NEA Perspectives on the Status of European Safety Cases

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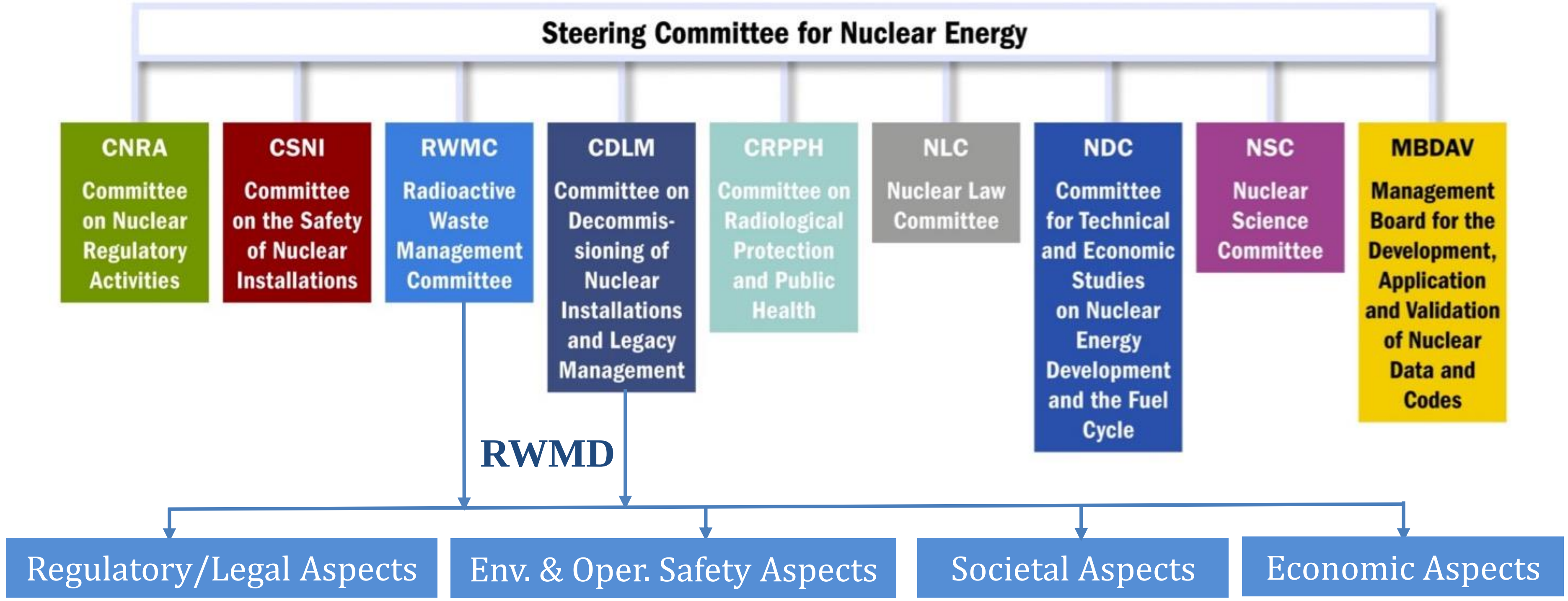
The NEA: 33 Countries Seeking Excellence in Nuclear Safety, Technology, and Policy

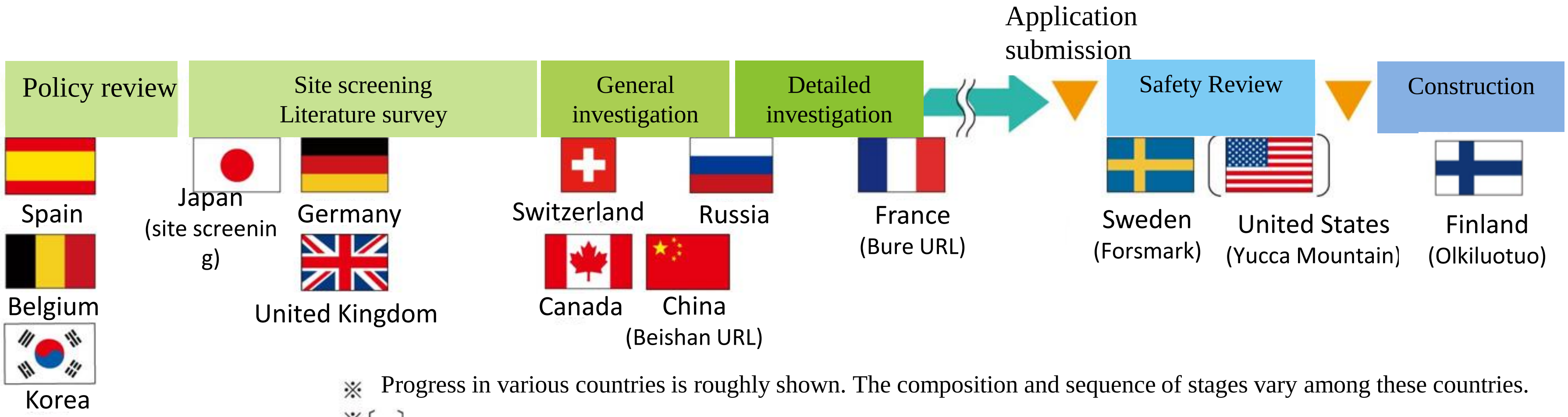
- 33 member countries + partners (e.g., China, India, Brazil, etc.)
- 8 standing technical committees and about 80 working parties and expert groups
- 24 international joint projects
- The NEA Data Bank - providing nuclear data, code, and verification services
- Growing global relationships with industry and universities

