

6. SITING AND LICENSING; THEME OVERVIEW

The repository site must be fit for the purpose of the construction and operation of a waste repository which is safe for time periods of up to one million years. The site must also be accepted both nationally and locally as being suitable. Three requirements must be fulfilled:

1. the constructed waste repository must be safe;
2. the stakeholders must agree to the location; and
3. it must be possible to construct and operate the repository without undue difficulty.

Siting has the goal to find and confirm the suitability of the site(s). The siting process starts with collecting existing information about potentially suitable sites broadly (on a national scale, e.g., national geological screening). Gradually the process leads to only one or a few sites to be investigated leading to a site licence when more information has been collected and evaluated and the licensing process has been successfully terminated. Licensing has also the goal to obtain the acceptance by relevant stakeholders. The site licence may also include the construction licence based on a repository concept with all the needed details for the formal decision to construct and operate the repository.

An overall plan for the entire process must be in place from the very beginning. This plan does not need to be detailed, but it must point out the important milestones and decision points and the activities needed to develop the material needed for decision-making. The level of detail will vary depending on the phase of implementation, and planning will typically focus in greater detail on the next step of siting. This plan should be a guide to the planning and execution of the on-going work and allow for flexibility to adjust to changing circumstances in the course of what could be a programme of work over many years.

The site selection procedure typically starts with large regions (possibly country-wide) and areas. Regions with, for example, high population and/or unsuitable geology could be excluded in an early stage (based on national specific screening criteria). It is important to have a broadly accepted list of disqualifying factors or screening criteria developed at a national level with decision makers as part of an open and transparent siting process. Using existing information, one or more favourable areas will be identified (for example by using data from the national geological survey and/or groups that hold and publish information about population densities and national infrastructure requirements). In case that the information basis is not sufficient to narrow down, collection of additional regional data may be necessary.

Site investigation is the activity within siting and licensing with critical importance and starts when you have arrived (on the basis of desk studies on a wider regional scale or available local information from other sources) at “one or more favourable locations”. It is through the gathered information that the entire process can be progressed towards finding and selecting the preferred site(s). Programmes typically aim for selecting one site for the disposal facility, but it cannot be guaranteed that a site will be identified with a



large enough volume of suitable rock to take the entire inventory for disposal in one place, or that they would be able to make a safety case for the entire inventory at such a site. Hence, some national programmes may result in several facilities for disposing of different waste types (see theme 1??).

Site investigation is an integral part and input to the overall disposal system development covering iterative cycles of: investigations, site evaluation, safety assessment, environmental impact, and design including developing a repository concept (in the early phase) and optimising the repository concept (during the construction and operations phase). Each one of the listed activities is linked with each other, requiring careful data, requirements, and configuration management. In this respect, site investigation needs to be carefully planned before it starts and aligned with regulatory licensing framework. The overall goal of licensing will become more focussed and evolve following the site investigation phase towards the application of the licence to construct the repository. During construction, characterisation work will continue.

KEYWORDS: site, characterisation, law, responsibility, regulation, schedule, interaction, resources, requirements, stakeholder

KEY ACRONYMS: SDM – site descriptive model; RWM – radioactive waste management; DGR – deep geological repository; WMO – waste management organisation; MS – Member State; RMS – requirements management system; WBS – work breakdown structure;

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TYPICAL SITING AND LICENSING GOALS PURSUED BY A DGR PROGRAMME

This section provides a goals breakdown structure (GBS) for the EURAD roadmap theme 6 on siting and licensing. It is organised in a hierarchy of 3 levels according to theme > sub-themes > domains. The remainder of the document describes activities according to sub-themes, which are also each further elaborated below.

