Technical Report No.: 112/2017

DGR DEVELOPMENT IN THE CZECH REPUBLIC

ACTION PLAN 2017-2025

Created by:

Ivan Prachar, Ilona Pospiskova,

Antonin Vokal, Lucie Steinerova,

Lukas Vondrovic

Reviewed by:

Juhani Vira, Peter Wikberg,

Kimmo Lehto, Timo Seppälä,

Mika Pohjonen

Prague, May 2017

SÚRAO

Project Name: Research support for the safety assessment of a deep geological repository

Report Name:

DGR Development in the Czech Republic

Action Plan 2017-2025

Internal SURAO number: SO2017-112

Authors:

Ivan Prachar[2], Ilona Pospiskova[1], Antonin Vokal[1], Lucie Steinerova[1], Lukas Vondrovic[1]

Reviewed by:

Juhani Vira[3], Peter Wikberg[4], Kimmo Lehto[3], Timo Seppälä[3], Mika Pohjonen[3]

Investigating institution:

SÚRAO [1], Independent expert [2], Posiva Oy [3], SKB [4]

Content

List of figures:

List of tables:

Abbreviations:

DFN	discrete fracture network
DGR	deep geological repository
EDU	Dukovany nuclear power plant
EBS	engineered barrier system
EIA	Environmental Impact Assessment
ETE	Temelin nuclear power plant
EU	European Union
GIS	geographic information system
HM	heavy metal
IAEA	International Atomic Energy Agency
ISR	Initial Safety Report
L/ILW	low- / intermediate-level waste
HLW	high-level waste
OECD/NEA	Organisation for Economic Co-operation and Development/Nuclear Energy Agency
PSR	Periodic Safety Review
RAW	radioactive waste
R&C	requirements and criteria
SNF	spent nuclear fuel
SÚJB	State Office for Nuclear Safety
SÚRAO	Radioactive Waste Repository Authority
WENRA	Western European Nuclear Regulators Association

Terms:

Initial Safety Report	The key documentation required for obtaining a licence for the siting of a nuclear installation according to Act No. 263/2016 Coll., the Atomic Act (requirements relating to the content of the documentation is provided in § 20 of Decree No. 378/2016 Coll. on the siting of nuclear installations)
Safety Case	Documentation according to IAEA SSG-23, the Safety Case and Safety Assessment for the Disposal of Radioactive Waste
Safety Assessment	An integral part of the safety case, which prioritises the systematic assessment of radiation hazards

1 Introduction

1.1 The purpose of the Strategic Action Plan

This Strategic Action Plan establishes the policy framework for the siting of the DGR as well as for the management of SNF and long-lived L/ILW in the Czech Republic. The plan covers the site selection strategy during the period in which SÚRAO´s primary aim will be to reduce the number of candidate sites initially from 9 to 4 and, subsequently, from 4 to the final and alternative sites.

Based on the results of previous geo-research, six potential sites were prioritised (Brezovy potok, Certovka, Cihadlo, Magdalena, Hradek and Horka). Since public opinion at these sites was not overwhelmingly positive, exploration activities were also launched at the Kravi hora site (which is located close to a former uranium mining facility).

The same reason formed the basis for the decision to commence geo-research activities in the vicinity of the Dukovany and Temelin nuclear power plants, so as to provide additional potential sites.

The main objective of the activities outlined in the Plan consists of the selection of potentially suitable sites for the construction of the deep geological repository (DGR), including their mutual comparison and selection according to safety, environmental and technical feasibility criteria. It is planned that the various activities will be conducted in cooperation with the local communities concerned in order to both reach consensus and to strengthen the overall level of public acceptance.

1.2 Background

Based on Council Directive 2011/70/EURATOM and previous primary documentation, the State is responsible for the safety of spent fuel and radioactive waste management. In compliance with the terms of the Atomic Act, as amended by Article 26 of Act No. 18/1997 Coll. (the previous version of the Atomic Act), the Radioactive Waste Repository Authority (SÚRAO) was established on 1 June 1997 as a government administrative body.

Aimed at meeting this responsibility, the Government of the Czech Republic initially approved the “Report on the adequacy of disposal capacity for spent nuclear fuel (SNF) and on the procedure for the selection of a final deep repository” (see Resolution of the Government of the Czech Republic No. 695 adopted on 9 July 2001). Subsequently, the “Concept for RAW and SNF Management in the Czech Republic” was approved by the

Government on 15 May 2002, by means of Decision No. 487/2002. The Concept declared that the basic strategy of the Czech Republic consisted of the direct disposal of SNF in a deep geological repository, the commissioning of which was set for 2065. Up to that time, SNF and RAW which were not acceptable for disposal in near-surface repositories would be safely stored by producers. The Concept further set out that the safety of the future deep geological repository must be confirmed prior to the commencement of construction by means of the conducting of long-term experiments in an underground laboratory and that the research of advanced SNF reprocessing technologies and techniques leading to the reduction of the volume of waste to be disposed of in the deep geological repository would be fully supported.

The Concept makes it clear that direct SNF disposal in a DGR represented the baseline conceptual option as far as the Czech Republic was concerned. However, the following two options were not expressly rejected: (1) the reprocessing of SNF abroad and the disposal of the residual waste in a deep geological repository in the Czech Republic and (2) the disposal of SNF/HLW in an international or regional repository. Moreover, the "zero option" of the long-term storage of SNF was not ruled out.

These aims remain the same up to the present day, as confirmed by the "Update of the Concept of Radioactive Waste and Spent Nuclear Fuel Management" which was published in November 2014. The updated Concept is based on the current situation concerning low-level and intermediate-level radioactive waste management, the development of a deep geological repository for RAW and SNF disposal, legislative changes, Government programming documents and international experience and trends. The updating of the Concept was further motivated by preparations for the construction of new nuclear units in the Czech Republic, legislative developments within the EU and IAEA, and OECD/NEA recommendations.

The Concept assumes that the site selection process will be conducted in several stages during which the number of sites and the surface areas thereof will be gradually reduced (see Table 1). In each stage, the suitability of the selected sites will be summarised in the form of a number of documents which will be structured in compliance with the requirements of the State authorities to which the documentation will finally be submitted (the State Office for Nuclear Safety (SÚJB), the Building Authority, the Czech Mining Office and the Ministry of the Environment). While different degrees of knowledge are assumed at each level, the overriding aim is to provide that information required by the various authorities which best addresses their concerns and responsibilities.
The involvement of the municipalities directly concerned as well as other stakeholders will be fully taken into account during the site selection process.

Table 1 Presumed timetable for the development, construction and operation of the deep geological repository *(Update of the Concept of Radioactive Waste and Spent Nuclear Fuel Management)*

Activity	Year
Research studies aimed at finding further potentially suitable DGR sites including the revision of studies performed prior to 2002	2016
Selection of two candidate sites based on the preliminary characterisation of the sites, including the position of the communities concerned	2020
Selection of the final site including the position of the communities concerned and the submission of an application for land protection at the selected site	2025
Commencement of the EIA procedure for the construction of an underground laboratory at the final site	2026
Submission of an application for planning permission for the underground laboratory at the final site	2028
Commencement of the EIA procedure for DGR construction	2035
Submission of documentation for DGR planning permission to all the institutions concerned including the SÚJB (Initial Safety Report)	2040
Submission of documentation for the granting of building permission	2045
Deep geological repository construction (including the first disposal section) and the drafting of documentation for the commencement of operation	2050–2064
Drafting of documentation for DGR operation authorisation, decision issuance	2063–2065
Commencement of deep geological repository operation	2065

A statement contained in the State Energy Policy of the Czech Republic is of particular importance with respect to the siting of the future DGR in that it confirms the responsibility to “select sites for final spent nuclear fuel repositories and to submit them to the government for its decision” (See point m) of Chapter 6.2 - Instruments in the area of state administration). Once the Government approves the final decision, the siting process will be successfully concluded.

1.3 Legal framework and responsibilities

1.3.1 Legal framework

The primary legal framework with respect to the Strategic Action Plan consists of that enshrined in Council Directive 2009/71/EURATOM which established a Community framework for the nuclear safety of nuclear installations. The Directive confirmed a fundamental principle, namely the national responsibility of Member States for the nuclear safety of nuclear installations (see Article 8 of the Directive). The Council Directive follows especially IAEA standard SF-1 and the Convention on Nuclear Safety which came into force on 24 October 1996.

The first ethical and environmental principles of the management of spent fuel and radioactive waste were introduced by the Nuclear Energy Agency (NEA) in 1995 and referred to IAEA standard 111-F. Two years later, the IAEA adopted the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. Currently, the field of nuclear safety is governed by Council Directive 2011/70/EURATOM of 19 July 2011 which established a Community framework for the responsible and safe management of spent fuel and radioactive waste. The Directive reaffirmed the ultimate responsibility of Member States for the safety of spent fuel and radioactive waste management.

Both Directives, *inter alia*, were incorporated into the amended Atomic Act, which came into force on 1 January 2017. Notably, the siting process currently adheres to regulations set out in the rules of State Office for Nuclear Safety (SÚJB) Decree No. 378/2016 Coll. of 7 November 2016 on the siting of nuclear installations.

In addition, the relevant IAEA and WENRA documentation contains a large number of principal requirements and rules. Two basic standards, SSR-5 and SSG-14, were published by the IAEA in 2011 followed by IAEA standard NS-R-3 (Rev. 1) published in 2016. WENRA published a document entitled “Radioactive waste disposal facility safety reference levels” in December 2014. And, finally, basic requirements referring to radiation protection are summarised in IAEA standard GRS Part 3 “Radiation protection and the safety of radiation sources”.

All the above-mentioned standards and documents focused strictly on nuclear safety considerations; nevertheless, the fundamental ethical principle governing the siting process is set out in par. 1.30 of IAEA standard SSR-5, which states that the “fundamental safety objective is to protect people and the environment from the harmful effects of ionising radiation”. This is to be achieved via the establishment of strict requirements concerning site selection and evaluation and the design, construction,

operation and closure of disposal facilities, including organisational and regulatory considerations.