NEA countries operate about 80% of the world's installed nuclear capacity

The RWMD Supports 2 Standing Technical Committees



Status of DGR Projects Worldwide



※ Progress in various countries is roughly shown. The composition and sequence of stages vary among these countries.

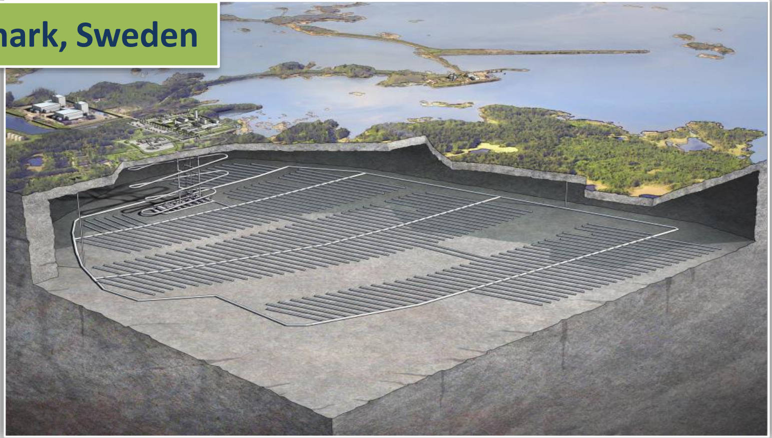
※〔 〕 The project is suspended now.

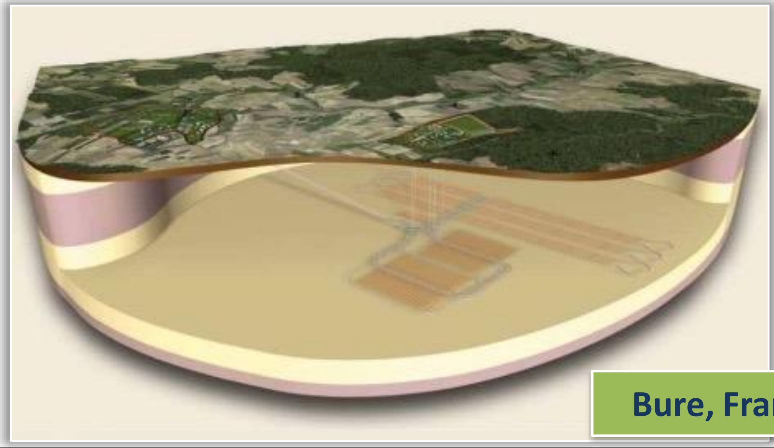
Revised from the picture on this webpage: https://www.numo.or.jp/chisoushobun/overseas/efforts.html

Safety Cases for Leading National DGR Projects

Waste type	Country	Location	Formation	Status	Year of Safety Cases
HLW/SF	Finland	Eurajoki	Crystalline rock	Under construction	2012
HLW/SF	Sweden	Forsmark	Crystalline rock	Licence pending	2011
LILW-LL & HLW/SF	France	Region of Bure (URL)	Callovo-Oxfordian Clay	Siting region identified	Argile 2001&2005 Granite 2002&2005&2009

Forsmark, Sweden





Bure, France

The Safety Case and its Use

- A safety case is a formal compilation of evidence, analyses and arguments that quantify and substantiate a claim that the disposal will be safe.
- A safety case has to demonstrate the possible evolutions and performance of a chosen site, its host rock, the engineered system is safe – bounded with confidence.
- A safety case is presented to support a decision, to help reviewing project status, to test safety assessment methods, or to prioritize R&D activities.

