

Characteristics and qualities

Sometimes it is less about the profession or organisation than the qualities its people exhibit.

What stakeholders are saying	What the implementer/regulator can do
"We don't trust institutions per se, we trust people who respect our 'stupid' questions!" We respect honesty from people who are open about uncertainties." "The Swiss Technical Forum for Safety is a good place to ask questions."	Hold a public forum where people can ask questions.
"At Swiss regional conferences, trust in experts has more to do with 'Do I get a good feeling from this person?'"	Give people the opportunity to talk to experts one on one.

Round table 3 on the trustworthiness of various information sources.

Professions and organisations

The institutions and professions in which people place their trust can vary across countries and cross-sections of the population. Some of the feedback received reflected this range.

What stakeholders are saying	What the implementer/regulator can do
In 2022 Andra carried out a survey of local communities to explore how their trust in different sources differed. The implementer was not the most trusted source. Instead, these were: 1) Scientists, 2) NGOs, and 3) Personal research. "Yes, scientists and engineers enjoy relatively high trust but so do family/friends/hairdressers. This can lead to echo chambers and filter bubbles." "In Japan, a university professor is trusted; people respect the status of a professor." "In France, Germany and the UK 'Authorities' are much less trusted than in Scandinavia." "In France, trust in politicians is low. Trust in scientists is relatively high (but not as high as it was pre-pandemic)."	The implementer/regulator can improve trust by ensuring it includes representation from across a diverse range of professions and areas that are familiar and accessible to the local community.
"Swiss regional conferences include doctors, engineers, mechanics, construction workers, but not geochemists or hydrogeologists."	It is important to ensure it has coverage across the key disciplines relevant to geological disposal to ensure communities have access to experts in these fields.
"Early in the siting process, communities in Canada did not know the regulator existed."	As an independent and knowledgeable party, the regulator can be a useful resource but to make best use of this, it needs to make sure people know who they are and what their role is.

Communication methods

Other times, it is not about who is communicating the messages, but the way they are communicated.

What stakeholders are saying	What the implementer/regulator can do
"I trust explanations in simple/easy to understand language and honesty about uncertainties."	Show the work and explain any assumptions.
"I believe in things I can see."	Provide visual demonstrations, like the tabletop experiments at Mont Terri. Give people the opportunity to visit rock labs and see geological features and experiments in person.
"I trust my own research"	Provide stakeholders with alternative sources of information.
"I have more trust in the Swiss process now than 10 years ago. Why? Answers were consistent over time"	Trust is built over time. Start communications early, engage consistently and be patient. A stepwise decision-making process is often more trusted.

Ongoing challenges

- **Representation**: Feedback was received that many organisations were struggling to get working people (<60) involved in community groups: interest came mostly from retired people and those from the anti-nuclear community. If sectors of the community miss out on early engagement, even if they become more engaged at later stages of the process, they will have missed out on years of progressive engagement and collaboration and the trust that comes with it, and the implementer/regulator will have missed out on receiving their views in the early stages or building an understanding of the best means of engaging with them. How can a more representative sample of the community be reached?
- **Expert disagreement**: Stakeholders said that "Expert disagreement is a problem – it leaves us wondering who to trust.", but also that they wanted involvement in the process and honesty about uncertainties. How is it possible to handle the fact that some answers will not be consistent over time, but will change as understanding grows? How can trust be built in areas where experts disagree without sacrificing transparency?
- **Interruption to communications**: It was clear that one-on-one conversations in public meetings are a valuable tool for engagement and building trust. Stakeholders said that the pandemic has had an impact in this regard: for a period of time in-person meetings were halted and, although these are being held again, the number of people attending is down. What impact has this had on trust, and what does it say about the effects of any future interruptions to engagement and is it possible to recover from them?
- **Organisational name changes**: A number of organisations involved in geological disposal have undergone name changes. Given the importance of continued communication, the struggles communities have already faced in understanding the differences between regulators and implementers, and time it takes to establish and build trust, what effect do these name changes have on trust? Can anything be learnt from the effects of creating new authorities in Japan after the Fukushima Daiichi accident?

Table 4 "Understanding" – Tom Peake (USA)

How deeply do you want to understand the safety case? How much technical detail would you like to have?