1.3.2 The Czech regulatory framework

According to Czech legislation, the future deep geological repository is considered to be a nuclear installation (see § 3, para (2), e) of Act No. 263/2016 Coll.). Therefore, Czech regulations are subordinate to the Atomic Act (Act No. 263/2016 Coll.) as well as international conventions and EU legislation related to the nuclear safety of nuclear installations and the responsible and safe management of spent nuclear fuel and radioactive waste, and IAEA and OECD/NEA standards and guidelines which refer to the siting process. State Office for Nuclear Safety Decree No. 378/2016 Coll. came into force on 1 January 2017.

In addition, underground disposal facilities in the Czech Republic are classified according to the Mining Act (Act. No. 44/1988, § 34, on the protection and use of mineral deposits) as special interventions into the Earth's crust. According to paragraphs of the Mining Act § 11 and § 16, the search for investigation of mineral deposits and the issuance of protection status for areas containing mineral deposits require an application for special intervention into the Earth's crust; these conditions apply to underground radioactive waste repositories.

Finally, requirements issuing from the Environmental Impact Assessment (EIA) Act (Act No.100/2001 Coll.) must also be fulfilled. Following the selection of the final site, the EIA procedure will commence in accordance with the above Act; this will be followed by the submission of documentation concerning planning permission for the DGR.

1.3.3 SÚRAO´s responsibility

According to Czech legislation, SÚRAO is responsible for the disposal of spent nuclear fuel and radioactive waste including the development of a deep geological repository in the Czech Republic.

The Update of the Concept of Radioactive Waste and Spent Nuclear Fuel Management obliges SÚRAO to select the final site for the construction of the DGR by 2025. In the period 2017 – 2025, SÚRAO will work towards both gradually reducing the number of candidate sites and selecting the final site.

1.4 Inventory

The disposal inventory is of particular importance and has a considerable influence on the deep geological disposal concept in terms both of its amount and form. The Czech Concept of RAW and SNF Management considers several options in this respect:

- Zero option (the long-term storage of SNF);
- Direct SNF disposal in a deep geological repository located in the Czech Republic;
- SNF reprocessing abroad followed by the disposal of the residual waste in a deep geological repository located in the Czech Republic.
- SNF/HLW disposal in an international or regional repository.

Direct SNF disposal within the country of origin is the preferred option with respect to the back-end of the fuel cycle. The estimation of the inventory is based on the following boundary conditions:

- The open fuel cycle is presumed in compliance with the Concept of RAW and SNF Management.
- The calculations include spent nuclear fuel from both existing operational nuclear installations (EDU1-4; ETE1,2) and that expected from the assumed construction of new nuclear power plants (EDU5, ETE3,4).
- The operational time of both current and planned NPPs is assumed to be 60 years.
- SNF and those types of RAW which do not meet acceptability conditions in terms of parameter requirements for disposal in existing RAW repositories will be disposed of in the future DGR.

Under such assumptions, the total inventory will amount to approximately 9,500 tonnes of HM and approximately 5,000 tonnes of radioactive waste which cannot be accepted by near-surface repositories.

The estimation of the radionuclide composition of the disposed of inventory will be subject to revision over the course of time. Those radionuclides which could have an impact on the environment during the DGR operational period include H-3, Co-60, Kr-90, Sr-90, I-129 and Cs-137 and those which must be considered from the long-term safety perspective include C-14, Cl-36, Se-79, Sr-90, Tc-99, Pd-107, Sn-126, I-129 and Cs-135. The total inventory of radionuclides in the DGR is estimated at approximately 2.29E+19 Bq.

1.5 Disposal concept

Based on the geological conditions of the Czech Republic, the disposal concept envisages crystalline rock environments and steel-based disposal canisters with bentonite as the engineered barrier system (EBS) material. The direct spent fuel disposal system will be applied and the encapsulation plant will be located within the DGR complex. It is planned that Czech bentonite (Ca-Mg type), excavated in the western part of the Czech Republic, will be used as the buffer and backfill material.

The technical concept of the DGR will reflect the basic safety requirement that the population is fully protected from the impacts of ionising radiation during both the operational and long-term phases of repository development. The technical concept will be flexible and adaptable with respect to individual sites and their specific conditions so as to ensure that safety and technical feasibility requirements are met in full.

2 Site selection strategy

2.1 General principles of the siting process

Siting consists of the process of selecting a suitable site for the facility using the appropriate criteria. The selection of a suitable site makes up one of the elements of the "defence at depth" concept which aims at the prevention of the occurrence of accidents, as set out in Principle 8 of the Fundamental Safety Principles (see the IAEA SF-1 standard).

SÚRAO closely follows the approach recommended by IAEA standards SSG-14 and NS-R-3 which set out that the siting process should consist of the investigation of a large region aimed at selecting one or more candidate sites, followed by a detailed evaluation of those sites.

SÚRAO´s current activities fall within the Site Investigation Stage as shown in the following chart taken from IAEA standard SSG-14.

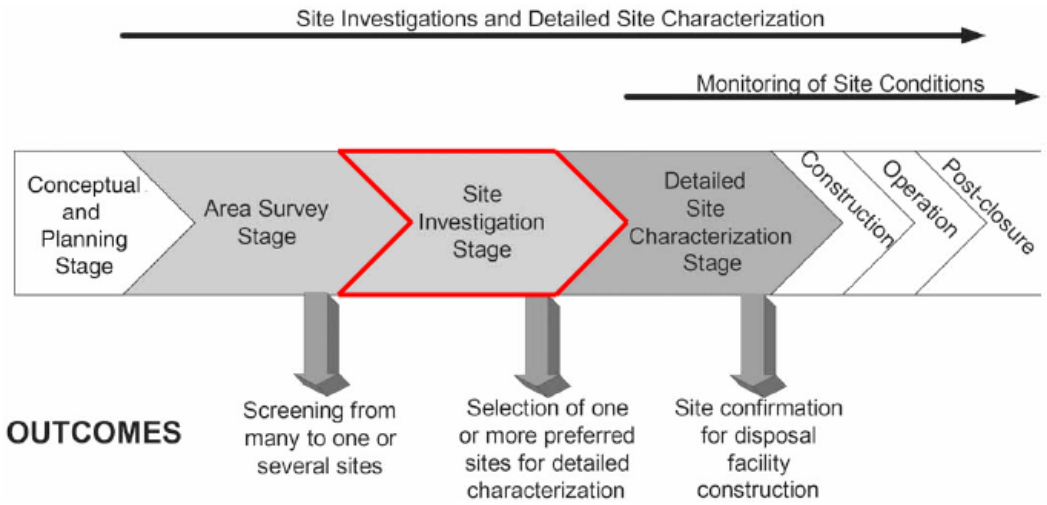

Figure 1 Site Investigation Stage flowing chart *(IAEA standard SSG-14)*

The Site Investigation Stage will be concluded by the selection of a final site as envisaged in the "Update of the Concept of Radioactive Waste and Spent Nuclear Fuel Management".

The Site Investigation Stage will be performed by SÚRAO in three basic stages as illustrated in the following chart.

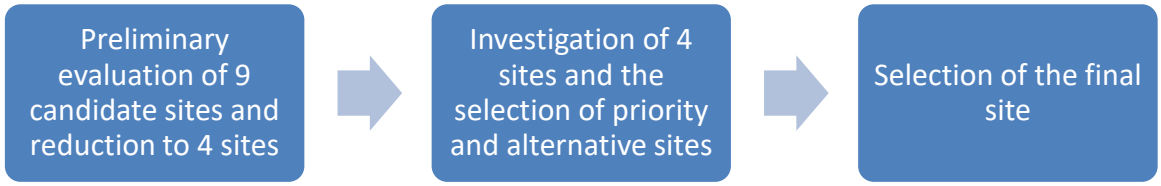

Figure 2 Three basic steps of Site Investigation Stage

Based on recommendations set out in IAEA standards and other relevant documents, the following principles will be observed in this stage:

- Emphasis on a step-by-step approach,
- Emphasis on ensuring nuclear safety,
- Emphasis on the provision of provable evidence supporting both nuclear safety and radiation protection,
- Emphasis on a conservative approach,
- Consideration of public opinion (provided that more than one option is capable of providing the required level of safety).

2.1.1 Step-by-step approach

The step-by-step approach accompanied by flexibility makes up one of the most important methodological approaches to the siting process. This approach allows for prompt reactions to improvements in both the knowledge of the relevant areas of interest and the results of safety analysis studies (see OECD/NEA document: Confidence in the Long-Term Safety of Deep Geological Repositories, 1999).

The step-by-step approach will be applied in each stage of the siting process with respect to reducing the areal extent of individual sites, reducing the number of sites to just one priority site and determining detailed information from the accumulation of data.

The logical sequencing of the steps will be chosen according to effectiveness. Those events or hazards which might potentially affect the safety of the repository (or result in the rejection of specific sites) will be considered at the beginning of the siting process.

Only later will those events that require engineering solutions so as to eliminate or mitigate their potential harmful consequences be evaluated.

Subsequently, work will concentrate on determining the advantages of the individual candidate sites included in the siting process, with respect to which the availability of data and the various advantages and disadvantages will be considered in the ranking process.

2.1.2 Ensuring nuclear safety

Ensuring safety, both in the DGR operational stage and following closure, forms the overriding concern at each decision point (see Requirement No. 4, par. 3.19 of IAEA standard SSR-5) and is expressed in Principle No. 8 of IAEA standard SF-1 thus: “All practical efforts must be made to prevent and mitigate nuclear or radiation accidents”.

In addition, the siting process is required to meet one of the conditions of IAEA standard NS-R-3 related to ensuring nuclear safety (see par. 2.4 of the standard) which states that “site characteristics that could affect the safety of the nuclear installation shall be investigated and assessed. Characteristics of the natural environment in the region that might be affected by potential radiological impacts in operational states and in accident conditions shall be investigated”.

This principle was incorporated into Czech legislation in article 47 of the Atomic Act (Act No. 263/2016 Coll.) which states that “sites intended for the construction of a nuclear installation shall be evaluated in terms of a) characteristics that might affect nuclear safety, radiation protection, technical safety, the monitoring of the radiation situation, radiological emergency management and security throughout the life cycle of the nuclear installation and b) the impact of the nuclear installation on individuals, the general public, society and the environment”.