Milestones in the Development of Safety Cases

1989

NEA Symposium

First consolidation of the state of the art in safety assessment methods

1994 - 2002

NEA Expert Group on Integrated Performance Assessment (IPAG)

started in 1994 and developed the concept of a safety case which is adopted by national programmes

2000 - ongoing

NEA Integration Group for the Safety Case (IGSC)

started in 2000 and develops the scientific basis, strategies and tools for safety cases of DGRs

NEA Activities on Safety Cases

Radioactive Waste Management Committee (RWMC)

Integration Group for the Safety Case (IGSC)

Working Group on the Characterisation, the Understanding and the Performance of Argillaceous Rocks as Repository Host Formations (Clay Club)

Expert Group on Repositories in Rock Salt Formations (Salt Club)

Expert Group on Geological Repositories in Crystalline Rock Formations – Crystalline Club (CRC)

Expert Group on Operational Safety (EGOS)

(Participation of 13 European Countries in IGSC)

NEA Activities on Safety Cases: Main Themes

Activities of IGSC and Relevant Groups at the NEA

Scientific Basis

- Geoscientific evidence of 3 kinds of host rock
- Performance of engineered barriers
- Sources and transport of gases
- Assessment of unknown issues

Safety Assessment Strategy & Tool

- Feature, Event and Process (FEP) Database
- Scenario development methodologies
- Deterministic and probabilistic approaches to assessment and uncertainty analysis
- Thermochemical Database (TDB) of Data Bank

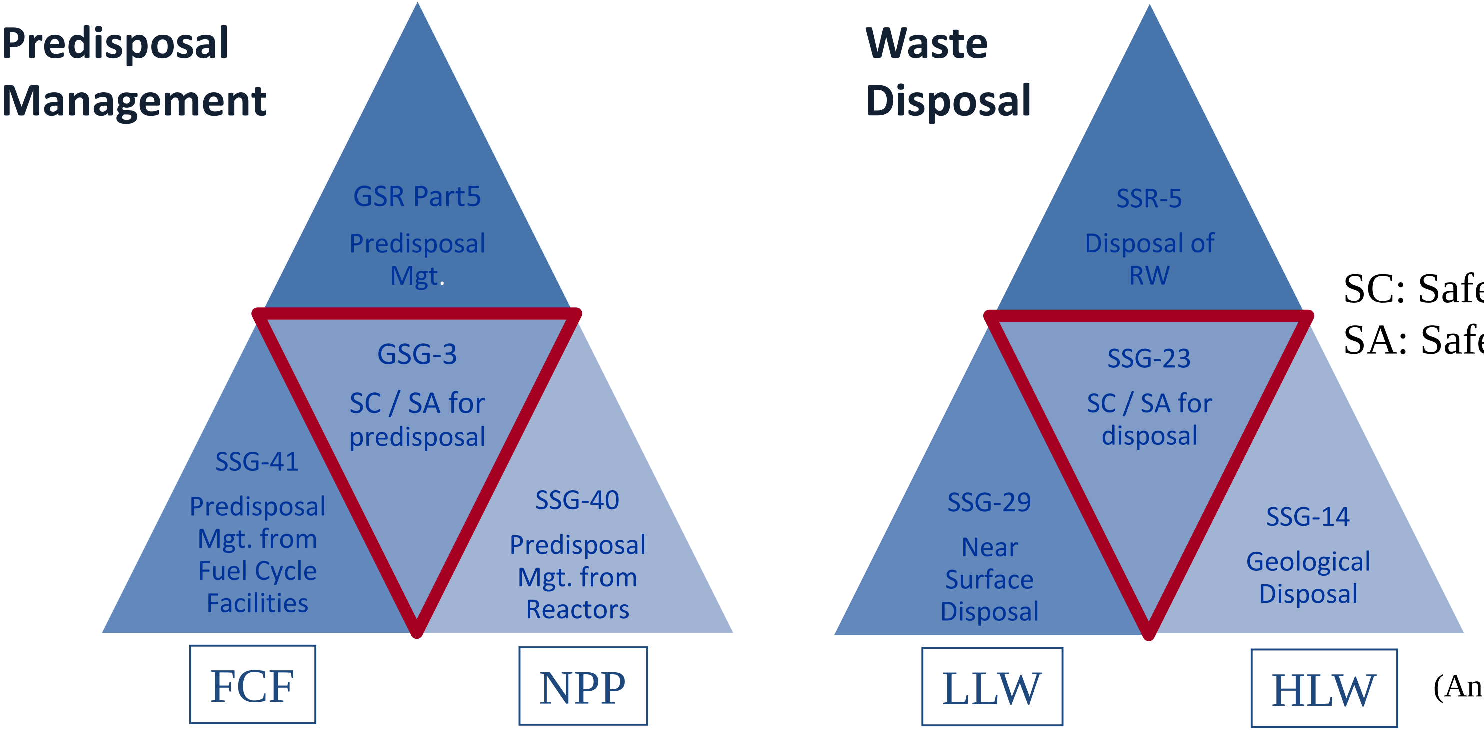
Design & Implementation

- Design pf engineered barrier system
- Operational safety
- Reversibility and retrievability – RWMC Project