Theme (Level 1)	
1. Demonstrate to regulators (and other stakeholders, incl. the public) that a properly sited disposal facility will protect people and the environment at the time of disposal and in the very long term, following closure (Siting and licensing)	
Sub-themes (Level 2)	Domains (Level 3)
6.1 Establish and implement an overall plan for the site selection process, and identify potential environments using available data (Establish site selection process and site screening)	6.1.1 Identify key decision points, and develop screening guidelines to enable a facility to be located to match national performance criteria and socio-economic, political, and environmental considerations (conceptual planning)
	6.1.2 Identify areas that may contain suitable sites by using the developed screening guidelines (area survey and site screening)
6.2 Investigate one or more sites to demonstrate that they would be suitable from the safety and other viewpoints (Site investigation and confirmation)	6.2.1 Initiate a site(s) investigation programme to obtain sufficient data to give strong assurance that the site(s) is/are likely to be suitable, based on a preliminary Safety assessment, and whether the final stage of site confirmation would be likely to result in a licence application (site investigation)
	6.2.2 Undertake detailed site(s) investigation, confirmation of the site, through a complete safety assessment, and preparation of an environmental impact assessment to the level required for construction and operational licence application submission (detailed site characterisation and site confirmation)
6.3 Obtain the necessary land use permits and nuclear licences to start implementation of the disposal facility (Permits and licensing)	6.3.1 Engage effectively with local government / regulators / consultative bodies / waste producers and the local population by providing open access to information to meet land use planning requirements (Local land use planning).
	6.3.2 Adhere to the licensing process set by national legislation and regulatory bodies (for nuclear installations) and meet the requirements relating to facility authorization (Regulatory licensing)

The GBS for theme 6 on siting and licensing is grouped into 3 sub-themes. The first sub-theme on the site selection process (6.1) starts with agreeing a process and identifying candidate areas on a broad basis, principally by excluding alternatives that are seen to be clearly unsuitable. The result from 6.1 completes following the screening from many to one or several sites that are taken forward for site investigation (6.2) first on the basis of an initial survey using existing information (together with appropriate evaluation criteria) and subsequently by deciding to focus detailed investigations at a limited number of preferred candidate sites. The result from 6.2 is the completion of detailed site characterisation and site

confirmation which is needed for licensing in 6.3. The GBS for siting and licensing in the EURAD roadmap broadly corresponds to the “main stages in a siting process” illustrated below in Figure 1 reproduced from the IAEA.

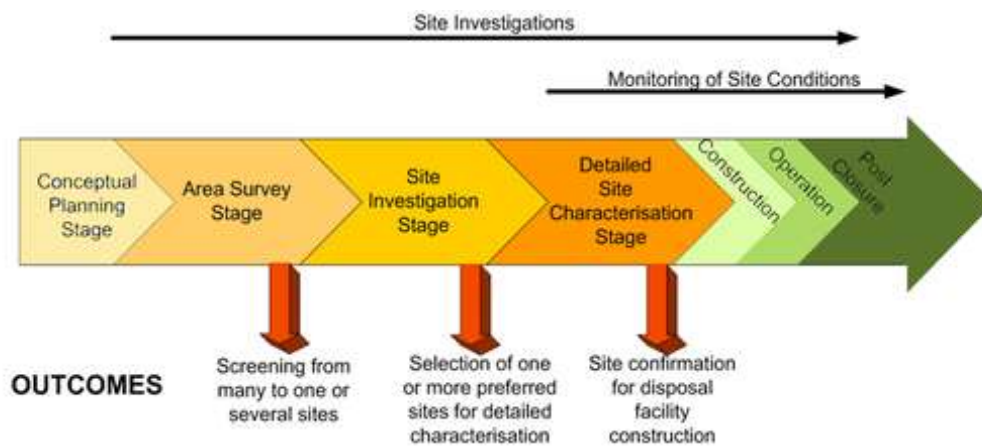


Figure 1: Reproduced from IAEA “*The Management of Site Investigations for Radioactive Waste Disposal Facilities*” (In-press 2022). Light yellow arrows = 6.1 Site Selection Process; Orange arrows = 6.2 Site Investigation; and Green arrows = 6.3 Licensing.