Public-facing presentations of the safety case need to include enough detail for people to understand how safe the disposal facility will be, what decisions are being made, and what support there is for these decisions.

	**Understanding the audience**: The public is not uniform. Implementers and regulators should take time to understand the various audiences and target people's interests and information consumption preferences.
	**Presenting information at different levels**: When presenting the safety case, it is important to present a summary that covers the main issues and helps explain and visualise how key concepts relate to one another. Some people will want high-level conceptual summaries, uncluttered by numbers and detailed scientific assessments, while others will want to explore the detailed analysis sitting behind the safety case: "How did you reach the dose number? What are the assumptions?" Information should be provided at various levels, e.g. summaries with more detailed information beneath them that people can access.
	**Linking information**: Information is not useful to people if they cannot find it. Information needs to be linked appropriately to make it as easy as possible to go from summaries to detailed information. Information needs to be understandable to the public. Where specialist terms and concepts are used, their definitions should be linked to, to ensure they are consistently used and understood.
	**Presenting information in different formats**: Information needs to be presented in formats that are accessible and understandable to the public.
	**Communicating changes**: Communication of the safety case will take place over a long period of time. Stakeholders said they appreciated coherent, reliable messages, which were consistent over time and clear on what was being investigated and what was still under investigation: "We want to know what the open questions are". It is important for the implementer/regulator to be clear, at each stage, about what work has been done, is being done, and remains to be done, and to identify and communicate changes and their significance.
	**Giving people a forum in which to ask questions**: With such variety in the breadth and depth of information addressed in the safety case and its supporting documents, it is useful for people to be able to address questions to a range of experts directly. The Swiss Technical Forum on Safety seems to be an effective means for the public to access experts and ask questions that are subsequently made public.

Round table 4 on the level of understanding expected from technical details on the safety case.

Case study: The Swiss Technical Forum on Safety

The Swiss Technical Forum on Safety discusses and answers questions from the public on technical and scientific aspects relating to the deep geological repository. It was set up in 2009 by the SFOE (federal office in charge of site selection procedure according to the sectoral plan) and is led by ENSI (the Swiss regulator). The forum comprises experts from the SFOE, ENSI, swisstopo (the Federal Office of Topography), the Federal Nuclear Safety Commission, Nagra, the cantons, neighbouring countries Austria and Germany, the Swiss Energy Foundation and up to two representatives from each of the proposed siting regions. Questions can be submitted by members of the public, communities, siting regions, organisations, cantons and communities in neighbouring countries that may be affected. Meetings tend to be in-person (although, as a result of the pandemic, web support capability has been added), and cover various questions with discussions at varying levels of detail. Previous discussions have covered topics such as erosion and glaciation. Over the years, the Swiss Technical Forum on Safety has built up a database of over 150 questions and answers, available online at https://eni.ch/de/technisches-forum-sicherheit.

Table 5 "Uncertainty" – Klaus-Jürgen Röhlig (Germany)

Which type of uncertainty is perceived as most critical in the safety case? Are there uncertainties you can "live with"?

Participants expressed concerns about topics such as the validity of models and data, the potential for human intrusion and the value (or otherwise) of markers, the timing of glacial events and uncertainties relating to repository construction and the infamous "unknown unknowns". However, the vast majority of the uncertainties discussed related to human factors, many of them present during the development of the programme and the safety case and difficult to address quantitatively.

- Societal stability: Political instability might result in the loss of financial or organisational support for the project. Also, instability might happen at different scales: From major changes (like war) to rather "creeping" changes such as loss of knowledge and awareness related to nuclear-related issues when phasing out of a nuclear programme.
- Stability of decisions, flexibility and direction: Decisions taken now may predetermine, or rule out, future options, for example around disposal rather than reprocessing or transmutation of spent fuel ("path dependencies"). Reversibility of programmes (including, perhaps, retrievability) might be a means to address this. On the other hand, disposal programmes and associated safety cases evolve under the preposition that, for example, policy decisions and resulting boundary conditions remain relatively stable. This is not necessarily true: on the contrary, even the values on which policies are based might change over time. The question was raised to which extent "waiting" for technological evolution (and, by doing so, questioning the DGR approach) might result in an undesirable and even unwarranted increase of uncertainties.
- Evolution of technology, safety culture: The implementer may develop tunnel vision, using only the tools and approaches with which they have a developed familiarity and not taking full advantage of new available technologies. It is important to develop a safety culture as well as to strengthen the independence of the regulator in order to avoid such tunnel vision thinking.
- Evolution of knowledge: Failures in knowledge management or transfer as the safety case develops may lead to loss of knowledge about why certain decisions were made, sticking to them even when the original reasons underlying them no longer apply.

