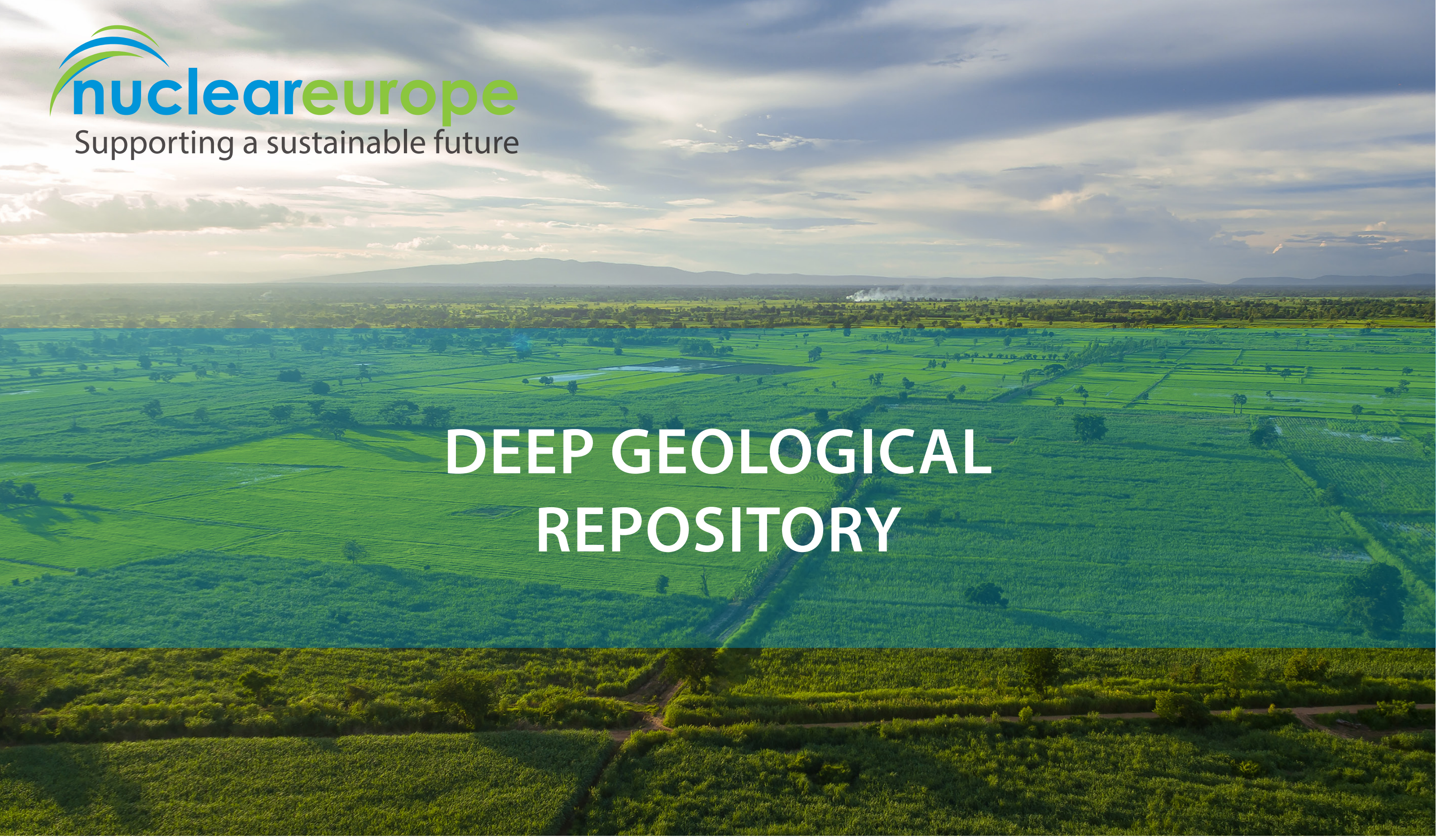

DEEP GEOLOGICAL REPOSITORY

NUCLEAR

IS A LOW-CARBON ENERGY SOURCE

ENSURES SECURITY OF SUPPLY

IS ENVIRONMENTALLY, ECONOMICALLY AND SOCIALLY SUSTAINABLE

EU NUCLEAR INDUSTRY IN NUMBERS

ACCOUNTS FOR **25%** OF ELECTRICITY

ALMOST **50%** OF LOW-CARBON ELECTRICITY

SUPPORTS AROUND **1Mn** JOBS

TURNOVER OF **100bn** PER YEAR

September 2022

Introduction

Many countries around the world operate or are considering building nuclear power plants. Nuclear is an efficient and reliable source of energy which contributes towards the development of the economy and human well-being. It also helps in the fight against climate change. Nevertheless, there are discussions ongoing around the world about nuclear as a technology and one of the main issues raised in this respect is the long-term management of radioactive waste.