To support effective programme implementation, the main phases of (I) conceptual planning, (II) area survey and site screening, (III) site investigation and (IV) detailed site characterisation and confirmation, should be further broken down into smaller steps. Stepwise execution provides better opportunities for a site-adapted investigation methodology and enables more effective feedback from ongoing evaluation. In such a process, each new step consists of confirming or rejecting the main results of the preceding step, answering any new questions that have come up and achieving the goals set for the particular stage. Each step builds further on the description that emerged from the preceding investigation step. In each step, all disciplines interact in the planning of the investigations and the evaluation of results.

Establish and implement an overall plan for the site selection process, and identify potential environments using available data (Site selection process and site screening)

- Site selection policies and procedures, regulatory arrangements and licensing requirements vary between member states, reflecting inter alia the legal framework, socio-political context, geological and geographic factors, and the waste inventory. The generic approach illustrated above, as set out by the IAEA (2021), starts first with conceptual planning of the process, followed by area survey to screen from many to one or several siting regions of interest. The NDA also published an international review of siting processes internationally (NDA, 2017).
- The site selection activities must be broad, complete and transparent. It must provide information to all kinds of stakeholders and create knowledge for them to be able to be part of the repository development program (for example, see: The Aarhus Convention obliges states and grants the public rights in three areas of the convention: access to information, public participation in decision-making and access to justice in environmental matters in accordance with the provisions of the Convention). Thus, the site selection activities are often also the start of interaction with the relevant stakeholders

and may include licensing activities (see also Roadmap Domain 1.1.3 on Public information and Participation).

- Investigations within the initiation survey and site screening should be limited to collection of existing information on a national scale. Additional investigations should only be conducted to obtain some key data for identifying potential specific area/site.

Investigate one or more sites to demonstrate that they would be suitable from the safety and other viewpoints (Site investigation and confirmation)

- The purpose of the site investigation is to collect all relevant information from the site(s) that is needed for assessment of the long-term safety and for assessment of feasible design and construction of a waste repository leading to site confirmation. The focus in the early stage of site investigation is on finding/identifying sites of suitable size to accommodate the repository within a large area in which there might be several sites of interest. It is also necessary to make the prioritization of possible sites. Available information from available sources such as geological maps, records from underground projects etc shall be systematically investigated. When one or a few potentially suitable sites are identified there is a need to confirm their suitability by drilling to repository depth at a few locations in the site(s), mainly to confirm the volume of good rock. After that it is possible to make the priority for one site for complete investigation.
- The contents of the detailed site investigation need to be carefully planned in advance of the execution. In URL-experiments (normally off-site RD&D URL), significant technology developments have been made (testing tools, sensors, etc.) that are essential for underground testing at repository sites.
- Detailed site characterisation (exploration of geometrical aspects, rock layers, structures, and characterisation of key rock properties), acquiring site parameters through the use of geophysical techniques, hydraulic, geochemical and geophysical measurements in boreholes and seismic investigations will contribute to the building of a more detailed site descriptive model of the candidate sites and ultimately to the selection of a preferred site.
- Site characterisation efforts are directed towards collecting the necessary data to a level of detail that is sufficient to provide a description of the site in support of both the design of the facility and the assessment of long-term safety. At this stage the interaction with the site descriptive model (SDM) team is most intensive and important (see more in Theme 4 on Geoscience, Domain 4.1.1 Site Descriptive Model). The SDM-team has a continuous interaction with the design and the safety assessment teams.
- Following selection and early licensing of the selected site, underground testing will be required as part of its subsequent development to allow detailed in-situ confirmation (and/or refinement) of some of the critical data on rock properties and state parameters before and during the construction of the repository (for example to check that excavated rock areas intended for disposal meet with the developed rock suitability criteria (RSC), see Roadmap Theme 4 on Geoscience for more details on RSC).