People live with comparable uncertainties in daily life. Why is this not easily transferred to geological disposal? Mathematical representations of uncertainty can be difficult to grasp: people found the presentation of worst-case scenarios and mitigating actions useful when considering uncertainties, but perceived uncertainty is also not just a function of mathematical uncertainty. It also depends on trust, aligned values and control.

Table 6 "Implementer/Regulator" – Miguel Ángel Cuñado Peralta (Spain)

What information about the safety case do you want to hear from the implementer and what do you want to hear from the regulator?

- There may be significant differences between communities. It is important to consult with local stakeholders first to find out what they want to hear, and from whom.
- There was recognition that regulators and implementer may have different areas of expertise and levels of resources. One participant expressed this as "The implementer will be one step ahead of the regulator in research, while the regulator will be one step ahead of the implementer in legislation and regulation."

From the implementer, local stakeholders expected:

Honesty, completeness, and the scientific basis for geological disposal.

This includes the provision of safety cases and assessments, a strong scientific basis underpinning these, and information that is easy to understand, presented at different levels, using accessible language and with supporting guidance on its use.

From the regulator, local stakeholders expected:

Clarity, guidelines, and monitoring and review of the implementer's work.

This includes clarity on legislation and regulations, particularly when these change, and guidance on their implementation and application to geological disposal, including taking care to make sure processes are not too rigid and adapting them when justified, review of the scientific basis presented by the implementer, and monitoring of the implementer's progress.

Both are expected to:

- have clearly defined roles, communicate these and demonstrate their competence to fulfil them;
- agree on criteria for assessments in advance wherever possible;
- clearly communicate the open questions at each stage; and
- deal with the evolution of information and adopt a learning attitude.

There was also discussion of the differing roles of the regulator and implementer in public engagement and research.

- Public engagement: There may be differences in stakeholder perceptions of regulators vs. implementers, given their differing roles and backgrounds. Local stakeholders may be more inclined to trust regulators to make impartial judgements, whereas implementers may have to work harder to earn the same level of trust. Fundamental to this is the clear demarcation of roles and the independence of the regulator. This can be facilitated by defining roles clearly, having representatives from both the implementer and regulator at public events, and having the regulator and implementer hold independent public events, at which the public can question them independently.
- Research: The large volume of research that underpins geological disposal needs to be peer reviewed by impartial experts. However, it can be difficult for experts to maintain impartiality if they are financed by the implementer. The regulator may play a more involved role in research by financing independent research. However, this can be costly, as illustrated by the example of the programme in France, where research is often carried out independently by both the regulator and implementer, extending to building and running two separate rock laboratories.

Round table 6 on the information expected from the implementer and the regulator.

Table 7 "Participation" – Rony Emmenegger (Switzerland)

The participation of the affected population (regional participation) is a central element in the site selection procedure for geological repositories in Switzerland. Does the safety case offer the possibility for the population of a siting region affected by a (future) geological repository to participate as well? Can participation inspire the required scientific research? If yes, how could this be realised?

Can the public inspire research and the safety case?

No

- The safety case is an expert domain.
- The extent to which the public as a whole can understand scientific complexity is limited.

How?

- Public engagement exists on a continuum:

  Informing » Consulting » Collaboration

- As the safety case develops, a number of decisions will be made that will increase the robustness and level of optimisation of the geological disposal solution. However, these decisions can also mean that the scope for public involvement can narrow as options close and areas for discussion become increasingly specialist.
- This can represent a structural tension between the direction in which robustness and optimisation draw the safety case, and that in which public engagement does. This can be addressed by:
  1. Training people to work as scientists so they can appreciate decisions made from a safety case viewpoint.
  2. Prompting safety case experts to raise more fundamental questions about the role of safety and risk, allowing the worldview of members of the public to shape the safety case at a more fundamental level.