The nuclear industry produces a very large amount of energy from a very small amount of fuel. Furthermore, the amount of waste produced during this process is also small when compared to the volume of energy produced. Only around 3% of the waste produced is radioactive and must therefore be carefully handled through specific channels. Radioactive waste is by-product of nuclear reactors, fuel production plants, medical and industrial facilities andresearch infrastructure. Radioactive waste also has to be managed during the decommissioning and dismantling of nuclear reactors and other nuclear facilities.

Of the different types of radioactive waste, spent nuclear fuel (SF) which has not been reprocessed and high-level waste (HLW) require long-term disposal. Prior to disposal, these are safely managed in different nuclear facilities with effective and safe interim storage granting experts the time needed to assess the best solution for the final disposal of HLW and SF. The scientific consensus today is that deep geological repositories (DGRs) are a safe and effective approach for the permanent disposal of HLW/SF.

The purpose of this document is to provide information regarding the final disposal of HLW and SF.

1. What is a Deep Geological Repository (DGR)?

According to the International Atomic Energy Agency (IAEA) Safety Glossary (2018 Edition) a DGR is defined as "*a facility for radioactive waste disposal located underground (usually several hundred metres or more below the surface) in a stable geological formation to provide long term isolation of radionuclides from the biosphere*". DGR's ensure safe radioactive waste management, thus protecting people and the environment from radioactive waste.

The concept of disposal is based on the properties of different clays and rocks (including their retention potential, low permeability, homogeneity, clay from geological formation or clay in engineered barrier) which can delay and mitigate the migration of the radioactive substances found in the low, intermediate and high-level waste destined for deep underground disposal. The aim is to delay their interaction with the biosphere until they pose no more of a danger than natural radioactivity.

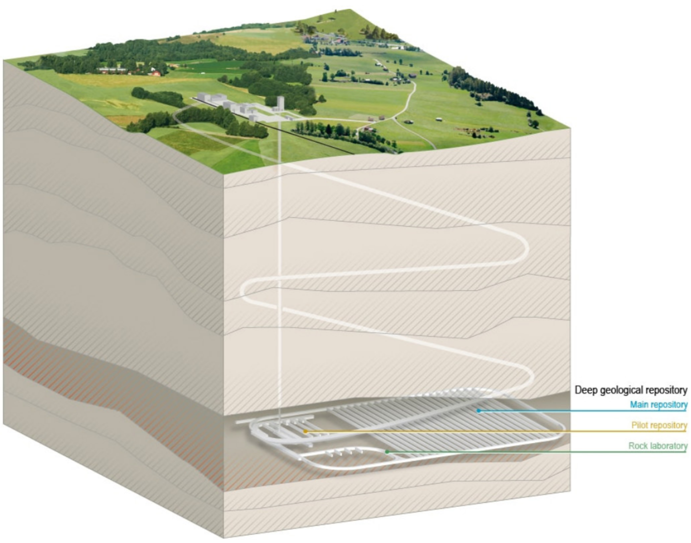

Figure 1: Illustration of a potential DGR design – Swiss Federal Safety Inspectorate (ENSI)

2. How does a DGR work?

A DGR is a facility built within a suitable geological formation that can be sealed, providing a passive barrier which ensures the long-term protection of people and the environment. Physical changes in geological formations are extremely slow in human terms: they stretch over geological ages, i.e., over millions of years. This means that the radioactive waste can be safely kept away from the living environment in the long-term without requiring maintenance or human surveillance after the DGR is closed.

DGRs use both an engineered barrier system and a portion of the natural geology, hydrology, and geochemical processes of the site to isolate radioactivity.

3. Waste Conditioning

Conditioning is defined according to the IAEA Safety Glossary (2018 Edition) as "Those operations that produce a waste package suitable for handling, transport, storage and/or disposal".

