

Final disposal of radioactive waste

- There is a strong, international scientific consensus that deep geological repositories (DGRs) are a safe and effective approach to the permanent disposal of high-level wastes and spent nuclear fuel.
- Countries are successfully selecting sites for DGRs using open and transparent activities that involve stakeholders as equal participants in the decision process. These positive experiences are shared through the Nuclear Energy Agency (NEA) Forum on Stakeholder Confidence.
- Demonstration of waste disposal technologies and analyses in underground research laboratories further increases confidence that DGRs are protective of both people and the environment. Several countries are implementing these demonstrations and have shared their experiences. The lessons learnt were a key area of interest in the recent meeting of the International Roundtable on Final Disposal of High-Level Radioactive Waste.
- The first DGR will likely be in Finland, with operations beginning around 2023.
- Confidence in the safe management and disposal of nuclear wastes is very high in the international scientific community, assurance that nuclear energy is on a sustainable and environmentally advantageous path towards a decarbonised energy future.

What's the issue?

Many countries around the world are either currently operating or are considering building nuclear power plants. For some countries, nuclear energy is an important component of their strategies to address climate change while assuring access to cost-effective and reliable energy. However, there has been debate about the “sustainability” of nuclear energy. Some have expressed the opinion that the high-level wastes and spent nuclear fuel from the operation of nuclear power plants presents an insurmountable challenge for which no solution exists, making nuclear energy “unsustainable.”

To the contrary, the facts demonstrate that nuclear waste is managed safely and effectively around the world and there is a strong scientific consensus regarding the safe disposal of high-level radioactive wastes.

Radioactive waste results from many different activities in health care, industry, research, and power production. All such waste must be managed safely, with the protection of human health and the environment as the highest priority. These materials

receive far more attention and technical analyses than hazardous wastes from industrial processes, which are produced in much larger quantities.

After decades of research, the international scientific community is confident that placing high-level radioactive waste in DGRs is safe and effective. The safety strategy for geologic disposal has been developed over many decades. A DGR isolates and contains the spent nuclear fuel and high-level waste (HLW) over very long time periods through the combination of robust engineered barriers and the intrinsic properties of the host rock that provides a stable safe environment. The passive safety features of the DGR make it possible to protect humans and the environment in the very long term without requiring any maintenance or remediation action by future generations. A DGR is comprised of multiple safety barriers that increases the robustness of the facility so that safety is not dependent on a single barrier, which is consistent with a defence-in-depth principle, a usual practice in the nuclear field for ensuring safety.

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Scientific investigation into the feasibility of DGRs for the safe disposal of spent nuclear fuel (SNF) HLW has proceeded for decades at a cautious and deliberative pace that has significantly expanded the volume and quality of scientific information on the safety of geological disposal.

Today there are dozens of underground research laboratories investigating and optimising DGR engineering by collecting information on specific rock characteristics to isolate and contain waste. All the scientific information is made available as part of the peer review that continuously advances the understanding of the safety provided by a DGR. Today there is scientific consensus that DGRs provide the best solution for the disposal of HLW and SNF.

Long-term radioactive waste management, including geological disposal, involves the construction of disposal sites and other facilities and it is therefore a national challenge with a strong local and regional dimension. DGRs are already in operation in some countries for different types of wastes – including radioactive waste.

Timeframes into the distant future cause all stakeholders to question the confidence in the safety case for a DGR. While it is difficult to guarantee the performance of a human-made construction for several hundred years, scientists agree that DGRs developed in suitable geological formations provide a stable and predictable environment over the very long time frames associated with these geological formations that already span millions of years. The stability of geological formations for siting a DGR is based on a global geological understanding derived from active earth science research that supports stability for geological formations far beyond the time periods required for the long-term containment and isolation of SNF HLW. The scientific evidence of the selected host rock makes it possible to

demonstrate the post-closure safety of a DGR as the proven stability of the geological characteristics and environment provide the multiple safety functions of the DGR in a fully passive way, even should human memory of the DGR be lost.

