

# THE LONG-TERM SAFETY CASE FOR GEOLOGICAL DISPOSAL OF RADIOACTIVE WASTE ITS CONCEPT AND CONTINUING EVOLUTION



**D**isposal of long-lived radioactive waste in engineered facilities or repositories, located in deep geological formations, is being researched, developed and implemented as the ultimate solution to protect humans and the environment for periods of time that can be compared with geological time scales. Over the past two decades, the international radioactive waste management community has established important concepts, methods and tools to address this challenge.

A long-term "safety case" documents evidence, analyses and arguments that are needed to satisfy the implementer, the technical regulator and the society at large that the facility will provide the required safe isolation and containment of the radioactive waste. Within the OECD Nuclear Energy Agency, the Integration Group for the Safety Case (IGSC) is dedicated to consolidating international best practices, to issuing guidance and to supporting future developments in the area of the safety case both for the long-term and for the operational safety of repositories.

## What is a long-term safety case?

A long-term safety case for geological disposal of radioactive waste is the synthesis of evidence, analyses and arguments to affirm that a repository will be radiologically safe by itself after repository closure.

A long-term safety case is continually developed and examined at specific points in the stepwise process of repository development and is part of the documentation that is needed for a legal permit to develop a repository project further. The long-term safety case includes a confidence statement to illustrate the sufficiency of

information / knowledge to support the decision at hand, and to identify topics that will require further attention in the next stage of development.

A long-term safety case is typically prepared also to help reviewing the current status of a project, to test the methods used in safety assessment or to prioritize the R&D programme, and it serves as a platform for informed discussions between the implementer and the technical regulatory authority, as well as with experts and other stakeholders.

## What are the essential elements of a long-term safety case?

The essential elements of a long-term safety case are (see below figure):

§ A **statement of purpose and context** describing the repository development programme, its current stage and relevant decision point. This sets the context for the type of information and level of detail that are needed at the time.

§ A description of the **safety strategy**, which is the high-level approach to achieve and demonstrate long-term safe disposal. It includes descriptions of (a) the strategy for managing the required activities for repository planning and implementation such as quality assurance approach and procedures, (b) the strategy for siting and design, including the principles

and legal requirements to be adhered to, such as distance from areas of known natural resources and the implementation of best available technologies entailing proportionate costs and (c) the strategy for assessing long-term safety, namely, how events and processes relevant to long-term safety are identified and how they will be taken into account in the safety analyses. The formulation of the long-term safety strategy provides sufficient flexibility to cope with new information and technical developments in later phases of the project.

§ The **assessment basis** is the collection of data, information and tools needed for assessing safety both qualitatively and quantitatively. It comprises a description of the repository and its geological setting;