Further principles are related to the evaluation of hazards as set out, e.g. in par. 2.5 of IAEA standard NS-R-3: “Proposed sites for a nuclear installation shall be evaluated with regard to the frequency and severity of external natural and human induced events, and potential combinations of such events, that could affect the safety of the installation” and paras. 2.14 and 2.15 of IAEA standard NS-R-3: “Proposed sites shall be adequately investigated with regard to all the site characteristics that could be significant to safety in external natural and human induced events” and “Possible natural phenomena and human induced situations and activities in the region of a proposed site shall be identified and evaluated according to their significance for the safe operation of the nuclear installation” respectively.

Disposal facilities destined to receive radioactive waste will, generally, consist of licenced nuclear facilities and will be required to operate under the terms of the relevant facility licence. The optimisation of protection is fully considered in both the design of the disposal facility and operational planning.

The afore-mentioned rules as adapted to disposal facility conditions are reflected in Requirement No. 15 of IAEA standard SSR-5 as follows: “The site for a disposal facility shall be characterised at a level of detail sufficient to support a general understanding of both the characteristics of the site and how the site will evolve over time. This shall include its present condition, its probable natural evolution and possible natural events,

as well as human plans and actions in the vicinity that may affect the safety of the facility over the period of interest". This standard also provides a recommendation in par. 4.26 relating to the site characterisation stage: "The focus must be on features, events and processes relating to the site that could have an impact on safety and that are addressed in the safety case and supporting safety assessment".

It is clear, therefore, that ensuring nuclear safety is based on an exhaustive characterisation of the site. One of the basic tools concerning events that might affect the safety of such installations consists of the requirements and criteria (R&C) system which provides a specific guide indicating how the site should be characterised and how to identify and evaluate the importance of potential hazards in relation to the safety of the disposal facility. In this respect par. 1.5 of IAEA standard SSG-35 states that "the siting process, from the beginning, must be guided by a clearly established set of criteria consistent with the relevant regulatory requirements".

The radiation safety requirements and related safety criteria covering the operational period of radioactive waste disposal facilities are identical to those relating to all nuclear facilities or activities involving radioactive materials. Disposal facilities destined to receive radioactive waste will, generally, consist of licenced nuclear facilities and will be required to operate under the terms of the relevant facility licence. The optimisation of protection is fully considered in both the design of the disposal facility and operational planning.

The siting requirements for the criteria to be applied as appropriate to site and site-nuclear installation interactions in the operational state and under accident conditions are summarised in recently issued IAEA publications NS-R-3 and SSR-5 which do not specifically address underground installations such as deep geological repositories, one of the reasons for which is that, as opposed to surface-based nuclear facilities, the primary aim of deep geological repositories is to protect people and the environment over the long term following the closure of the disposal facility.

Reasonable assurance must be provided that both the dose and risks to which humans are exposed over the long term do not exceed those dose and risk constraints that formed part of the design criteria (no risk constraints are set out in the Czech Atomic Act with concern to disposal facilities). In order to comply with dose limits, disposal facilities are designed so that the calculated dose for a representative person who might be exposed in the future respects both IAEA Specific Safety Requirements SSR 5, i.e. a dose constraint of 0.3 mSv in one year, and the Czech Atomic Act, Chapter 2, § 82, i.e. 0.25 mSv in one year.

The migration of radionuclides into the accessible biosphere and the consequent exposure of humans may occur at some time following repository closure. In contrast to

surface-based nuclear facilities, the host rock at the DGR site will provide an important barrier to the migration of radionuclides to the biosphere. One of the most important aims in the DGR site selection stage will be to find a site with favourable properties with respect to nuclear safety, radiological protection, construction safety, the monitoring of the radiation situation, the management of events during a radiological emergency and the security of the nuclear installation during the operational stage; in addition, the site must exhibit favourable geological conditions that will be able to contribute significantly, in tandem with the engineered barrier system, towards the long-term confinement and isolation of the radioactive waste, i.e. the rock environment will be required to:

1. Protect the engineered barrier system through stable and favourable rock conditions, i.e. provide support for the confinement capacity of the engineered barrier system.
2. Slow down radionuclide transport facilitated by the physical and chemical processes underway in the lithosphere, i.e. retain radionuclides within the rock environment for the maximum time possible.
3. Prevent inadvertent human access to the waste, i.e. effectively isolate the waste from the environment.

For site selection purposes, SÚRAO has developed criteria/indicators based both on these three requirements (safety functions) and general requirements published in the IAEA publication “Geological Disposal Facilities for Radioactive Waste, SSG-14”, especially:

1. The geological setting of a disposal facility should be amenable to overall characterisation and exhibit favourable geometrical, physical and chemical characteristics.
2. The depth and dimensions should be sufficient for hosting the disposal facility.
3. The mechanical properties should be favourable for the safe construction and operation of the facility.
4. The host rock should not be liable to be affected by future geodynamic phenomena (e.g. climate change, neotectonics, seismicity, volcanism, diapirism).
5. The hydrogeological characteristics and the setting of the geological environment should tend to restrict ground water flow, and the ground water system should be well understood.
6. The physicochemical and geochemical characteristics of the geological environment should be favourable in terms of limiting the transport of radionuclides and contribute towards the containment function of the engineered barrier system.
7. The siting of the disposal facility should be conducted with the consideration of current and potential human activity at or near the site.

In combination with the step-by-step approach, each level of information will be detailed in the form of additional steps. In the very early stage, at which time no specific data from repository depth is yet available, it will be possible to perform only a basic comparison. The result of this evaluation of the sites will form only a recommendation with respect to the next stage of activities concerned with reducing the total number of sites.

2.1.3 Submission of evidence

The principle of the submission of evidence is particularly important in terms of the transparency and the degree of trust accorded to the siting process. This principle is set out as requirement No. 14 of IAEA standard SSR-5 which states that “the safety case and supporting safety assessment for a disposal facility shall be documented to a level of detail and quality sufficient to inform and support the decision to be made at each step and to allow for an independent review of the safety case and supporting safety assessment”.

The submission of evidence makes up the most important general requirement of the regulatory body which is reflected in the obligation of the applicant to submit an Initial Safety Report (ISR) to the regulator in order to obtain a licence. This obligation is enshrined in article 24 of the Atomic Act (Act No. 263/2016 Coll.); moreover, in Annex No. 1 of the Act, the Initial Safety Report basically makes up a specific form of Safety Case processed on the basis of a detailed characterisation of the final site. The requirement to submit evidence is in compliance with Requirement No. 12 of IAEA standard SSR-5 which states that “a safety case and supporting safety assessment shall be prepared and updated by the operator, as necessary, at each step in the development of a disposal facility, under operation and following closure”.

2.1.4 Conservative approach

It is essential that a conservative approach be applied which, with concern to the nuclear sector, is defined as follows: “if reasonable doubts appear concerning the evaluation of a hazardous event, the least favourable assessment of such an event should be taken into account”.

Currently, international practice tends to indicate the adoption of a probabilistic approach which involves selecting the most probable scenario and forming an assessment of the epistemic uncertainty thereof.

.

2.1.5 Public involvement

Radioactive waste management is embedded in a range of broader societal issues such as the environment, risk management, energy production, health policy and sustainability, with respect to which there is an ever-increasing demand for public involvement, participation and engagement.

Guidance provided by the various public authorities involved also generally encourages greater public involvement which may assume different forms at different phases of project development and includes the sharing of information, consultation and dialogue concerning decision-making with the relevant stakeholders. Stakeholder involvement should be seen as making up a meaningful part of both formulating and implementing public policy. There is no single technique which can be applied to the organisation of engagement, rather initiatives should respond to the context and the particular needs of stakeholders. As the number of both stakeholder involvement approaches and publications which describe them continues to increase, new opportunities are also opening up via social media, which has become an important tool with respect to stakeholder involvement in recent years.

Source: Adapted from AccountAbility, United Nations Environment Programme, Stakeholder Research Associates Canada Inc. (2005), *The Stakeholder Engagement Manual Volume 2: The Practitioner's Handbook on Stakeholder Engagement*, AccountAbility, London, p. 11.

www.accountability.org/images/content/2/0/208.pdf (accessed 24 February 2015).

Figure 3 Effective stakeholder engagements *(The Stakeholder Engagement Manual, Canada)*

3 Site selection process

The site selection process is based on three pillars: 1. Requirements and criteria; 2. Site characteristics (i.e. knowledge of and data on the site); 3. Decision-making procedures (see the following chart).

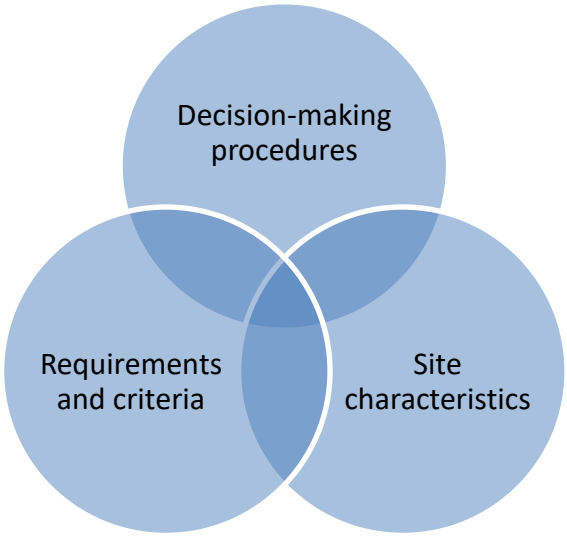

Figure 4 Pillars of the site selection process

Further steps introduced into the Working Plan focus on all three areas (pillars) of the site selection process. A number of themes related to the above-mentioned areas are discussed below together with a justification and planned timing.

The primary objective of the Working Plan consists of the transparent and responsible selection of the final site while fully respecting the requirements of Czech legislation and IAEA, WENRA and NEA regulations and recommendations.

3.1 Requirements and criteria

The requirements and criteria (R&C) system provides a basic tool with respect to events that might affect the safety of the facility. The system represents a specific guide to the approach to characterising the site and identifying and evaluating the importance of potential hazards in relation to the safety of the disposal facility. This approach is in accordance with par. 1.5 of IAEA standard SSG-35 which states that “the siting process, from the beginning, must be guided by a clearly established set of criteria consistent with the relevant regulatory requirements”.