Information Management & Communication

- Preservation of records and memory across generations
- Information management – collaboration with Expert Group on a Data and Information Management Strategy for the Safety Case (EGSSC)
- Communication with stakeholders – collaboration with Forum on Stakeholder Confidence (FSC)

Safety Requirements: IAEA Standards

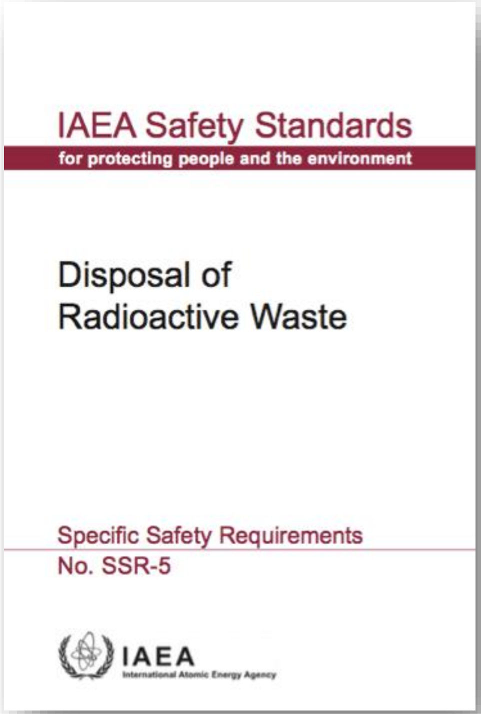


SC: Safety Case
SA: Safety Assessment

(Andrew Orrell, 2018)

Safety Requirements: IAEA Standards

- **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, in operation and after closure.
  - Shall be submitted to the regulatory body for approval.
  - Shall demonstrate the level of protection of people and the environment provided and shall provide assurance to the regulatory body and other interested parties that safety requirements will be met.


IAEA Safety Standards
for protecting people and the environment

Disposal of Radioactive Waste

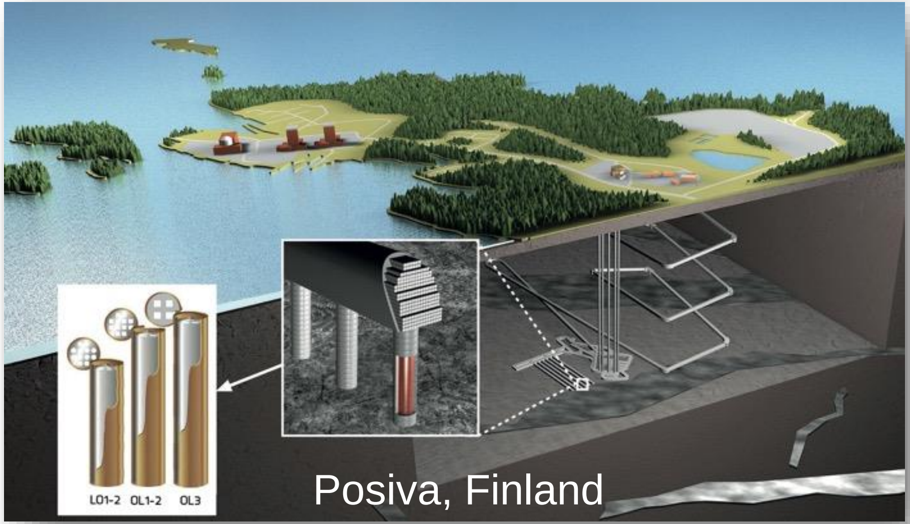
Specific Safety Requirements
No. SSR-5

IAEA
International Atomic Energy Agency

Safety Requirements: Finnish Example

- **Law**
  - **Government Decree on the Safety of Disposal of Nuclear Waste (736/2008):** compliance with the requirements shall be proven through a safety case
- **Guide**
  - **Disposal of Nuclear Waste (YVL D.5/2013):** detailed requirements on the content of a safety case to demonstrate long-term safety