Yes

- The public may have expertise and can build competence. Many local stakeholders have been through a capacity-building process through their membership in the regional conference.
- The public's diversity of expertise can provide creative insights and bring tools and learning from other areas.
- Review by a broad spectrum of stakeholders can contribute to quality control.
- Members of the public do not need a detailed in-depth understanding of all safety case domains. A desire to understand the science behind the safety case can lead them to pose critical questions that inspire further work.
- Improved scientific understanding in the community will create trust. It is difficult to achieve this level of understanding purely by informing the public about what has been done and why. Engaging with the public and collaborating with them will help build an understanding, not only of the key issues and how they are addressed, but the scientific process that underpins safety case work, through direct application. This will shape future discussions and questions raised.

Involvement of members of the public with the safety case will depend on how advanced the safety case is. It is important to keep in mind the differences between the basis of understanding from which lay people and scientists are working.

Challenges

- People will have different bases of understanding, areas and levels of interest and desire to influence the safety case.
- Differences in understanding, values and priorities (real or perceived) between scientists and wider society can lead to mutual distrust.
- There may be questions about who should participate:
  1. the people who live in the local community, as they will be directly affected; or
  2. the entire nation because the long-term management of radioactive waste is an issue that affects everyone.

5. Conclusions

Conclusions: Lucy Bailey

There has been a great diversity of backgrounds represented at this conference but a real sense of working together, shared values, respect and healthy disagreement. Engagement with the community is needed, as is collaboration between the technical and social sciences. The role that members of the public play in building the safety case must be understood.

Feedback from representatives from the siting regions

- "When we think about information, we also need to think about where it comes from – is it fake news or is it trustworthy?"
- "Uncertainty has to do with science and acquisition of knowledge, but when scientists communicate uncertainty to the public, it is often perceived as insecurity, and we need to overcome this challenge somehow. We need to treat the feeling of insecurity – we need to consider understandability: the plausibility of our scientific results, the details of scientific papers, and the models and model parameters we are using."
- "The Swedish process has opened up over the years. I am impressed by how Sweden is dealing with the problems. They are aware of and thinking about the limitations. Non-government organisations are integrated into the process and have funds available to them, siting communities are able to conduct their own reviews – it feels like a common project that everyone is working on, that is supported by society. When I read the invitation to this workshop, I had a feeling that this was a way of trying to convince us, but was pleasantly surprised to find participants were interested in what we had to say. Having learned about the Swedish example, I have the impression that it has been about finding a common solution."
- "The public needs to be able to understand and literally touch things, visiting sites underground and above ground. We need to build personal relationships between the people involved. It is not just about PowerPoint presentations – it is important to have real examples of what is being done. The questions and concerns coming from different countries seem to be similar (e.g. how can we demonstrate safety over 1 million years?). It also became clear that the expectations of members of the public and scientists are high."
- "We need to bring together the worlds of lay people and experts and then a solution will be possible."
- "With participation, it is not just about informing the people who participate but about improving trust and improving the quality of the solution."

- "I have learned many things – it is interesting how these questions are being addressed in different countries. We are being heard: people are listening to us and hearing our concerns. It has been a very good opportunity to see participation and the success of the process in action. It reminded me of the book "Mister God, This Is Anna" – we have too many answers and are not emphasising enough asking the right questions."
- "Wow, so many engaged women. We all face the same challenges, although not everyone is at the same point. Switzerland is at a good point. I hope you will take home a good impression of the Swiss procedure."

Closing remarks: Greg Lamarre

This workshop has been an excellent opportunity to build relationships between the different parties involved in geological disposal and to connect technical and non-technical viewpoints. This will be continued in the future through similar workshops.

A novel risk communication training course is to be rolled out by the NEA, not just for professional communicators, but for technical staff. It will teach attendees how to address the audience and their needs and parcel information at appropriate levels.

Stakeholder involvement workshops will continue, including the very relevant "Third Stakeholder Involvement Workshop: Optimisation in Decision-Making" in late 2023, revisiting the framework for decision making to make it more inclusive and coming up with a generic framework that can be adopted and adapted more widely.

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