The R&C system is based on a set of requirements which covers a range of different fields concerned with natural features, the local population and human activity. The R&C document also includes a hierarchy of criteria which allows for distinguishing any unacceptable site conditions (exclusion criteria) and identifies those criteria which can be employed in the decision-making process concerning site suitability. The criteria are used for the screening, comparison and ranking of candidate sites.

The SÚRAO requirements and criteria system (the *Requirements, suitability indicators and criteria for the selection of potential deep geological repository sites, 2015* report*)* was based on the following legislation and standards:

- Czech Atomic Act No. 263/2016 Coll. and relevant amending regulations;
- Czech Act No. 100/2001 Coll. on environmental impact assessment and relevant amending regulations,
- Council Directive (EC) 2011/70/EUROATOM of 19 July 2011 establishing a community framework for the responsible and safe management of spent fuel and radioactive waste
- IAEA, Geological disposal facilities, Specific Safety Guide, SSG-14, Publication 1483, 2011, Appendix I “Siting of geological disposal facilities”.
- IAEA document, Safety fundamentals SF-1, 2006
- IAEA document, Disposal of Radioactive Waste, Specific Safety Requirements, No. SSR-5, Pub. 1449, IAEA, Vienna, 2011
- IAEA document, The Safety Case and Safety Assessment for the Disposal of Radioactive Waste, Specific Safety Guide, No-SSG-23, 201
- Radiation protection recommendations as applied to the disposal of long-lived solid radioactive waste, ICRP Publication 122, ICRP Annals of the ICRP, 2013
- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. Czech Ministry of Foreign Affairs Notification No. 3/2012.

The system is based on a set of requirements relating to the following areas:

1) **Site characterisation programme** describing sites at a level sufficient for the preparation of design, safety, environmental and socio-economic studies and decision-making.
2) **Feasibility (design) studies** showing that the repository at the finally selected site(s) will have the capacity to accept the proposed inventory and will demonstrate technical feasibility in terms of construction using verified currently available technologies. The costs of DGR construction and operation must be in line with the radiation protection optimisation principle, i.e. fully taking into account economic and social factors.
3) **Safety studies** showing that the site can guarantee the required level of safety. This must subsequently be demonstrated on the basis of existing knowledge of

the site, taking into account all the potential risks which may arise during the repository operation and post-closure stages.

4) **Environmental studies** showing that the siting of the repository will not be in obvious conflict with, or pose a significant threat of excessive damage to, highly sensitive ecosystems, and that it does not lead to the deterioration of the status of any component of the environment or of the living conditions of the population in the area concerned.
5) **Socio-economic studies** describing local socio-economic conditions at the sites and demonstrating that repository siting will not lead to a decline in local living standards, including opinion polls which show the level of public acceptance of the DGR siting decision.

As mentioned at the beginning of this chapter, SÚRAO intends to reduce the number of sites employing a step-by-step approach. With respect to the current level of information and in combination with this approach, the level of information will be refined in subsequent steps. With respect to the stage in which no specific data from repository depth is yet available, conceptual comparisons only can be performed.

The requirements and criteria system (see SÚRAO report “Requirements, suitability indicators and selection criteria for the siting of the deep repository”) was developed prior to the adoption of the updated Atomic Act (Act. No. 263/2016 Coll.) and Decree No. 378/2016 Coll. on the siting of nuclear installations. Therefore, the system will be updated and improved so as to reflect the newly-introduced requirements and criteria.

Special consideration will be accorded to the development of specific safety criteria relating to the underground part of the DGR according to Decree No. 378/2016 Coll. and IAEA standard SSG-14.

The evaluation of the sites using the R&C system also requires the collection of evidence demonstrating compliance with the relevant requirements and criteria. Therefore, SÚRAO considers the formulation of evidence to be as important as the development of the criteria.

The obligation to obtain evidence will be incorporated into the investigation plans and every effort will be made to obtain such evidence; moreover, the evidence must be sufficiently detailed, conclusive and credible. Further, the statements contained in the evidence must be supported by provable data (the results of observations, expertise, expert opinions, maps, studies, analysis, measurement results, sample analysis, etc.).

It must be noted at this point that the R&C system cannot be considered a static document. In line with legislative changes (for example the new Atomic Act) and increasing knowledge of the sites, SÚRAO will continue to develop its evaluation and decision-making procedures as well as the criteria themselves.

Output:

Technical Report „Requirements and criteria for selecting the DGR site“

- June 2017
- With respect to legislative changes and increasing knowledge if deemed necessary

3.2 R&D Plan

The R&D Plan (*Medium-term plan for the research and development of activities needed for DGR siting in the CR in the period 2015 – 2025)* makes up a basic document focusing on research and development activities connected with the siting of the deep geological repository. The various R&D activities have been identified on the basis of a detailed analysis of research and development work conducted at both the national and international levels.

The selection of the activities scheduled for this period stems from the requirement to a) determine the characteristics of candidate sites to a level sufficient for the detailed comparison of the sites from the perspectives of feasibility, safety and the impact of the DGR on the environment and the living conditions of local inhabitants and b) prepare the most suitable methods, tools and procedures for assessment purposes.

The R&D Plan cannot be considered a static document; it will be regularly reviewed and updated in line with increasing knowledge of the sites, the DGR concept and the needs of the process.

Output:

Update of the R&D Plan

- October 2019
- With respect to increasing knowledge and the needs of the process if deemed necessary

3.3 Training the personnel of survey and research institutions

Site evaluation employing the R&C system requires knowledge of what exactly is meant by evidence and hazard parameters on the part of the personnel employed by survey and research institutions. Such “field” personnel will search for answers to questions

posed by safety evaluators and risk analysts. Therefore, in order to ensure that the siting process is effective, open communication channels will be established between the two expert groups which will ensure that both parties acquire a comprehensive understanding of the data required for the compilation of the DGR safety analysis and hazard assessment.

Outputs:

Workshops on the subject: “Data needs for the site characterization”

- continuously

3.4 Licences and permission documentation

Licences and permission documentation will be required.

No licence is required under the Atomic Act for the period of time under consideration. However, the Atomic Act foresees (according to Section 108 (4)) that:

“The process of the designation of an exploration area for the disposal of radioactive waste in underground repositories, the designation of a protected area for the disposal of radioactive waste in underground repositories, the authorising of the operation of a radioactive waste disposal facility and the ensuring of the consideration of the interests both of municipalities in terms of receiving contributions from the Nuclear Account under § 117(1) and the citizens thereof with respect to these processes requires special legislation.”

Prior to commencing geological exploration activities in preliminary selected areas, the applicant must obtain permission from the Ministry of the Environment for the official recognition of so-called geological survey areas on the basis of an application which complies with legislation on geological work (Act. 62/1988).

In addition, the application must be subjected to the so-called “fact-finding procedure” according to Act No. 100/2001 Coll., on Environmental Impact Assessment, prior to the drilling of deep boreholes at the respective sites.

The participants in the process consist of the affected municipalities, State authorities and other concerned stakeholders. The comments of all the stakeholders must be addressed prior to the issuing of permission by the Ministry of the Environment. Exclusionary conditions include a conflict of interest with the State raw material policy, the State policy on environmental protection and the decision that the public interest has higher priority than the project under consideration.

The process requires that the borders of protected areas be marked in the territorial development principles of the relevant district due to the determination of a protected area for special intervention into the Earth´s crust; the principles must be approved by the relevant municipal authority. A detailed evaluation of sustainable development and the subsequent EIA process (issuing authority - the Ministry of the Environment) form part of the proposal. Further documentation consists of the municipal territorial development plan of protected area cadastres which must be included in the approved version of the district territorial development plan.

Following the exploration process, the applicant is required to submit an application to the Ministry of the Environment for the protection of the site for DGR construction. In this case, the applicant is the only participant in the process.

Following site selection, the EIA procedure will commence according to environmental legislation (Act No. 100/2001 Coll.) and, finally, documentation will be submitted for the granting of planning permission for the DGR.

The Initial Safety Report (ISR) must be submitted to the regulator (the State Office for Nuclear Safety) during the authorisation phase for the siting of the nuclear installation. In addition, the Basic Design must be submitted to the competent regional office. The State Office for Nuclear Safety is also responsible for issuing permission for the siting of a nuclear facility according to the Atomic Act.

Permission for mining activities is issued by the Czech Mining Authority on the basis of an application to the Authority.

According to the Building Code (Act No. 18/3/2006, section 13, as amended), it is not possible to launch DGR siting proceedings until all the above-mentioned applications have been approved. The Ministry of Regional Development makes up the relevant building authority.

The afore-mentioned process has been slightly modified as a result of new legislation to be introduced in compliance with section 108, paragraph 4 of the Atomic Act No.

263/2016. Proceedings for the determination of exploration areas, the determination of protected areas and permission to manage the disposal of radioactive waste in underground spaces will be stipulated in legislation; the interests of the municipalities concerned must be respected.

3.5 Site characteristics

3.5.1 Site investigation programme

Site investigation activities involve the development of both site descriptive models aimed at supporting the DGR safety case and technical feasibility studies compiled employing field data. The site investigation strategy is divided into the following phases:

- The surface-based exploration stage using only ground survey methods (2014-2018)
- The exploration stage for so-called deep horizons (2019 to final site selection)

Surface-based exploration is aimed at allowing for a reduction in the number of sites from 9 to 4. The methods used in this stage, in accordance with exploration permission documentation, do not involve intrusion into the Earth's surface (i.e. no borehole drilling). The aim is to create preliminary structural-geology, hydrogeological, DFN and transport models based on existing data. The models will be created at two levels: regional (with an area of approx. 150 km^2) and local (approx. 30 km^2). The regional models will be constructed according to archive data, whereas the local models will be constructed based on a combination of archive and field data; currently, an extensive archive data investigation is underway. The local models, which will cover potential geological blocks suitable for DGR construction and the surrounding geological units, will be based on the regional models and will be updated according to data acquired from remote sensing analysis, complex geological mapping, geophysical measurements, hydrogeological monitoring and geotechnical investigation. Moreover, the local geological models will depict precise lithological boundaries, the occurrence of surface springs, tectonic features and the brittle pattern employing a combination of geological mapping and remote sensing techniques. The field data will be stored in a uniform database both in a GIS-based environment and by means of an SQL server. The data will then be incorporated into 3D geological and other models which will, eventually, be used for the final validation of the candidate sites.