Obtain the necessary land use permits and nuclear licences to start implementation of the disposal facility (Permits and licensing)

- Licensing is governed by the national legislation. The national policy towards DGR siting and the established siting process (1.3.1) will set out clearly the roles and responsibilities of the different organisations. In many countries, licensing is a government or parliamentary decision, advised by the appropriate regulatory body after examination of the licence application. In some countries, the national nuclear regulatory authority will take the leading role. Appropriate forms of communication

between the appointed authorities (which may be on a national and local/region level) and the prospective licensee are important.

- Prior to nuclear licensing, if the repository is considered a major infrastructure project, it will require examination (and potentially separately licensing) from the perspective of environmental legislation and land use planning consents.
- The licensing activities will input to and connect with work undertaken on communications and community engagement (see also Roadmap Domain 1.1.3 on Public information and Participation). The longer the DGR project continues, the more local residents will be engaged in it and evidently the local residents might become a strong supporter for the location of the DGR. The level of community engagement, and ultimately the willingness of a community to host a DGR is a fundamental requirement that needs to be satisfied

References

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RWM (2017), Geological Disposal: Overview of International Siting Processes 2017, NDA Report NDA/RWM/157, UK, (2017).

SITING AND LICENSING ACTIVITIES OVER DIFFERENT PHASES OF IMPLEMENTATION

Siting and licensing activities during DGR Programme Initiation (Phase 1)

Programme Implementation (integrated actions in theme 6 on siting and licensing linked to wider programme activities)

- Regulators should start developing applicable regulatory requirements in accordance with well-accepted international bases and initiate interactions with the WMO (*See, 1.2.1 Licensing Framework, 1.2.2 Licensing Criteria*). This will be linked to the work to establish a national policy on siting (*See, 1.1.1 National RWM Policy*).
- Both WMO and regulator should identify relevant stakeholders who are external to statutory legal and regulatory interactions and initiate a dialogue on the procedures and ground-rules for stakeholder interactions (*See, 1.1.3 Public information and participation*).

Establish the site selection process and prepare for site screening

- Establish national stepwise decision making process (and criteria) on how to identify potential geological regions and select a site to host the facility. The actors leading and involved in this process will vary depending on the national preferences.
- Determine initial list of potential siting issues of concern to national authorities and officials. Again, this will be a national specific list of issues, but it is worth reviewing the significant issues encountered and lessons learned from the early phases of advanced programmes when establishing their national site selection process. A typical example is whether voluntary engagement in the siting process and community veto is important? Or if geological screening (a nomination approach) is carried out at a national level prior to a volunteer approach. Another is the definition of benefits associated with a DGR or establishing within the process at what stage they will be defined. The benefits which are made available to potential host communities vary from country to country in their approach, scope, amount and when they become available.
- The list of siting issues must not be too detailed, and the issues should be monitored and if required, the siting approach modified depending on how the process proceeds, e.g., a voluntary process needs a large freedom to be able to keep an open communication with all involved parties.

Prepare for site investigation and confirmation

- In the DGR programme initiation phase there is no anticipated detailed site investigation activities envisaged.,
- Start to collect information on national geology and regional seismicity for understanding potential geological options (see for example SKB, 2000) in readiness for the next phase of implementation when the site selection process will start to be implemented and site screening (or area surveys) will start.
- Survey and update site investigations and characterisation methods and tools, e.g., latest state of the art in readiness for commissioning or undertaking any necessary non-intrusive geophysical surveys in the next phase of implementation.

Understand national requirements for permits and licensing

- Start to build capability of a team in the context of future predicted needs based on the known (or establishing) regulatory and licensing environment for a DGR. Develop an understanding of the base position with respect to needed knowledge, capability and range / extent of Permit and Consents which will need to be secured through the siting process.

References

SKB (2000), Geoscientific programme for investigation and evaluation of sites for the deep repository, Technical Report TR-00-20, Svensk Karnbranslehantering AB August 2000, https://inis.iaea.org/search/search.aspx?orig_q=RN:32011858

IAEA (2007), Factors affecting public and political acceptance for the implementation of geological disposal IAEA-TECDOC-1566 (2007).