The waste package, which acts as an engineered barrier, is designed to ensure operational protection during interim storage, transport and packaging handling operations. It may also provide a long-term containment feature. In addition, it could include the conversion of the waste to a solid waste form, enclosure of the waste in containers and, if necessary, provision of additional layers of protection overpack .

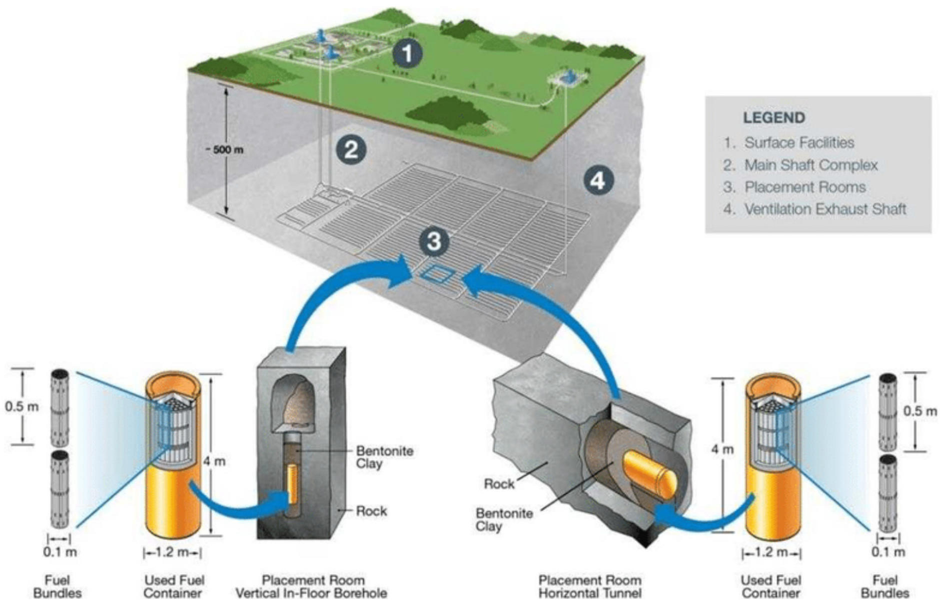

Figure 2: 2017, David S. Hall, Peter George Keech. *An overview of the Canadian corrosion program for the long-term management of nuclear waste*

4. Spent nuclear fuel, high-level waste and long-lived radioactive waste

The high-level and long-lived radioactive waste placed into the DGRs consist of, for example:

- Spent nuclear fuel
- Graphite used in the reactor
- High-level waste[1]
- Intermediate level long-lived waste[2]

[1] See nucleareurope's Background paper on RWSF for examples

[2]Ibid.

5. National policies

In general, radioactive waste and SF management are a national matter. Each Member State is responsible for considering the options in accordance with its own legal framework. Although Member States are required by EU law to report regularly on their inventories, they are free to choose their own approaches and to use their own methods and tools based on specific national circumstances and conditions.

For the moment such a national focus is still highly prevalent. There is a common political basis (or shared objective) which is to consider that the present generation must resolve waste management issues without placing any undue burden on future generations. However, many of the national programs plan to postpone their decision on final disposal or SF reprocessing far into the future. Some countries, with small volumes of radioactive waste, are looking into the possibility of either developing a common international repository or making use of a larger repository in another Member State. But these options are only expected to become available in a relatively distant future.

The development of any DGR project is crucial, not only for the management of national waste inventories, but also in order to support consistencies between political objectives and effective short-term policies.

Options for managing high-level waste

A HLW management scheme can be described as follows:

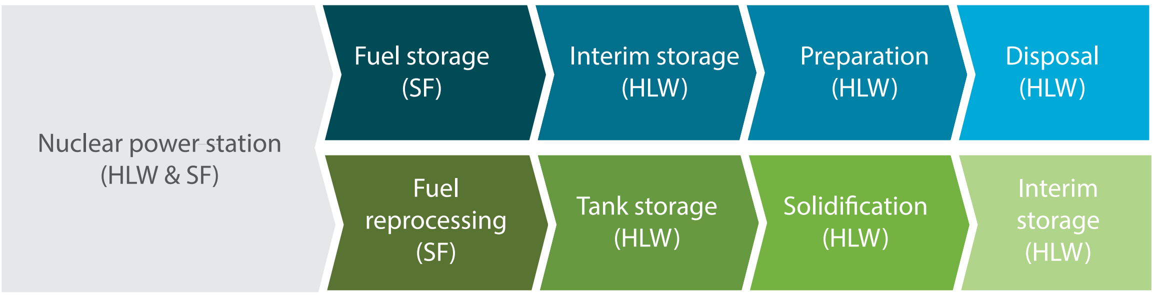

Figure 3: Generation, conditioning, storage, and disposal of SF/HLW[3]

6. Are DGRs a safe solution for the final dispose of HLW/SF and long-lived radioactive waste?

The IAEA has recognised that: "*The safety of geological disposal is widely accepted amongst the technical community and a number of countries have now decided to move forward with this option*"[4].