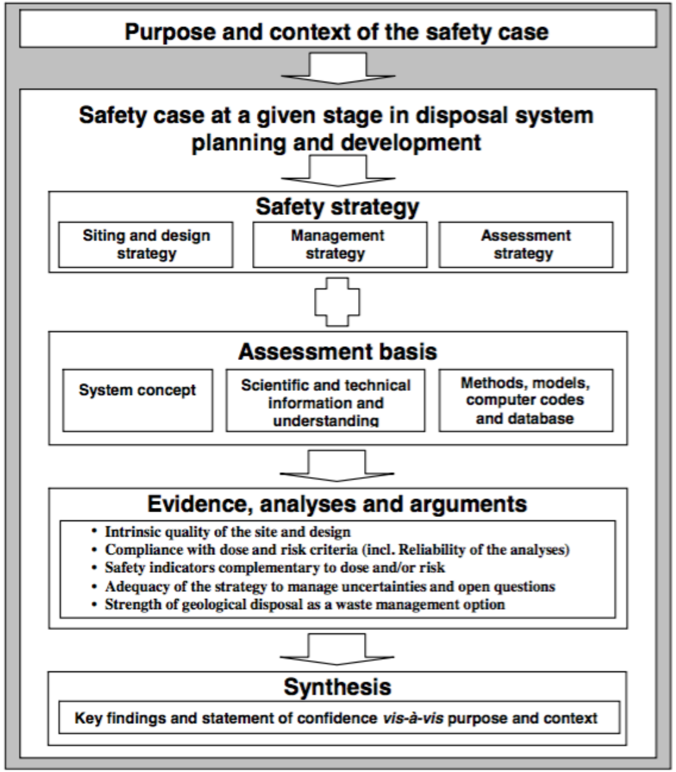
Onkalo Spent Nuclear Fuel Repository



Safety Case Production

- No universal format, key elements accepted worldwide are:
  - a statement of purpose and context,
  - safety strategy,
  - assessment basis,
  - safety assessment,
  - synthesis

(NEA, 2004)



Main Steps of Safety Assessment for Forsmark DGR in Sweden

Reference design | Site description | R&D results | Results of earlier assessments | FEP databases