Outputs:

Preliminary Site descriptive models for 9 sites that will include:

- Preliminary regional 3D geological, DFN and hydrogeological models – regional stage
- Preliminary 3D geological, DFN and hydrogeological models – local stage
- Database of raw data
- Remote sensing analyses
- Preliminary DFN models

- January 2018

The exploration stage for deep horizons will be focused on the selection of the final and backup sites from the 4 sites identified in the previous stage.

It is planned that the exploration stage will include the use of deep borehole drilling methods and the conducting of comprehensive geophysical surveys. The methods applied will focus on the validation of the brittle tectonic pattern, the lithological homogeneity of the rock mass, the hydrogeological properties of the rock and geotechnical parameters. The investigation work will allow for the updating of the models constructed in the previous stage and the construction of geosphere models (e.g. geotechnical, geochemical models). These models will subsequently be integrated into the site-descriptive models and serve as a knowledge base for the site-specific safety case and the technical feasibility study. The resulting models and site descriptions will also form part of the licencing process documentation finally submitted to the regulatory body.

Complex drilling and geophysical exploration methods require a well-organised supply chain; thus, prior to the commencement of exploration work pilot studies must be conducted focusing on the methodology to be employed for both obtaining the data required and incorporating it into existing 3D models. Pilot studies will be conducted in the following areas:

- Geophysical measurement

3D seismic, magnetotelluric and other methods will be employed so as to optimise the methodology used for corroborating the brittle tectonic pattern, lithological contacts and the homogeneity of the rock mass.

- Borehole drilling programme

The data acquired will be stored in the uniform database and classified according to SÚRAO and nationally applied standards. Only then will the complex modelling stage commence. Modelling will focus on the generation of DFN, geological, geotechnical, hydrogeological, transport and other geosphere models.

Data modelling

The acquired data will be stored in the uniform database and described according to the SURAO and national standards. After that the complex modelling will be performed. The modelling effort will be focused of generation of: DFN model, geological model, geotechnical model, hydrogeological model, transport model and other geosphere models.

Outputs:

Technical Report "Site descriptive models of 4 potential DGR sites"

- Approx. 5 years following the granting of a favorable decision by the Ministry of the Environment allowing the commencement of geological survey work

3.5.2 Technical feasibility

The technical design of the DGR will focus on the development of a technically feasible and economically optimised solution that fulfils all the relevant safety requirements.

The approach to determining the technical design of the deep geological repository must respect the geological and tectonic condition of the rock massif in order to satisfy long-term safety requirements. The fact that the geological environment will, most likely, not allow the entire volume of the repository to be used for the disposal of disposal canisters will have to be taken into account. Moreover, it is important to consider that the disposal area may be intersected by brittle structures (fractures and fissures), fault zones and lithological and other structural inhomogeneities. Rock environments featuring major faults will not be considered for the construction of the waste disposal area.

The properties of the rock itself, the behaviour of the rock massif, groundwater flows and the stress conditions of the rock environment will play important roles in the construction of the underground area of the DGR and will exert an effect on the tunnel driving technology and the costs thereof.

A further important technical consideration with respect to the site eventually selected for DGR construction consists of the quality of the local infrastructure, i.e. the road and railway networks, power distribution network, the availability of land for the depositing of the excavated rock and earth, mobile phone coverage, relatively easy access for medical emergency services, the fire brigade and mine emergency services and proximity to RAW producers).

Clearly, it will be imperative that the technical design finally adopted will be adequately robust from the point of view of safety. However, financial considerations will also be taken into account, i.e. the selected design must guarantee the required level of safety and be economically feasible.

The technical design will be outlined in greater detail during each of the three stages of the siting process, from the basic feasibility study to the basic design which will be included in the final siting application submitted to the regulatory body.

Outputs:

Technical Report „The preliminary feasibility study for 9 sites“

- February 2018

Technical Report „The preliminary feasibility study for 4 sites, including the recommendation of a final site and alternative one“

- Approx. 5 years following the granting of a favorable decision by the Ministry of the Environment allowing the commencement of geological survey work

3.5.3 Safety case

One of the most important elements of the site characterisation process consists of the identification of external natural and human-induced hazards that might affect the safety of the repository (see para. 2.14 and 2.15 of IAEA standard NS-R-3).

In addition to making up one of the requirements set out in the Atomic Act, the identification of factors which might affect safety is crucial with respect to the hazard evaluation process. Potential hazards will be evaluated in terms of their potential impact on those structures, systems and components (SSC) which are important with concern to safety. Thus, the relevant SSCs will have to be identified well before the

commencement of the investigation of natural and human-conditioned hazardous factors and the evaluation of such hazards.

Operational safety evaluations must be drawn up with a view both to normal operation and the occurrence of accidents which might have a significant impact on the environment and public health. In the first stage, interest will focus particularly on the identification of hazards at potential sites that could influence nuclear safety, radiation protection, technical safety, the monitoring of the radiation situation, the management of events following a radiological emergency and the security of the encapsulation unit in which spent fuel assemblies will be transferred from Castor casks to waste disposal containers. Hazards which might potentially occur as a result of earthquakes, the development of surface faults, meteorological events, flooding and geotechnical and external human-induced events will also be evaluated; it will also be necessary to investigate the potential simultaneous occurrence of such events..

The long-term safety of the DGR will rely on both the man-made engineered barriers (the disposal casks/canisters, buffer, backfill and sealing materials) and the long-term stability of the rock environment throughout the time period in which a threat continues to be posed by the radioactive waste disposed of, i.e. several thousand to hundreds of thousands of years.

In the first stage of DGR development, research will focus on determining transparent indications and arguments concerning the long-term safety of the DGR at selected sites. The basic principle is that it is necessary to select sites which can be expected to satisfy requirements concerning both the operational and long-term safety of the deep geological repository design concept for the disposal of radioactive waste generated in the Czech Republic. Preference will be accorded to sites that meet the safety criteria with a sufficient reserve taking into account all the potential hazards envisaged over the lifetime of the DGR, i.e. that the site is sufficiently robust.

The first phase of site selection involves the use of sporadic data which does not allow for the compilation of detailed safety assessments, principally since no data is yet available from depths at which the repository will be constructed.

With respect to the preliminary evaluation of sites from the viewpoint of long-term safety, it will be necessary to determine the characteristics of the host rock, following which it will be possible to select the most suitable sites for the siting of the deep geological repository. Finding a homogeneous rock mass of sufficient size with no significant faults will make up one of the most important characteristics, while other characteristics will consist of a low degree of host rock variability and a low rate of flow of water at depth. A particularly important indicator of suitability consists of the potential to accurately predict the properties of the host rock so as to form a good understanding of the properties of

the site in agreement with Requirement No.6 of the IAEA's specific safety requirements (SSR-5) which states that "the operator of a disposal facility shall develop an adequate understanding of the features of the facility and its host environment and of the factors that will influence its safety following closure over suitably long time periods, so that a sufficient level of confidence in safety can be achieved". The characteristics required of the sites/suitability indicators for DGR siting are listed in the *Requirements, suitability indicators and criteria for the selection of potential deep geological repository sites*, SÚRAO, 2015 document, which is currently being updated so as to include recent requirements set out in SÚJB Decree 378/2016 Coll. on the siting of nuclear installations.

The main objective of work in this field is to combine data, arguments, justification, models and other information in the form of a safety case for the selection of the most suitable locality for the DGR and for obtaining a siting permit for the DGR at the selected locality.

The main objective of the development of the initial safety cases will consist of the determination of the robustness and potential overall understanding of individual candidate sites from the perspective of long-term safety on the basis of selected criteria and screening computations, and a general overview of whether the long-term safety of the DGR at a given site can be assessed with an acceptable level of uncertainty.

In the subsequent phases of the project, safety case studies will be supported by more detailed safety assessments for all the selected sites based on data obtained from the site characterisation programme.

Outputs:

Technical Report „The preliminary safety case studies for 9 sites with screening safety assessments"

- July 2018

Technical Report „The preliminary safety case studies for 4 sites, including screening safety assessments"

- Approx. 5 years following the granting of a favorable decision by the Ministry of the Environment allowing the commencement of geological survey work

3.5.4 Environmental and socioeconomic issues

According to IAEA recommendations SSG 14, I.44 to I.47, the siting of a deep geological repository should be managed in such a way that the quality of the environment is adequately protected and potential adverse impacts can be mitigated to an acceptable level with respect to technical, economic, social and environmental factors. Repository siting should not lead to any conflicts of interests that will be difficult to reconcile within the area assessed and which indicate the very significant long-term endangering of or excessive damage to very sensitive ecosystems and the deterioration of the status of individual components of the environment with direct, demonstrably adverse impacts on human health.

All the potential sites will be analysed with respect to both the number and complexity of conflicts of interest in terms of the legal protection of property, phenomena, natural objects, and buildings and structures present in the area (e.g. with concern to power lines, gas supply pipes, communications networks, surface water and groundwater protection, transport, bio-diversity and landscape protection, mineral raw materials and the rock environment, archaeological concerns and forest protection).

Environmental impact studies will be prepared for each potential site which will map the current situation in an impartial manner and, based on the outcome, evaluate and compare the suitability (degree of risk) of DGR siting for the potential sites and their immediate surroundings.

The comparison of the sites will be based primarily on the following site properties:

- Deterioration of the environment due to mining activities and other industrial operations connected with DGR construction.
- Impacts on areas of significant public interest, especially legally protected areas (national parks, nature reserves, areas of special scientific or cultural interest and historical areas).
- Impairment of the water supply and the vulnerability of existing surface water and groundwater resources.
- Impacts on the landscape.
- Impacts on the local flora and fauna (particularly endangered species).
- Impacts on the economy of the region and local municipalities.
- Impacts on the development of the infrastructure of the region and local municipalities.
- Impacts on the value of land and real estate.
- Impacts on the recreational potential of the area.