Siting and licensing activities during DGR site identification and selection (Phase 2)

Programme implementation (integrated actions in theme 6 on siting and licensing linked to wider programme activities)

- Align site identification and selection activities with the overall waste management plan (*See, Sub-theme 1.2 Programme Planning*).
- Integrate requirements for site identification within the overall RMS to allow early iterative feedback from the initial assessment of key design and safety aspects from Phase 1 as part of the iterative development of the disposal system (*See, 5.1.1 Design Specification*).
- The WMO, regulator and other stakeholders, should identify and agree the activities involved in the different steps in the site identification, site investigation and final site selection (*See also, 1.2.3 Allocate Responsibilities*). *The established site selection process in Phase will most likely include a form of stakeholder mapping in relation to different types of decision will enable continued dialogue with relevant stakeholders to explore their concerns and to solicit their input to the site selection process (See, 1.1.3 Public information and participation).*
- WMO to carry out the activities and produce the documented evidence needed (for example, preliminary environmental impact assessment, preliminary safety assessment and design concept) for permit and licence requirements as established in the site selection process in Phase 1. As a general rule, some kind of formal (nuclear) regulator acknowledgement or confirmation that it does not appear to be an unsuitable place will probably be appropriate (as part of the national arrangements for the siting process). However, the permits required to start site investigation will typically not be part of the nuclear regulator remit and a separate submission and engagement on these with the appointed authorities will be required, leading to any requisite approvals to move to the next phase of work (See 1.2.1 Licensing framework, 7.2.1 Safety case production).

Implement the site selection process and complete site screening

- Complete area surveys to identify potential geological regions and areas suitable for detailed investigations (see for example, SKB 2000a).
- Update the initial list of potential issues of concern to local/regional authorities and officials (as established in Phase 1). It is also critical to be able to respond to the issues that are important to the

stakeholders and communities that engage in the siting process, e.g., local infrastructure and other impact from the surface facilities, (see SKB 2001 Ch. 8).

- It is good practice is to work collaboratively with communities to understand what is important to them and feed this into DGR and surface facility assessments and evaluations.

Initiate site investigation and site confirmation

- Up until the beginning of site characterisation, it is anticipated that most of the information being evaluated (both existing and newly-commissioned surface based surveys) will be focused on the surface areas or sites, with sub-surface information limited to existing desk-based information such as that provided through the National Geological Survey, local geological knowledge and geological memoirs or potentially newly-commissioned nonintrusive geophysical surveys.
- Update conceptual models (e.g., the site descriptive model) in potential host regions for geology, hydrogeology, hydrogeochemistry and geotechnical properties (See, 4.1.1 Site descriptive model) and develop preliminary conceptual model for the biosphere: release mechanisms and exposure pathways (See, 4.1.3 Biosphere model).
- Survey and update site investigations and characterisation methods and tools and capacity build in readiness for procurement and/or implementing extensive underground investigations as part of the next Site Characterization Phase.
- Depending on the national site selection process there might need to be some form of site confirmation or a major decision step (perhaps by government or parliament) first, effectively identifying the chosen site(s) to be taken forward for detailed site characterisation.

Apply for permits and prepare for licensing

- Assemble and submit the permits (e.g., environmental permit and mining permit) relevant for site investigations in the site characterisation phase. Such permits will ensure compliance with relevant occupational, safety, and health regulations, and environmental regulations.
- If necessary and based on what is specified in the established site selection process, engage with the nuclear regulator on any preliminary assessments that are completed prior to the commencement of site-specific underground investigations. Typically, site characterisation is not part of a process carried out under a licence issued by the nuclear regulatory authority. The nuclear regulatory body may be given the authority (through specific legislation or Government instruction relating to site selection) to follow the process, and in some countries may require a specific licence.