1 Processing of features, event and processes (FEPs)

2a Description of site initial state

2b Description of engineered barrier system (EBS) initial state

2c Description of repository layouts

3 Description of external conditions

4 Compilation of Process reports

5 Definition of safety functions and function indicators

6 Compilation of input data

7 Definition and analyses of reference evolution

8 Selection of scenarios

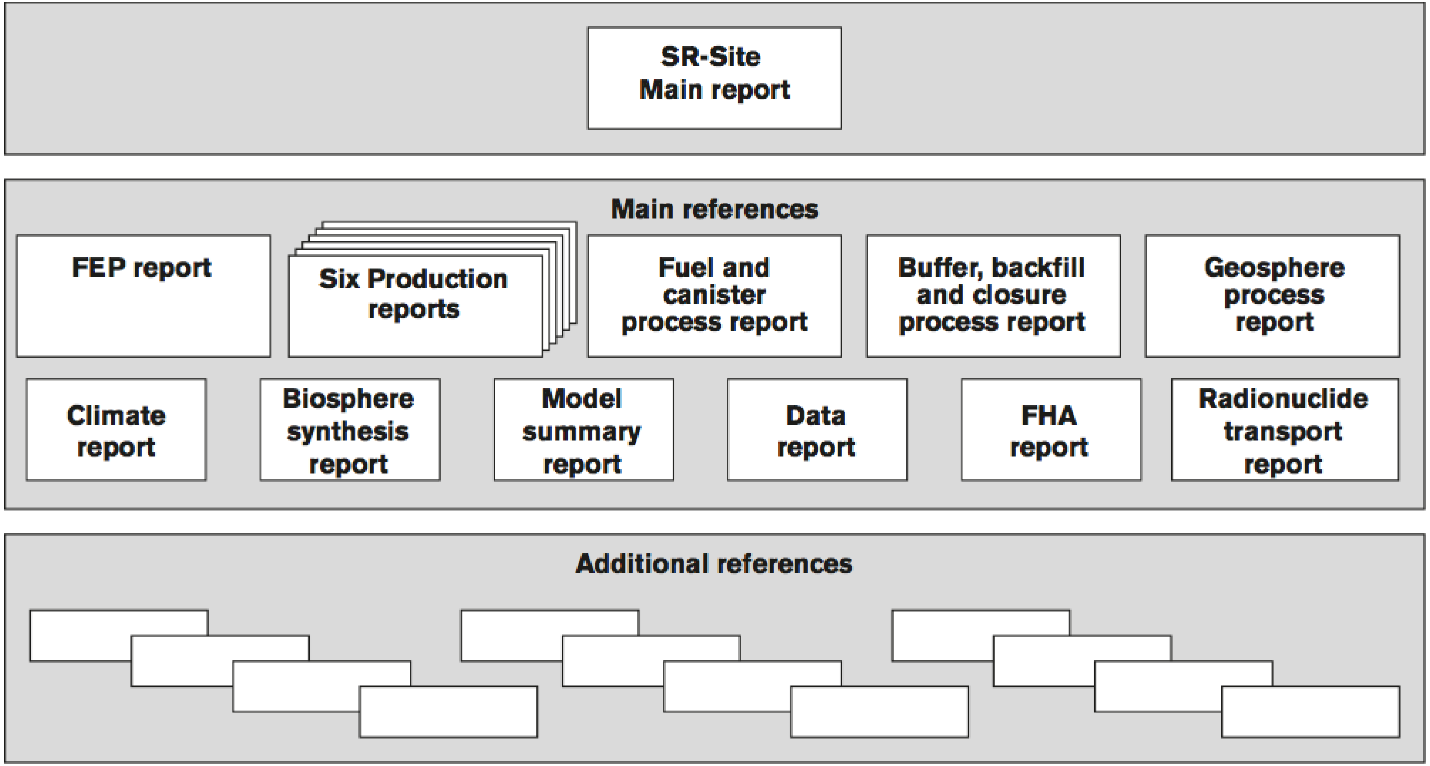
9 Analyses of selected scenarios

10 Additional analyses

11 Conclusions

(SKB, 2011)

Structure of SR-Site Report for Forsmark DGR in Sweden



(SKB, 2011)

Safety Assessment (SA)

- **Roles**
  - To quantify the disposal system performance;
  - To evaluate confidence;
  - To provide the required input to support decision making.
- While no standardized structure for SA, typical building blocks include:
  - Scenarios;
  - Modelling;
  - Outcomes of SA;
  - Handling of uncertainty

Scenarios

- **Roles**
  - To describe a potential evolution of the disposal system from a given initial state;
  - As a basis for assessing safety by assessing the consequences.
- **Key Points**
  - Scenarios are derived by compiling safety relevant information;
  - Conceptually described scenarios in conceptual models and mathematical models;
  - Important to examine what scenarios could “endanger” safety functions.

Modelling

- Models improve understanding of the processes + their relevance for safety.
- Modelling can demonstrate compliance.
- Models do not provide exact predictions. They illustrate possible ranges of system performance which support the safety case, i.e. multiple lines of evidence.
- Deterministic assessment: fixed, single-valued parameters.
- Probabilistic analysis is often used to assist the choice of data for deterministic calculations.

Outcomes of Safety Assessment

- Numerical results for specific **safety indicators** (e.g. potential dose / risk) + statements concerning uncertainty / sensitivity in calculations synthesis of evidence, analyses and arguments that quantify / support the safety case;
- Based on the available evidence, arguments and analyses, synthesis should show all relevant data have been considered, models tested adequately, a rational assessment procedure has been followed;
- Discuss limitations of the presented evidence, arguments and analyses;
- Revise the assessment or the design in cases of lack of confidence

IAEA Classification of Indicators by Purpose

Indicators

Safety Indicators

- A measure of the overall safety of the entire repository system
- Usually compared with quantities (i.e. reference values)
- Calculated repository releases VS equivalent abundances of naturally occurring radionuclides in the rocks and groundwaters at the repository site

Performance Indicators

- A measure of the behaviour of an individual repository component or sub-system
- Usually compared with independent quantities (i.e. indicator criteria)
- Containment times provided by individual barriers or the flux of radionuclides across them

(IAEA, 2003)

NEA Classification of Indicators in Safety Cases

Indicators

Primary Indicators

- Typically dose and risk
- Compared to a legally or regulatory defined radiological constraint

Complementary Indicators

- Indicators at the sub-system and component or process level

	Compartment			
Indicator Type	Wasteform	Engineered barriers	Geosphere	Biosphere
Concentration and content indicators	✓	✓	✓	✓
Flux indicators		→	→	→
Status of barrier indicators	✓	✓	✓	

(NEA, 2012)