Outputs:

Technical Report „The study of environmental impacts for 9 sites“

- February 2018

Technical Report „The study of environmental impacts for 4 sites, including the recommendation of the final site and the alternative one“

- Approx. 5 years following the granting of a favorable decision by the Ministry of the Environment allowing the commencement of geological survey work

3.5.5 Working with stakeholders

Radioactive waste management is embedded in a range of broader societal issues such as the environment, risk management, energy production, health policy and sustainability, with respect to which there is an ever-increasing demand for public involvement, participation and engagement.

Guidance provided by the various public authorities involved also generally encourages greater public involvement which may assume different forms at different phases of project development and includes the sharing of information, consultation and dialogue concerning decision-making with the relevant stakeholders. Stakeholder involvement should be seen as making up a meaningful part of both formulating and implementing public policy. There is no single technique which can be applied to the organisation of engagement, rather initiatives should respond to the context and the particular needs of stakeholders. As the number of both stakeholder involvement approaches and publications which describe them continues to increase, new opportunities are also opening up via social media, which has become an important tool with respect to stakeholder involvement in recent years.

Communication concerning the DGR project will closely follow the milestones set out for the siting process. Free access to information is guaranteed on radioactive waste management and its disposal as well as geological survey work and the current status thereof corresponding with the geological survey work underway at potential sites and fully respecting the needs of the local public and local authorities.

Goals to be attained:

- General communication – enhanced public understanding of the DGR project
- Increasing of public acceptance
- Lex Specialis completion

Activities and topics to be communicated:

1. Planning of the future form the stakeholder involvement framework should assume (a new “Working Group” at the national level and future local stakeholder groups ready to work together on the next phase of the siting process – with just 4 then 2 sites subjected to geological research work)

   With concern to the next phase of the siting process (reduction in the number of sites to 4), the establishment of local stakeholder groups will be beneficial with concern to:

   - Directly involving the local public.
   - The co-framing of issues for consultation, evaluation and decision-making, which will assist in improving legitimacy, especially with respect to contentious situations.
   - Independent financing, this will guarantee the independence of stakeholder input.
   - Providing local independent sources of information
2. Cooperation and supporting of legislation on stakeholder involvement (Lex Specialis) in the DGR siting decision-making process
   - Clear description of the DGR decision-making process and the roles of the various stakeholders.
   - Clear rules with respect to the stakeholder involvement process – institutional (local stakeholder group status) and financial frameworks.

In general, SÚRAO will communicate its responsibilities and the results of its work according to an agreed Communications Strategy which fully respects the need for transparent communication, dialogue with stakeholders and the national concept.

Outputs:

Communication strategy concerning DGR project

- continuously

Socio-economics studies for 9 sites

- December 2016

Socio-economics studies for 4 sites

- Approx. 5 years following the granting of a favorable decision by the Ministry of the Environment allowing the commencement of geological survey work

Opinion polls

- Continuously

Lex specialis

- Continuously

4 Decision-making procedures

4.1 Baseline information

4.1.1 Goals and objectives

SÚRAO must meet two basic goals:

1. Selection of the final site for the construction of a DGR in the Czech Republic.
2. Demonstration that the site is suitable according to the criteria set out in the Atomic Act and other regulations and has the potential to attract the required level of public and political support.

4.1.2 Timing of decision-making

According to the State Concept, SÚRAO is obliged to take two decisions by 2025:

1. Selection of two candidate sites in 2020.
2. Selection of the final site in 2025.

With respect to the current status of the DGR project, however, this time schedule is generally seen as somewhat over-ambitious. Therefore, SÚRAO has proposed that the process be divided into three stages and that more time is allowed.

It is proposed that a further step be introduced aimed at reducing the number of candidate sites as soon as possible. The revised list of decisions, therefore, is as follows:

1. Reduction in the number of sites from 9 to 4 in 2018.
2. Selection of a priority and alternative site in 2025 (as follows from the investigation plan).

4.1.3 Decision-making powers

The decision-making procedure ultimately respects the fact that the final decision will be made by the Government of the Czech Republic.

The decision-making powers of SÚRAO are limited to forwarding recommendations to the Government based principally on technical aspects whilst taking into account social factors and public opinion.

The role of SÚRAO is clarified in the State Energy Policy of the Czech Republic which sets out that SÚRAO's task is to "select sites for final repositories for spent nuclear fuel and to **submit them to the Government for a final decision to be passed**".

4.1.4 Limitations and risks

Four basic groups exist with respect to limitations within the siting process and the time-schedule, i.e. strategic, legal, technical and socio-economic limitations.

Strategic limits and risks

As mentioned above, the final decision on the site selected will be made by the Government of the Czech Republic, and one of the most significant potential strategic limitations consists of an unexpected change in terms of political priorities and the SNF management concept. Similarly, a change to the national approach to the utilisation of nuclear energy would also represent a strategic limitation.

The suspension of the DGR project is not anticipated since SNF already exists (unless a decision was made to develop an international DGR). Any changes to the national concept would require time for the adjustment of geological investigation plans, including the timetable.

Legal limitations and risks

The second group of limitations involves legislative issues. The future DGR will be considered a nuclear facility with both surface and underground facilities; therefore, it will be necessary to satisfy the strict requirements of relevant nuclear and mining legislation, and fully respect underground construction engineering limitations and environmental concerns. While no essential changes to mining or environmental legislation are anticipated, the implementation of any such changes would require time for the adjustment of geological investigation plans, including the timetable.

The legislative re-structuring of the public involvement issue, which is governed by the Atomic Act (No. 263/2016 Coll.) could have a substantial negative effect on the site selection process.

It should be mentioned here, however, that the public does not participate in the administrative procedure concerning activities which fall under the scope of the Atomic Act, e.g. the siting of nuclear facilities. Pursuant to Article 19 of the Atomic Act, applicants for the siting of such facilities make up the sole party to such proceedings with the State Office for Nuclear Safety.

Nevertheless, the current wording of the Atomic Act (Article 117) allows the provision of a financial contribution from the Nuclear Account to municipalities in whose cadastral territory the following are located:

a) exploration areas for the disposal of radioactive waste;
b) protected areas for the underground disposal of radioactive waste;
c) operational radioactive waste repositories.

While the Senate (the upper chamber of Parliament) approved the Atomic Act, it adopted a resolution which requests the Government to propose legislation on municipality involvement in the DGR site selection process. The Senate referred to Article 108, paragraph 4 of the Atomic Act, which requires "…. action to ensure that the interests of those municipalities mentioned in Article 117, par. 1 and the citizens thereof are respected and provided for by means of specific legislation".

A proposal outlining legislation on municipality involvement in the DGR site selection process is currently being discussed by the Government of the Czech Republic, and the Minister of Industry and Trade has been charged with preparing a legislative proposal by 30 June 2018 (see Resolution of the Government of the Czech Republic No. 27 adopted on 16 January 2017).

Technical limitations and risks

Technical limitations and risks include those technical requirements and limitations issuing from the characteristics of the site chosen for DGR construction, and it is not inconceivable that no suitable site will be defined. In terms of the underground complex, such requirements relate primarily to the quality and quantity of the rock mass destined for SNF disposal, i.e. data on the principal faults and fragile and ductile deformations of the massif, the velocity and tendency of vertical movements within the Earth´s crust, the stress state within the rock mass, the geotechnical and thermal properties of the rock mass, the regime and circulation of groundwater, and the chemical composition of the local groundwater. With regard to the surface complex, considerations include, for example, the morphology of the area, current geodynamic phenomena, and the depth of the pre-Quaternary basement which might influence the foundations and areal extent of the surface complex.

Socio-economical limitations and risks

The risk also exists that there might be a lack of funding for the project caused by an imbalance between funding which has accumulated in the Nuclear Account and the actual financial demands of DGR construction and operation.

Further risks include a potential lack of skilled personnel and suppliers as well as inconsistencies in the inspection of deliveries.

Outputs:

Periodic review of the Project plan, timetable, financial analysis and quality management system. Lessons must be learnt from last steps.

- annually

4.1.5 Expert Team and its role in the decision-making process

SÚRAO assumes that an Expert Team will be established to supervise the decision-making process. The team will consist of experts nominated by the Ministry of the Environment, the Ministry of Industry and Trade, the State Office for Nuclear Safety and the Czech Mining Authority. The team will be responsible for supervising the siting process and be involved in compiling the final analysis and recommendation of selected sites to be submitted to the Government.

The main task for SÚRAO in this respect will be to establish and build the Expert Team to be involved in deciding site suitability.

Outputs:

Monitoring new trends, standards and international experience in the nuclear energy branche Communication with regulatory body and responsible State representatives

- regularly

Establishing of the Expert Team, organization of team sessions

- September 2017 and continuously

4.2 The decision-making procedure

SÚRAO and the Expert Team will face two main decisions concerning site selection:

1. Reduction of the number of sites from 9 to 4 (2018)
2. Selection of priority and alternative sites, then approval of the final site (post 2025)

It is intended that the final site selection decision will be preceded by the comparison and subsequent ranking of the sites. The comparison will be conducted in compliance with the document *Requirements, suitability indicators and criteria for the selection of potential deep geological repository sites*, which will be updated and modified according to the level of detail of the available data.

One of the key conditions for reaching a responsible and credible decision consists of the availability of information on the sites in a well-structured form. The “Site

Assessment Document" will include a description of the characteristics of the sites which will, in turn, include a description of each site from the geological and environmental perspectives and technical feasibility, conflict of interest and social impacts, and a discussion on how the set criteria will be met. The Site Assessment Documents will be expanded within the site selection process according to the availability of the relevant data.

Outputs:

Technical Reports – Preliminary Site Assessment documents for 9 sites

- June 2018

Technical Reports – Site Assessment documents for 4 sites

- Approx. 5 years following the granting of a favorable decision by the Ministry of the Environment allowing the commencement of geological survey work

Important note:

The selection of the final site will be supported by a number of key documents, e.g. the State Office for Nuclear Safety requires, in accordance with Annex 1 of the Atomic Act No. 263/2016 Coll. the submission of the Initial Safety Report (ISR) as one of several documents required for authorisation for the siting of a nuclear installation and, in accordance with Act No.100/2001 Coll., the Environmental Impact Assessment (EIA) can only be completed following the issuance of documentation authorising the siting of a nuclear installation.