▼ References

SKB (2000b), What requirements does the KBS-3 repository make on the host rock? Geoscientific suitability indicators and criteria for siting and site evaluation, SKB Report TR-00-12, Sweden, 2000.

SKB 2001, Integrated account of method, site selection and programme prior to the site investigation phase SKB Technical Report TR-03-01 , Sweden 2001

Siting and licensing activities during DGR site characterisation (Phase 3)

Programme implementation (integrated actions in theme 6 on siting and licensing linked to wider programme activities)

- WMO implements the programme for DGR site investigation, final site selection and further repository concept development, leading to a construction licence application (*See, 1.5.2 Options and Concept Selection, 6 Design*).
- WMO to develop repository designs adapted to the site(s) (*See, 5 Design*).
- Waste producers and WMO to develop agreed approach to pre-disposal management of wastes to ensure eventual disposability in the emerging DGR design (*See, 2.2 Disposability Management*)
- WMO to develop a safety case supporting the construction licence (*See, 7 Safety Case*).
- WMO to develop (and agree with the regulatory agencies) plans for the qualification and quality control needed to ensure that the repository construction of the manufacturing of the EBS meet with specified requirements (*See, 5.2 Constructability, demonstration and verification testing*).
- WMO to develop (and engage with the regulatory agencies) on a monitoring programme to be applied during the construction and operational phases, considering health, operational and post closure nuclear safety and environmental aspects (*See, 5.5.2 Monitoring during construction and operations*).
- Finalise requirements for site suitability confirmation, linking closely with the site descriptive model (*See, 4.1.1 Site descriptive model*) and the established site-specific safety assessment and design (*See, 5.1.1 Design specification and 7.3.1 Performance assessment and system models*).

Complete the site selection process

- WMO to make their site selection and apply for a facility licence/government decision to have it confirmed. Not all regulatory regimes group together site confirmation and repository construction in the same decision. This was not the case, for example, at Olkiluoto (or, for that matter, Yucca Mountain). Government approval for site selection in the Finnish case (based on a reference design) enabled the underground characterisation and other experimental facilities to be constructed, but no nuclear construction licence was given.
- Update and select repository design option(s) relevant to selected site(s) and update list of key site properties affecting safety for this/these option(s).
- Update list of potential issues of concern to local/regional authorities and officials.

Perform detailed site investigation

- Conduct site characterisation to acquire site-specific geological information for construction licence.
- Survey and update site investigations and characterisation methods and tools in readiness for further investigations that may take place during the construction phase.
- Communicate with the local residents about the outcome of investigations and plans for the further investigations required in the next phase of implementation.

Obtain a licence for construction of the DGR

- Assemble and submit the nuclear licence application for construction.
- Assemble and submit the environmental impact assessment (EIA) for construction, which is usually prepared first as part of the initial land use permit submission where public consultation is typical.
- Regulatory agencies and/or higher authority e.g., Government (depending on the national legislative framework) to receive construction licence application, review and, if approved, issue a licence, with any conditions considered necessary.

- Continue the dialogue between WMO, regulatory agencies and other relevant stakeholders to explore stakeholders concerns and to solicit their input to the licensing process.
- Obtain permits relevant for construction.

References

SKB (2021), SKB Construction Licence Application, <https://www.skb.com/future-projects/the-spent-fuel-repository/our-applications/>

Intera (2006), Intera Engineering Ltd, Geoscientific Site Characterization Plan DGR - Bruce Nuclear Site. OPG Report No. 00216-REP-03902-00002-R00. Canada (2006).

Siting and licensing activities during DGR construction (Phase 4)

Programme implementation (integrated actions in theme 6 on siting and licensing linked to wider programme activities)

- WMO to carry out the DGR construction and prepare for repository operation, including any test and demonstration activities considered necessary.
- WMO to update the RMS for the DGR based on the knowledge gained from the assessment of key Design and Safety aspects from Phase 3 (See, 5.1.1 *Design specification*).
- Finalise repository design, including the engineered barrier and waste emplacement systems, and further adapt it to the site conditions found as construction progresses. This further design development would be especially important if the repository operational phase includes further construction of the repository (See, 5 Design).
- WMO to implement the underground monitoring programme agreed at the time of approval of the construction licence, in Phase 3, and further update it to cover monitoring needs during the operational phase (See, 5.1.1 *Baseline Monitoring*, 5.5.2 *Monitoring during construction and operations*).