European Council Directive 2011/70/EURATOM[5] (establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste) states in paragraph 23 that "*deep geological disposal represents the safest and most sustainable option as the end point of the management of high-level waste*".

Long-term safety is based on the concept of multi-barriers. Radioactive substances are contained within a variety of barriers in order to ensure that radioactive waste cannot be released into the environment or accessible to human beings. Whilst each barrier supports the other, they remain as independent of each other as possible, in order to ensure that the failure of one barrier does not jeopardize the overall functioning of the isolation mechanism. Barriers include the physical condition of the fuel, the disposal canister, the bentonite clay buffer, the backfilling of the tunnels and the surrounding rock.

[3] IAEA BULLETIN -VOL.21, NO.4

[4] IAEA (2003). The Long-Term Storage of Radioactive Waste: Safety and Sustainability

[5] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32011L0070

All Member States with nuclear power programmes (with the exception of one[6]) have plans to develop geological disposal facilities. Of these 15 Member States, Finland, France, and Sweden have demonstrated concrete steps towards practical implementation of such facilities.

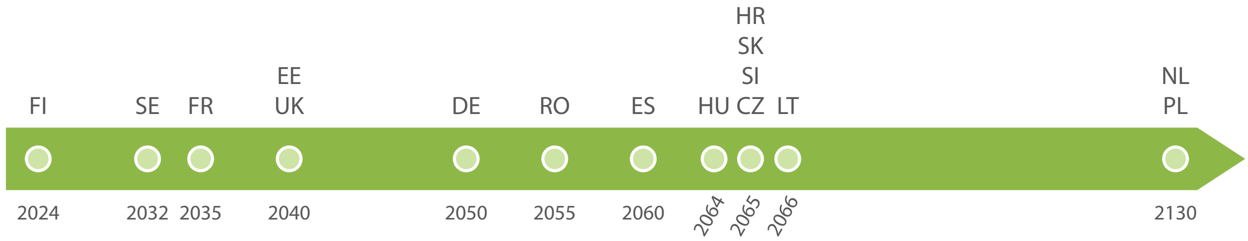

Figure 4: European Union Member States planning for DGR[7]

7. Which locations and geologies are suitable for the construction of DGRs?

Following decades of scientific research, sites located in a variety of host rocks are being recommended as suitable for DGRs. Supported by site investigations and Underground Research Laboratories (URLs), sites are being selected, established and developed in, for example:

- Granite host rock (URL and DGR Finland)
- Granite host rock (URL and DGR Sweden)
- Clay host rock (URL and DGR France)
- Clay host rock Research Facility (Belgium)

8. Reversibility and retrievability concepts

The planning and implementation of a DGR incorporates distinct stages with decisions to be taken at each stage. In this respect, technical, regulatory and policy developments may lead to changes and adaptations. For example, safety considerations for such facilities may evolve as more knowledge is gained about the site's features and there is improved understanding of events and processes relevant to the performance of the repository.

Changing conditions relating to the facility can affect not only current decisions but may also lead to the re-evaluation of earlier decisions. Consequently, it may be useful to apply a flexible approach to the decision-making process as this can facilitate the ability to reverse decisions (reversibility) and to retrieve the radioactive waste (retrievability).

The concepts of reversibility and retrievability are currently being discussed and defined within the national program of several countries, with views continuing to differ on their desirability, as well as on the methods and degree to which they should be implemented.

[6] Italy.

[7] European Commission (2019). Communication on progress of implementation of Council Directive 2011/70/EURATOM and an inventory of radioactive waste and spent fuel present in the Community's territory and the future prospects.

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About us

nucleareurope is the Brussels-based trade association for the nuclear energy industry in Europe. The membership of nucleareurope is made up of 15 national nuclear associations and through these associations, nucleareurope represents nearly 3,000 European companies working in the industry and supporting around 1.1 million jobs.

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