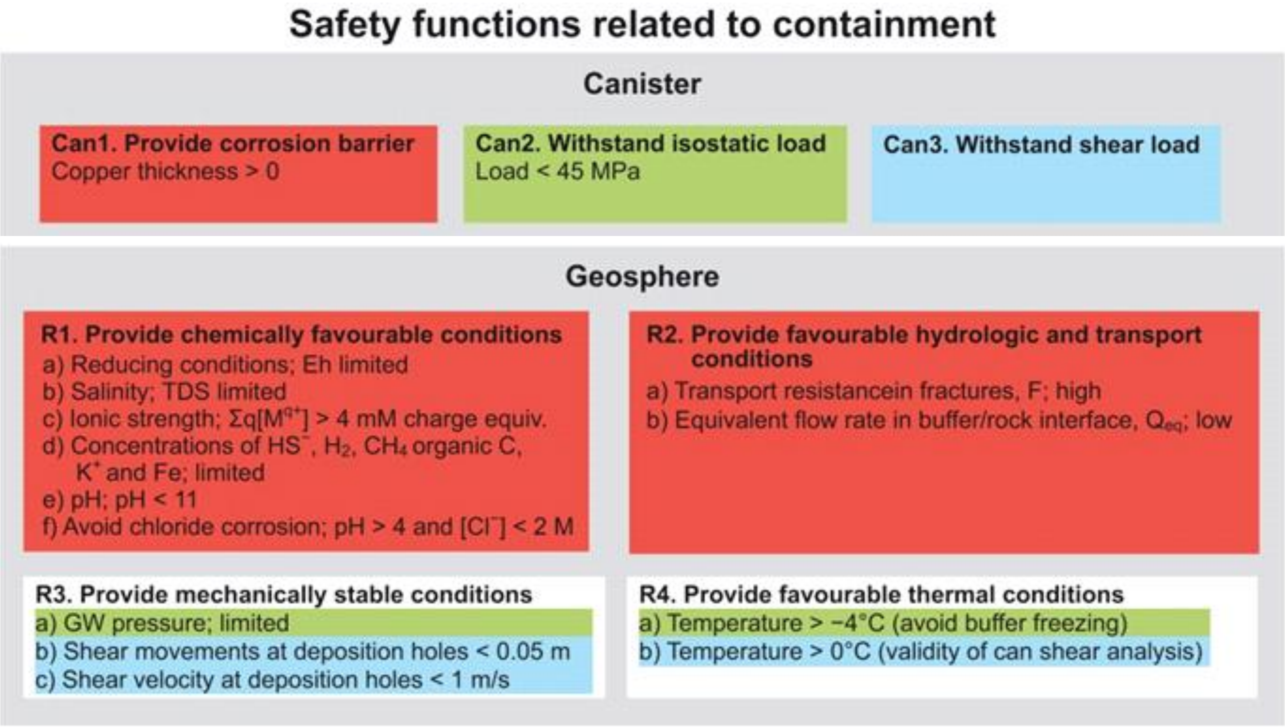
Performance Indicator Examples in Finnish Safety Cases

- STUK in Finland is the first regulatory authority to include a constraint on the amount of activity that may be released from the repository to the accessible environment.
- The requirements on nuclide-specific radioactivity fluxes:
  - 0.03 GBq/a for the long-lived, alpha emitting Ra, Th, Pa, Pu, Am and Cm isotopes;
  - 0.1 GBq/a for the nuclides ^{79}Se, ^{129}I and ^{237}Np;
  - 0.3 GBq/a for the nuclides ^{14}C, ^{36}Cl and ^{135}Cs and for the long-lived U isotopes;
  - 1 GBq/a for ^{94}Nb and ^{126}Sn;
  - 3 GBq/a for the nuclide ^{99}Tc;
  - 10 GBq/a for the nuclide ^{93}Zr;
  - 30 GBq/a for the nuclide ^{59}Ni; and
  - 100 GBq/a for the nuclides ^{107}Pd and ^{151}Sm.

(STUK, 2009)

Performance Indicator Examples in Swedish Safety Cases

- Based on the process identification, 14 safety functions related to the primary safety function “containment” and 15 safety function for the secondary safety function “retardation” were derived.



(NEA, 2012)

A Performance Indicator Example in French Safety Cases

- **Indicator**
  - The distribution of dissolved radionuclide concentrations in the host clay rock and in the surrounding sedimentary formations
- **Safety functions**
  - ‘limiting the release of radionuclides and immobilising them in the repository’
  - ‘delaying and reducing the migration of radionuclides
- **Performance Statement**
  - Callovo-Oxfordian clay host rock can lead to “almost total confinement of actinides within a zone only a few meters wide in the near-field clay adjacent to the disposal cells”.