4.2.1The first decision

The first decision will be taken when the site selection process is in the early stages, at which time the information available for decision-making purposes will be incomplete and insufficiently detailed. Therefore, the following principles will be applied:

1. Decisions will be made by competent experts.
2. Responsible decision-making requires the regular assessment of whether or not requirements and criteria are being met as the body of knowledge increases.
3. Ensuring safety is paramount.

4. Decision-making will be based predominantly on expert opinions.
5. Characteristics which make up potential exclusion criteria must be assessed first. If the knowledge base is inadequate, the question must be asked “is it possible that an exclusion criterion is involved, and what is the degree of likelihood?”.
6. Conflicts with any of the requirements and criteria must be judged from the viewpoint of ensuring safety, the difficulties involved in terms of the engineering work required to eliminate or mitigate any potential harmful consequences and cost factors.
7. If the safety levels of all the sites are comparable, the strengths and weaknesses of the sites in terms of non-safety criteria should be used for determining the final decision.
8. The chances of selected sites being both safe and feasible in terms of other relevant considerations should be assessed in the form of an overall point of view which considers all the factors involved.

Decision-making procedure

It is anticipated that the process will consist of two stages, the first of which will involve the collection and organisation of data on each site. Subsequently, the exclusion criteria will be applied so as to determine whether respective sites are suitable for DGR siting. The identification of just one excluding criterion will render a site ineligible for consideration and will be removed from the list of sites.

The second stage will consist of a comparison of the strengths and weaknesses of the remaining sites; public acceptance will be taken into account. **The outcome of this stage will be a list of sites: the first four sites will be prioritised for more detailed exploration work and the remainder will be classified as back-up sites.** Due to the limited level of knowledge gained and degree of uncertainty at this stage in the process, these sites will not be completely excluded at this stage.

It is planned that the ranking process will be based on “brainstorming” meetings which will include the attendance of experts who have been apprised of the specific features of the various sites and at which issues relating to the features of the sites and their potential evolution will be discussed in detail.

The use of a precise scoring system will not be considered at this stage since the data required for arriving at a conclusive decision in this way will not yet be available.

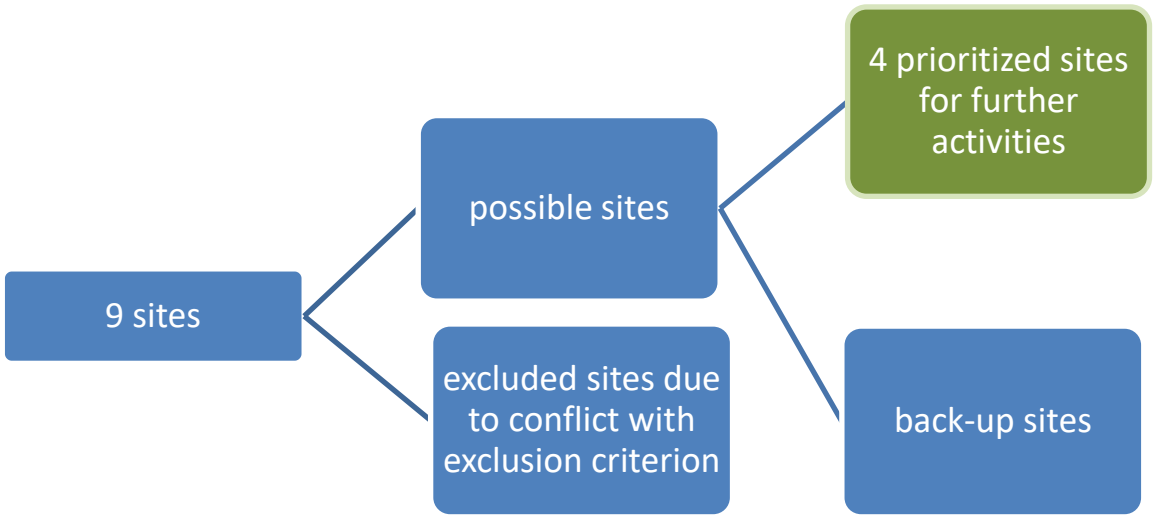

Figure 5 Decision making procedure

Output:

Recommendation of 4 sites, submitted to the Government

- November 2018

Uncertainties and risks inherent in the first decision

A number of uncertainties will, undoubtedly, be inherent in the first decision, most of which will be associated with a lack of reliable data and the consequent requirement to base the decision to a great extent on expert opinion. Uncertainty concerning the validity of the choice of site is perceived as the most serious issue in this respect and, moreover, there is a risk that a potentially very good site will be overlooked. Conversely, an ill-advised decision may well be expensive in terms of both funding and time.

It should also be noted in this respect that there is the risk of disagreement with and a lack of understanding of the choice of the Expert Team, the resolution of which could lead to delays with concern to commencing the next stage of the process.

4.2.2 Outline of subsequent decisions

Feedback - definition of the strategic objectives for the next period

Any redefinition of the various objectives and ways forward resulting from the implementation of the first decision will cover the following issues:

- investigation plan,
- evaluation procedures,
- communications strategy,
- decision-making procedures.

Investigation plan

The Concept of Radioactive Waste and Spent Nuclear Fuel Management allows SÚRAO a very limited time period in which to reduce the number of candidate sites to two, then one final site. Therefore, the optimisation and streamlining of the investigation plan is assumed so as to ensure the success of the site selection process.

Based on the outcome of the first decision, more detailed investigation plans will be drawn up for all the candidate sites which will focus principally on the investigation of any weaknesses identified. This will allow for the identification of unacceptable features and conflicts via the application of the various criteria as soon as possible and, therefore, prevent the wasting of time and funding on unsuitable sites.

This procedure may lead to the investigation process taking longer at some sites than others and even to the exclusion of the prioritised site and its substitution with the back-up site.

Evaluation procedures

Clearly, it will not be possible to form a definitive evaluation of certain features at the sites following a single investigation; rather the process will have to be conducted repeatedly as the knowledge base expands. Such re-evaluations should be conducted on a continuous basis, i.e. at intervals which are shorter than the time period between the decisions. Each such evaluation must be comprehensively documented, especially if safety requirements are involved.

Communication strategy

The publication of the outcomes of the decisions may meet with issues concerning public acceptance of the selected sites; therefore, a plan for managing a potentially negative public reaction should be drawn up.

Decision-making procedures

Any modifications to the above-mentioned issues will also need to be reflected in the various decision-making procedures. A certain amount of flexibility with concern to decision-making should be introduced in order to streamline the site selection process. At the same time, the process should be fully open and transparent.

4.2.3 The second decision

Since a two-step decision process is prescribed in all the relevant strategic documents, the final requirement for a final and alternative site allows for the consolidation of the decision-making procedure and improves the probability of achieving the various aims set out in the Concept.

Nevertheless, in view of the current public attitude to the process**,** it is advisable that **the second decision be defined as a decision which is not fixed in terms of time**; the duration of the investigation process should, however, be defined, **with the zero-milestone consisting of the date on which permission is granted by the Ministry of the Environment.** This approach will allow enough time to reach a responsible and technically sound decision on the final site in accordance with the overall time schedule.

The second decision will, of course, prioritise safety issues since, in the previous phase, it will not have been possible to address the full range of safety requirements in sufficient detail. However, other factors are likely to become increasingly important in terms of the decision-making process, e.g.:

- Anticipating potential conflicts of interest.
- The consideration of changes regarding the public acceptance issue and indications of political influence.

The conclusion of the second decision-making procedure **will consist of the selection of the final site and an alternative site** which will continue to be ranked second in terms of suitability.

4.3 Documentation

In order to demonstrate the transparency of the decision-making stages, the decision-making process must be well documented and each decision must be fully justified.

The Expert Team will, therefore, be required to maintain written records of their proceedings and all the decisions taken by the Expert Team will have to be justified in the form of explanatory memoranda.

4.4 Support and validation of decisions

SÚRAO will establish a system which will allow for the validation of processes and decisions implemented by independent bodies; the system will comprise:

- international cooperation,
- communication with the scientific community,
- communication with the regulatory body,
- independent reviews and scientific missions.

International cooperation

The objective of international cooperation consists of the exchange of experience. With respect to the decision-making process, this includes the collection of information on how to avoid both errors and deadlock. In addition, it is anticipated that international cooperation will provide support for the communications strategy and the enhancement of the level of public acceptance of the project.

Communication with the scientific community

The main benefit anticipated with respect to communication with the scientific community consists of access to newly-developed procedures, which is crucial to ensuring a “state of the art” DGR project in the Czech Republic.

The involvement of the scientific community will also make a valuable contribution to internal reviews of the decisions made by the Expert Team, i.e. with respect both to their accuracy and feasibility.

Communication with the regulatory body

Good communication with and the provision of information to the regulatory authority is a key factor in the success of the site selection process and the licencing process for the DGR. It will also assist in optimising the site selection process by enabling a higher level of effectiveness in terms of responding to the various requirements of the regulator.

Independent reviews and scientific missions

Prior to submitting a decision on the final site to the regulator, it is anticipated that an invitation will be extended to the WATRP mission to compile an independent review of the site selection process.

5 Summary

The Government makes up the decision-making power with respect to the siting process in the Czech Republic and the role of SÚRAO is limited to submitting recommendations to the Government based, primarily, on the various technical considerations while taking into account both social factors and the position of the public.

SÚRAO and the Expert Team are “faced with” making a number of key decisions concerning the site selection process:

- The selection of 4 sites for more detailed geological investigation work in the first phase (2018)
- The selection of the priority and alternative sites in the second phase (2025)
- The approval of the final site in the third phase (post 2025)

The siting process up to 2018 (1st phase) will proceed in two stages, the first of which will involve the collection and organisation of data on each site. Exclusion criteria will be applied in order to determine whether the sites are suitable for DGR siting. ***If just one exclusion criterion is identified, the site will be considered ineligible and will be permanently excluded from the list of potential sites.***

The second step will consist of a comparison of the strengths and weaknesses of the sites; public acceptance issues will be fully taken into account. ***The result of this stage will consist of a list of sites, the first four of which will be subjected to more detailed exploration work; the rest will be classified as back-up sites*** - due to the limited extent of knowledge available at this stage, they cannot be completely excluded.