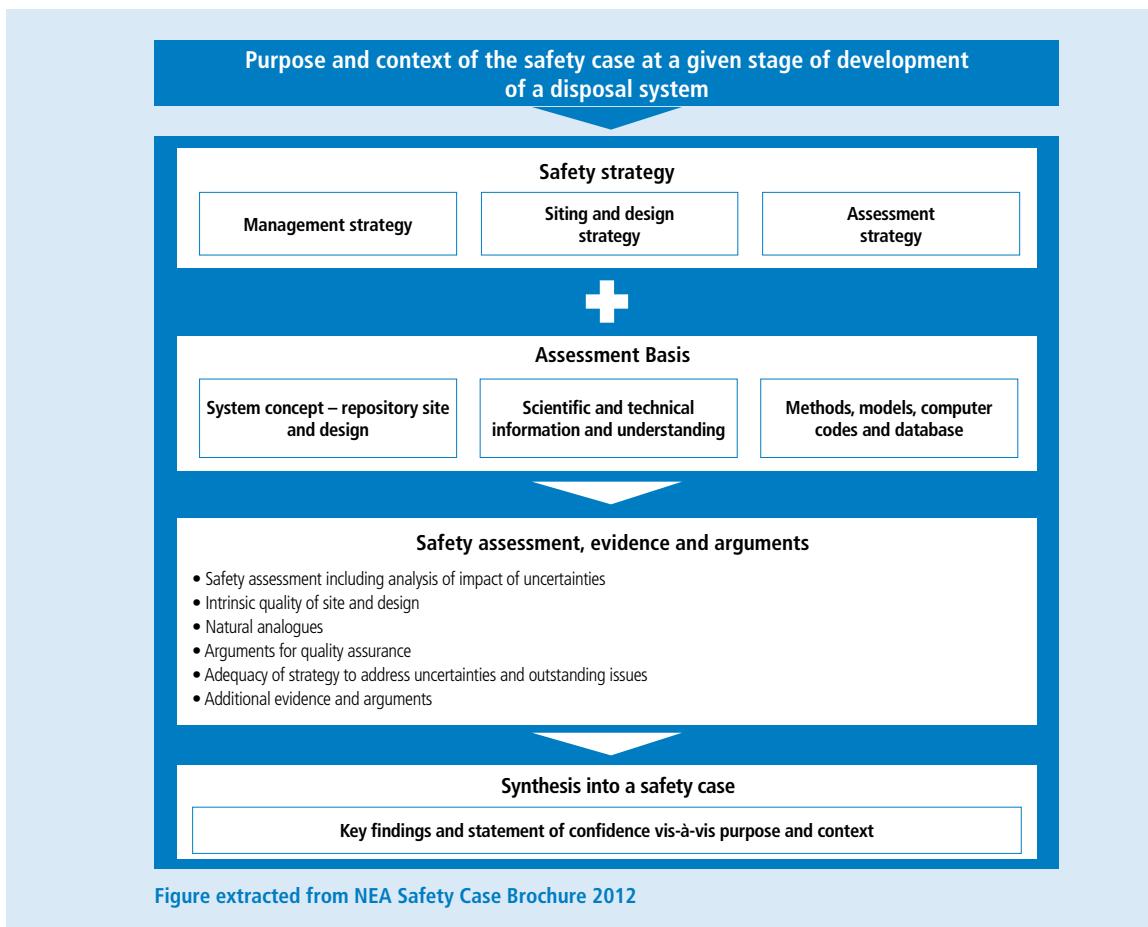


Figure extracted from NEA Safety Case Brochure 2012

the relevant technical data; the present scientific understanding; the range of evolution scenarios to be addressed; and the methods, models, computer codes and databases to be used for analysing performance. Evidence and arguments are also included to support the quality and reliability of the information and to illustrate the depth of the current understanding.

behaviour of the system over a range of scenarios. The information also includes how safety is affected by uncertainty. Multiple complementary lines of evidence are used as arguments that give additional confidence in safety. To the extent that repository operations may also affect long-term safety, these operational aspects are also taken into account.

## § Safety Assessment, evidence and arguments

**for safety.** This is the core part of a safety case, where the performance and robustness of the system are assessed. The safety assessment illustrates how the site and design of the repository fulfil the relevant safety functions and meet the technical requirements for the intrinsic safety of the installation. The quantitative estimate of the potential radiological consequences is presented based on a range of possible evolutions of the system over time. Insights are provided on the

**§ The synthesis into a safety case** summarizes the foundations for long-term safety while describing the uncertainties that remain and further efforts to increase the robustness of the predictions. A statement of confidence is included as to the existence, at the current stage, of sufficient confidence in long-term safety to justify a decision to proceed to the next stage of planning or implementing a disposal system (or to otherwise meet the needs of the study, if it was intended for a different purpose).

## How and why did the concept of a long-term safety case develop?

The concept of a long-term safety case arose in the mid-90s. The concept recognises that the results of numerical calculations do not, by themselves, provide sufficient confidence in safety. In a long-term safety case, the results of safety assessment – i.e., the

calculated numerical results for safety indicators such as radiological dose – are supplemented by a broader range of evidence that gives context to the conclusions and provides complementary arguments, either quantitative or qualitative.

## *Operational safety*

Historically, long-term safety studies have been the driving factors in design and development of geological repositories, because the post-closure time will be much longer than operational times of repositories and because of the unprecedented challenge to show that the repository will be radiologically safe by itself for such extensive periods of time. Also, depending on national regulations, operational and long-term safety may be addressed under separate regulations.

As deep geological repositories for spent fuel and high-level waste are close to being developed, consensus has arisen on the need to give, in the long-term safety case, an appropriate weight to operational aspects that may have long-term safety implications. In particular, measures are needed to ensure that the requirements for operational safety and post closure safety are considered together when optimising for radiological protection.

## *How is a long-term safety case documented and presented?*

The documentation of a safety case may be organised in various ways. Separate sections or reports may address specific topics (for example: safety assessment, site characterisation and engineering design). A hierarchical structure of documentation may be used to convey key results in a simplified way, while retaining the detailed technical basis. This approach is also useful to make information accessible and understandable to various audiences with a range of technical and non-technical backgrounds.

Terminology for the long-term safety case is not uniform across national programmes; a "long-term safety case" may be referred to as a 'safety case' or 'a post-closure safety case', or a "post-closure safety

assessment". In fact, not all programmes use the term 'long-term safety case' to describe the broader range of arguments and evidence of which the safety assessment forms one part (see figure). In France, for example, the word 'dossier' has been used to capture the idea of a compilation of information relevant to judging safety. Other terms used are 'safety evaluations', 'safety reports' or 'license application' (depending on the purpose and decision at hand).