Complete site investigation and confirmation

- Complete detailed geological investigations at the selected site for operational licence and update site descriptive models.
- Update and agree action plans / management strategies for any remaining issues of concern to local/regional authorities and officials for the industrial phase of operations.
- Survey and update site investigations and characterisation methods and tools to learn about any advances that might have benefit or optimise envisaged processes for ongoing site investigation that will have during operations.

Obtain a licence for operation of a DGR.

- Assemble and submit the nuclear licence application for operation.
- Obtain permits relevant for operation.

References

POSIVA, 2017, Safety Case Plan for the Operating Licence Application , POSIVA Report 2017-2, Posiva Oy.

Siting and licensing activities during DGR operations & closure (Phase 5)

Programme implementation (integrated actions in theme 6 on siting and licensing linked to wider programme activities)

- WMO to carry out the DGR operation including deposition activities and further underground construction in a quality-controlled manner (See, 5.2 Constructability, demonstration and verification testing).
- WMO to update the RMS on a regular basis considering experiences from the operation and repeated safety assessments (See, 5.1.1 Design specification).
- WMO to revise repository design specifications, based on updates to the RMS, if judged necessary or beneficial (See, 5.1 Design).
- WMO and regulatory agencies to agree and WMO to implement the monitoring programme for the operational phase and update when judged needed (See, 5.5.2 Monitoring during Construction and Operations).
- WMO to update the safety case periodically and in accordance with any stipulations in the operational licence (See, 7 Safety Case).

Ongoing site investigation

- Throughout the operational phase (e.g. in conjunction with enlarging the facility), ongoing site characterisation will continue to make periodic update to site descriptive model in readiness for the closure licence.
- Continue constructive dialogue on issues of concern to local/regional authorities and officials for the industrial phase of operations.

Maintain the operational licence and obtain a licence for closure of the DGR

- Towards the completion of the operational phase, assemble and submit the nuclear licence application for closure.
- Obtain permits relevant for closure.
- Assemble and submit the environmental impact assessment for closure.
- If required, obtain permits relevant for post-closure monitoring surveillance.
- As set out in the regulatory framework, the Regulator and/or national authorities and officials to review and agree proposals from WMO for closure and any post-closure actions, and issue closure licence.
- A “licence for closure” would typically have a series of conditions attached (possibly including post-closure monitoring) and that, once the conditions were shown to be fulfilled, this would enable the licence to be withdrawn. In Sweden, prior to repository closure, the final safety assessment must be renewed and subjected to a safety review in accordance with regulations. Once such conditions are fulfilled, the licence can be withdrawn (official termination of the nuclear facility).

AVAILABLE CAPABILITIES: STATUS AND OUTLOOK

This section describes programme capability needs (including infrastructure) that are required to successfully complete the activities and actions recommended to achieve generic goals on siting and licensing.

Knowledge and understanding

For the establishment of the siting and licensing programme, special attention must be given to:

- Disposal of nuclear waste in a deep geological repository is an unusual underground construction issue. Within the programme management there are needs for an understanding of the special (additional) concerns that have to be addressed when undertaking the rock excavation work.
- Nuclear facility operational procedures have to be considered early during the planning of the construction of the disposal facility. Development of the appropriate safety culture and organisational structure is necessary to prepare for when the DGR programme management switches from prospective licensee (pre-construction phase) to licensee (in the construction phase and the operational phase) when the programme and facility operations are formally subject to nuclear regulation.
- During the early phases of siting, when the scientific basis and safety case for the facility are being established, the programme is typically driven by an applied science methodology. Once the programme moves into an industrial phase, with a mature safety case and detailed site-adapted design, the programme becomes implementation driven, with execution aligned to standardized procedures and industrial processes.
- The long-term safety assessment (assessment of safety after closure of the waste facility) is different from the operational safety assessments of other nuclear facilities mainly because there are no means to mitigate any erroneous functions. Therefore, the safety case (the description of what makes the repository safe) must be well developed/presented and understood by the programme management team on an individual basis. Strong scientific leadership is essential throughout all programme phases.