The first decision will, undoubtedly, be accompanied by a number of uncertainties, most of which will arise due to a lack of reliable data and the need to depend, to a considerable extent, on expert opinion. Thus, it is anticipated that the uncertainty surrounding the overall validity of the selection of sites will pose the most serious threat to the process. In addition, the risk exists that a potentially good site for DGR selection might be overlooked at this stage. At the same time, an ill-thought-out decision which will lead to a waste of both time and financing must be avoided.

The siting process up to 2025; in view of the current public attitude to the process, it is intended that the second decision will be defined as a decision which is not fixed in terms of time; the duration of the investigation process should, however be defined, with

the zero-milestone consisting of the date on which permission is granted by the Ministry of the Environment. This approach will allow enough time to reach a responsible and technically sound decision on the final site in accordance with the overall time schedule.

The second decision will, of course, prioritise safety issues since, in the previous phase, it will not have been possible to address the full range of safety requirements in sufficient detail. However, other factors are likely to become increasingly important in terms of the decision-making process, e.g. anticipating potential conflicts of interest and the consideration of changes regarding the public acceptance and indications of political influence.

The conclusion of the second decision-making procedure will consist of the selection of the final site and an alternative site, which will be ranked second in terms of suitability.

The siting process post 2025 will focus on ***the approval of the final site***.

The following table provides a summary of the various goals and milestones, including those risk factors which may affect the time-schedule of the siting process:

Table 2 Site selection process goals and risks

Activity	Milestone	Risk to the siting process if the activity fails
The first decision		
Technical Reports "The preliminary site description model" for 9 sites	01/2018	If the technical reports are not completed, there will be a lack of data for the Preliminary Site Assessment document
Technical Reports "The preliminary feasibility study" for 9 sites	02/2018	If the technical reports are not completed, there will be a lack of data for the Preliminary Site Assessment document
Technical Reports "The preliminary safety case studies with screening safety assessments" for 9 sites	06/2018	If the technical reports are not completed, there will be a lack of data for the Preliminary Site Assessment document

Activity	Milestone	Risk to the siting process if the activity fails
Technical Reports "The study of environmental impacts" for 9 sites	02/2018	If the technical reports are not completed, there will be a lack of data for the Preliminary Site Assessment document
Socio-economic studies for 9 sites	06/2018	If the studies are not completed, there will be a lack of data for the Preliminary Site Assessment document
Technical Reports "Preliminary Site Assessment document" for 9 sites	**06/2018**	**If the Preliminary Site Assessment documents are not completed, there will be no data available for the decision-making process**
Establishment of the Expert Team, organisation of team sessions	09/2017, continuously	If no Expert Team is in place, there is a greater likelihood of NGOs disputing the decision
Recommendation of 4 sites for subsequent more detailed survey	11/2018	
Government approval of the decision		**Protracted discussion on and the postponement of Government approval may influence the milestones set out for the siting process**
The second decision	**T0 = zero milestone**	
Geological survey licence provided by the Ministry of the Environment	**T0**	**A protracted authorisation process will lead to a failure to comply with deadlines set out in the Concept**
Technical Report "Preliminary structural geological models of potential sites for the DGR"	T0+5 years	If the technical report is not completed, there will be a lack of data for the Site Assessment document
Technical Report "Preliminary feasibility studies for 4 sites, including the recommendation of the final and alternative sites"	T0+5 years	If the technical report is not completed, there will be a lack of data for the Site Assessment document

Activity	Milestone	Risk to the siting process if the activity fails
Technical Report "Preliminary safety case studies for 4 sites with screening safety assessments"	T0+5 years	If the technical report is not completed, there will be a lack of data for the Site Assessment document
Technical Report "The study of environmental impacts for 4 sites, including the recommendation of the final and alternative sites"	T0+5 years	If the technical report is not completed, there will be a lack of data for the Site Assessment document
Socio-economics studies for 4 sites	T0+5 years	If the studies are not completed, there will be a lack of data for the Site Assessment document
Technical Reports "Site Assessment documents" for 4 sites	**T0+6 years**	**If the Site Assessment documents are not completed, there will be no data available for the decision-making process**
Expert Team discussions		If no Expert Team is in place, there is a greater likelihood of NGOs disputing the decision
Recommendation of final and alternative sites and submission to the Government	**T0+6 years**	
Government approval of the decision		**Protracted discussion on and the postponement of Government approval may influence the milestones set out for the siting process and DGR construction and operation**
Final site approval		**If detailed investigation work fails to confirm the suitability of the site, the alternative site will be characterised.**

Activity	Milestone	Risk to the siting process if the activity fails
Ongoing activities		
Update of the Technical Report "Requirements and criteria for selecting a DGR site"	06/2017 If needed	Non-compliance with the various legal bases may lead to the non-acceptance of the regulator.
Update of the R&D Plan	10/2019 If needed	Neglecting R&D, lessons learned and the needs of the DGR development process may negatively affect the management of the process
Communication with the regulatory body and the responsible state authorities.	regularly	An insufficient level of communication indicates that the process is being badly managed
Monitoring of new trends, standards and international experience in the nuclear energy field.	regularly	Neglecting new trends and international experience indicates that the process is being badly managed
Periodic review of the Project Plan, timetable, financial analysis and quality management system. Lessons learnt from last steps	annually	Neglecting lessons learned from the process, QA standards and economic issues indicates that the process is being badly managed
Workshops on the subject: “Data needs for site characterisation”	continuously	A non-competent team may arrive at the wrong decision
Communications strategy concerning the DGR project	continuously	The lack of a transparent communications strategy will complicate the process and, potentially, render it worthless

6 References

Act No. 263/2016 Coll. (Atomic Act) and relevant Decrees.

Act No. 114/1992 Coll. on Nature and Landscape Protection.

Act No. 100/2001 Coll. on Environmental Impact Assessment.

Act No. 41/1988 Coll. (Mining Act)

Concept for RAW and SNF management in the Czech Republic, approved by the Government on 15 May 2002, by means of Decision No. 487/2002.

EU Council Directive 2009/71/EURATOM

EU Council Directive 2011/70/EURATOM

IAEA (1997): Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.

IAEA (2014): Managing Environmental Impact Assessment for Construction and Operation in New Nuclear Power Programmes. IAEA Nuclear Energy Series No. NG-T-3.11

OECD/NEA (1995): The Environmental and Ethical Basis of Geological Disposal of Long-lived Radioactive Wastes. A Collective Opinion of the Radioactive Waste Management Committee of the OECD Nuclear Energy Agency.

OECD/NEA (1999): Confidence in the Long-Term Safety of Deep Geological Repositories: Its Communication and Development.

Convention on Nuclear Safety (1994).

WENRA (2014): Radioactive Waste Disposal Facilities Safety Reference Levels. Working Group on Waste and Decommissioning (WGWD).

WENRA (2015): Guidance Document. Issue T: Natural Hazards. Head Document (Guidance for the WENRA Safety Reference Levels for Natural Hazards introduced as lesson learned from TEPCO Fukushima Dai-Ichi accident).

EPRI (2015): Identification of External Hazards for Analysis in Probabilistic Risk Assessment. Update of Report 1022997. Electric Power Research Institute, Technical Report, 142 pp. October 2015.

SF-1. Fundamental Safety Principles. Safety Fundamentals No. SF-1. International Atomic Energy Agency, Vienna, 2006.

SSR-5. Disposal of radioactive waste. Specific Safety Requirements No. SSR-5. International Atomic Energy Agency, Vienna, 2011.

NS-R-3. Site Evaluation for Nuclear Installation, Safety Requirements. Standards Series No. NS-R-3, Rev. 1. IAEA. Vienna 2016.

GSR Part 1. Governmental, legal and regulatory framework for safety. General Safety Requirements Part 1. International Atomic Energy Agency, Vienna 2010.

GSR Part 3. Radiation protection and safety of radiation sources. General safety requirements, Safety standard series No. GSR Part 3. International Atomic Energy Agency, Vienna, 2014.

SSG-9. Seismic Hazards in Site Evaluation for Nuclear Installations. Specific Safety Guide, Safety Standards Series No. SSG-9. IAEA. Vienna 2010.

SSG-14. Geological disposal facilities for radioactive waste. Specific Safety Guide No. SSG-14. International Atomic Energy Agency, Vienna, 2011.

SSG-21. Volcanic Hazards in Site Evaluation for Nuclear Installations. Specific Safety Guide, Safety Standards Series No. SSG-21. IAEA. Vienna 2012.

SSG-35. Site survey and site selection for nuclear installations. Specific Safety Guide, Safety Standards Series No. SSG-35. IAEA. Vienna. 2015.

GS-G-4.1. Format and content of the safety analysis report for nuclear power plants. Safety guide. International Atomic Energy Agency, Vienna 2004.

TECDOC-1767. The Contribution of Palaeoseismology to Seismic Hazard Assessment in Site Evaluation for Nuclear Installations. IAEA-TECDOC series. International Atomic Energy Agency, Vienna 2015.

TECDOC-767. Safety indicators in different time frames for the safety assessment of underground radioactive waste repositories. IAEA-TECDOC series. International Atomic Energy Agency, Vienna 1994.

Aarhus Convention (International Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters). Århus, 25th June 1998. Ratified in the Czech Republic in 2004.

The European SPIN project (2000-09-01 - 2002-11-01). Identifying and testing indicators for sensing the long-term performance of geological repositories. Project FIKW–CT–2000–00081.

VOKÁL A., POSPÍŠKOVÁ I., VONDROVIC L., KOVÁČIK M., STEINEROVÁ L., DUSÍLEK P., WOLLER F. (2015): Requirements, suitability indicators and criteria for the selection of potential deep geological repository sites, Technical Report, SÚRAO 2/2015.

VAĽOČÍK J., PRACHAŘ I. (2016): Expert assessment of external hazards. Technical Report, Amec Foster Wheeler s.r.o.

POSPÍŠKOVÁ I., VOKÁL A., VONDROVIC L. et al (2015), Medium-term plan for research and development of activities needed for DGR siting, 2015 – 2025, SÜRAO 1/2015

NAŠE BEZPEČNÁ BUDOUCNOST

SÚRAO

Správa úložišť radioaktivních odpadů
Dlážděná 6, 110 00 Praha 1
Tel.: 221 421 511, E-mail: info@surao.cz
www.surao.cz