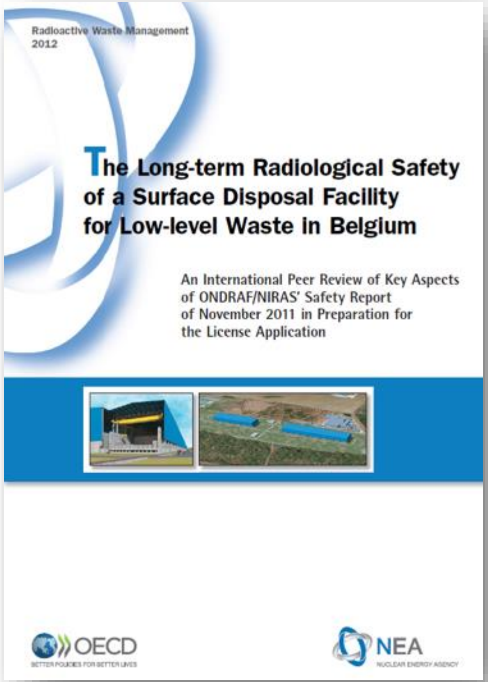
(Bure URL, France)

Safety Case Production: Challenges

- **Integration**
  - Integration requires interdisciplinary collaborative working and the pooling of knowledge and experience from safety assessors and subject-matter experts.
- **Handling of uncertainty**
  - The challenge is to show that any uncertainty that could call the safety case into question can be avoided, mitigated or reduced.
- **Knowledge management**
  - Managing the ever-increasing amounts of information and knowledge across a project lifetime spanning multiple generations is a challenge.
- **Optimisation**
  - Optimisation accounts not only for safety requirements, but also factors such as use of resources and social expectations.

NEA Activities on Safety Cases: Peer Review

- **Aim**
  - Ensure the best practices in the regulatory and technical methodologies are adopted
- **European examples**
  - Safety cases of surface disposal facilities (Belgium)
  - Safety cases of deep disposal facilities (France, Sweden, Switzerland)
  - R&D programme on the deep geological disposal (Belgium, France)
  - Methodology for scenario and conceptual model development (UK)



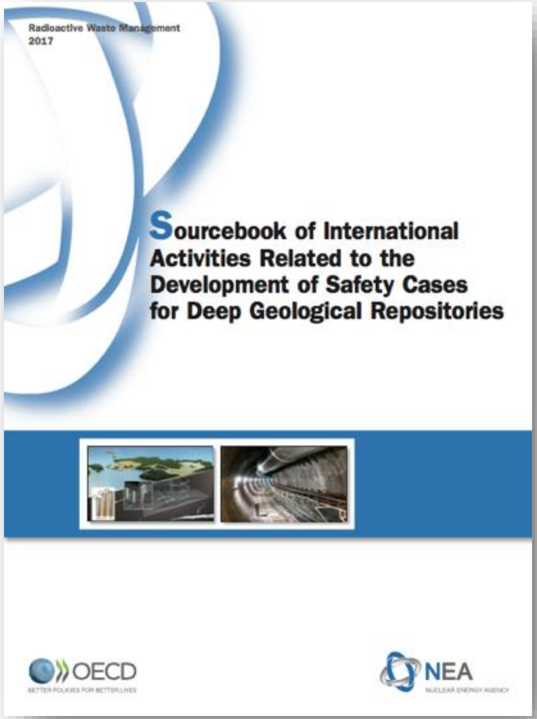
Conclusions

- The safety case is an essential tool to support decision-making at every stage of a geological disposal programme.
- Internationally, the safety case has been incorporated in IAEA's Safety Standards, and some national regulatory requirements are formulated on the basis of the safety case concept.
- Evidence of the use of safety case could be seen by Finland and Sweden.
- The key challenge is communicating safety case to all stakeholders.

(Joint IGSC and FSC Workshop, 2017)

Resources

- Integration Group for the Safety Case (IGSC)
  www.oecd-nea.org/rwm/igsc/
- Feature, Event and Process (FEP) Database
  www.oecd-nea.org/fepdb
- Thermochemical Database (TDB) Project
  www.oecd-nea.org/dbtdb/
- Peer Review www.oecd-nea.org/rwm/peer.html
- Sourcebook of International Activities Related to the Development of Safety Cases for Deep Geological Repositories www.oecd-nea.org/rwm/pubs/2017/7341-sourcebook-safety-cases.pdf



Thank you for your attention

If you have questions of this presentation, contact Rebecca Tadesse [Rebecca.Tadesse@oecd-nea.org].

www.oecd-nea.org/rwm/