Regardless of the exact structure or label attached to such reports, the essential features are that they reflect the elements defined in international guidance and national regulations to support safety and that they are adapted for the intended audience and stage of repository development.

## *What is the current international situation?*

Recent development in national programmes and NEA activities show that long-term safety cases are useful tools both for legal purposes and for building confidence for a wide range of stakeholders. The safety case concept and elements are used by radioactive waste management programmes worldwide and there is international consensus on best practices for many elements and aspects of safety cases.

Numerous national programmes are developing comprehensive safety cases. Programmes in earlier stages of development may focus on specific aspects of the scientific or modelling basis in anticipation of making a broader, long-term safety case later. Long-term safety evaluations performed at various stages are used to refine site characterisation plans, experimental approaches, designs and modelling tools in subsequent stages.

Differences in scope and in degree of detail of long-

term safety cases reflect the progression in planning and implementing a geological repository. It takes time and resources to develop an information base, a R&D programme and sufficient modelling capability to assess the long-term performance of a proposed repository in an integrated way. As development of a geological programme progresses a long-term safety case matures and is progressively refined through this iterative process.

National programmes in NEA countries also continually refine the scientific basis and methods that underpin long-term safety cases. Developments include:

- Structured documentation to improve the clarity and traceability of information.
- More sophisticated analytical tools and databases.
- The concept of 'safety functions', which describe key aspects of disposal system performance and make

more transparent the role of various components (and their synergies) in the repository system.

- Use of performance and safety indicators besides the traditional ones of radiation dose and risk.
- Discussion – in the safety case – of issues of concern and the identification of a path forwards to resolution.

The preparation of a long-term safety case is a complex endeavour. It requires the integration of many different disciplines in a way that satisfies a wide range of potential reviewers. Studies and information must be kept updated over the decades that a repository is expected to operate. This requires

resources for continuous review of the state of the art and investments in knowledge management, both within organisations and by the wider society. Waste management agencies increasingly recognise these organisational aspects and are developing means to address them.

International cooperation, e.g., through the Integration Group for the Safety Case (IGSC) of the OECD Nuclear Energy Agency, plays an important role in the formulation of the long-term safety case concept. The programme of work of the IGSC supports and documents best practices as the concept and implementation of safety cases continue to evolve.

## *General considerations to establish credibility*

In order to be credible, the long-term safety case documentation must be broadly auditable by a number of audiences including, but also beyond, the technical regulator. A number of additional considerations must be taken into account when preparing the safety case. These include:

- Transparency. A safety case should be both clear and understandable to the intended audience(s); the objective is to inform the audience's decisions regarding safety.

- Traceability. For more technical audiences, it must be possible to trace all key assumptions, data and their bases, either in the main safety case documents or in readily available supporting records.
- Openness. Remaining uncertainties and open technical questions that may affect safety or confidence in safety should be discussed in documentation.
- Peer review. Both internal and external peer reviews are valuable tools for enhancing confidence in a safety case on the part of its author, and also the wider scientific and technical community

A LONG-TERM SAFETY CASE FOR GEOLOGICAL DISPOSAL OF RADIOACTIVE WASTE IS THE SYNTHESIS OF EVIDENCE, ANALYSES AND ARGUMENTS TO AFFIRM THAT A REPOSITORY WILL BE RADIOLOGICALLY SAFE BY ITSELF AFTER REPOSITORY CLOSURE. A LONG-TERM SAFETY CASE IS CONTINUALLY DEVELOPED AND EXAMINED AT SPECIFIC POINTS IN THE STEPWISE PROCESS OF REPOSITORY DEVELOPMENT AND IS PART OF THE DOCUMENTATION THAT IS NEEDED FOR A LEGAL PERMIT TO DEVELOP A REPOSITORY PROJECT FURTHER. THE PREPARATION OF A LONG-TERM SAFETY CASE IS A COMPLEX ENDEAVOUR. IT REQUIRES THE INTEGRATION OF MANY DIFFERENT DISCIPLINES IN A WAY THAT SATISFIES A WIDE RANGE OF POTENTIAL REVIEWERS AND MUST BE BROADLY AUDITABLE FROM A NUMBER OF AUDIENCES INCLUDING, AND BEYOND, THE TECHNICAL REGULATOR. INTERNATIONAL COOPERATION HAS PLAYED AN IMPORTANT ROLE IN ESTABLISHING THE MODERN CONCEPT OF THE LONG-TERM SAFETY CASE AND PLAYS A SIMILAR ROLE IN THE REFINEMENT OF ITS PRACTICE.