Although the majority of work on siting and licensing will take place in the DGR phases up to operations, as the overall programme is likely to run over more than one decennium, persons with core capability will need to be exchanged by new persons with competence in siting and licensing (See, 7.2.2. Information, Data, and Knowledge Management, and 1.3.2 Skills and Competence Management).

Experts and practical skills

Regarding implementation of technical activities, as suggested by the IAEA (2021), a prerequisite in advanced site investigations will be a management decision about whether the programme management undertakes all or the majority of the site investigations based on an in-house capability and capacity to carry out the work (i.e., large workforce of specialist employees), or a small team of in-house technical managers who procure the services of external contractors and consultants commissioned to carry out the work required. IAEA (In-press 2021) describes the benefits and disadvantages of both options and the expertise and illustrative organograms for the team through the 4 stages of a siting programme, focussing on five discipline areas:

- Geology
- Hydrogeology
- Hydrochemistry
- Geotechnics
- Biosphere studies

Many waste disposal programmes have recently started DGR siting programmes within and outside of the EU. For these programmes there is experience and skill to be obtained from programmes that have successfully sited a DGR, completed site characterisation, and have experience of obtaining the necessary permits and licences needed for the facility. Such programmes have a retiring workforce and are in a very different stage of programme implementation, which can mean the skills that the newly started programmes would need, is no longer available within the old programmes. This is a knowledge management issue common to the nuclear industry, and not specific to the theme of siting and licensing.

Equipment, tools and technology

Site investigations require careful design and differ substantially from standardised geological prospecting activities. Due to the relatively large costs involved, programme management should not consider the investigation activities as “off the shelf” matters that can be requested from many deliveries strictly on a commercial basis. Critical technology capability is (i) data and information management; (ii) non-intrusive data acquisition tools and techniques and (iii) intrusive data acquisition tools and techniques (see, IAEA In-press 2021, Sections 4.2.7, 6.3 and 6.4 respectively) which comprehensively describe programme capability needs and options for:

- Remote sensing
- Surface-based geophysics
- Surface mapping and walk-over surveys
- Borehole drilling
- Downhole geophysical logging
- Hydrogeological testing
- Groundwater pressure monitoring
- Rock, water and gas sampling

Laboratories and centres of excellence

Laboratories capable of carrying out the required tests and analysis should be identified well in advance of sample collection in the field, and in some circumstances (e.g., where analysis of environmental isotopes will be required), specialist laboratory testing and analysis may not be possible using nationally available resources due to a lack of experience or equipment (for more, see, IAEA in-press 2021, Section 6.5).

Industrial Facilities and Manufacturing

Programmes may choose to utilise or construct underground research laboratories to provide in situ data and information on the subsurface environment on a significantly larger scale than can be obtained from an individual borehole (for more, see IAEA in press 2021, Section 6.6).

Contractors and Human/Material Resources

A cross-functional team of human resources is needed to deliver the siting and licensing programme of a DGR. This can comprise a combination of generalist skills/capabilities on the market, combined with more specialist skills that may need to be developed and maintained by the scientific community to address specific issues where uncertainty exists. A good communication between the safety assessment and the scientific community should be based on a long-lasting cooperation. Procedures for construction and infrastructure can be applied through consultancy services by national and international companies. Close cooperation should be established with geo-technical, -scientific consultants with experience from deep underground investigations, and with experience from repository or research facility construction.

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