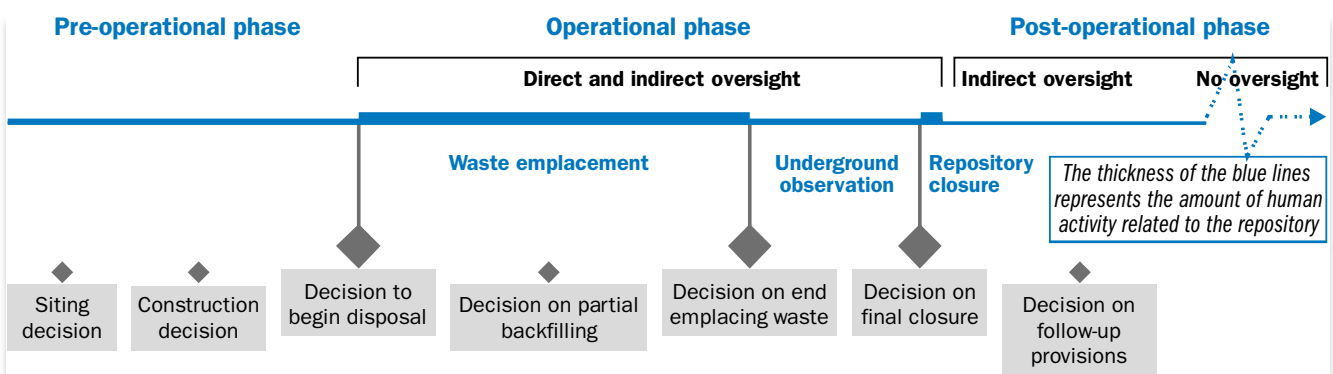
Public information, consultation and/or participation in environmental or technological decision making must take place in different forums, in different locations and at different times (Figure 1). Assuring national commitment and obtaining strong local and regional involvement in decision making are two essential dimensions of the complex task of securing continued societal agreement for the deep geological disposal of radioactive waste.

There has been limited progress in some countries in developing DGRs, but this is not due to scientific or technological uncertainty but rather because of the careful, deliberative stakeholder processes underway to ensure that the public has confidence in the safety of the facility and the fairness of the criteria used for site selection.

Where technical questions arise, they are not questions about the safety or sustainability of the DGR approach but more likely to be engineering issues in the specific approaches taken in some designs. Such issues are expected in a complex undertaking such as the construction of a DGR.

Several countries are making very good progress towards the establishment of DGRs. In particular, after a long and careful technical assessment, the national safety authority of Finland has granted a licence to construct a DGR. This national waste management programme is on track to begin disposal operations by the mid-2020s.

Figure 1. Repository life phases and examples of major decision points



Why is this important?

While the government of each country has the absolute right and responsibility to implement the energy and environmental policies it believes are best, it is paramount that these important matters are informed by objective facts. In the case of the attributes of nuclear energy and the disposal of radioactive waste, debates should be informed by objective facts.

The strong scientific consensus regarding the use of DGRs for the disposal of nuclear wastes has been developed after decades of scientific analyses, engineering tests, development and operation of underground research laboratories, and actual operation of deep geologic repositories.

The basis for the development of safety cases for the deep geological disposal of radioactive waste is assuring safety over the long period during which the radioactive waste remains hazardous. The largest part of the intrinsic hazard of the waste decreases with time, but some hazard remains for extremely long periods. Safety cases for geological disposal typically address performance and protection for thousands to hundreds of thousands of years into the future. The very concept of the DGR is to dispose the waste in a well-characterised geological formation, stable enough for the science to assure protection of humans and the environment over very long time frames.

Who is working on this?

The disposal of nuclear wastes is the responsibility of national governments. As such, they are supported by multinational organisations that collect and share expertise. Principally among these are the NEA, the Vienna-based International Atomic Energy Agency (IAEA) and the European Commission, all of which have various activities and publications addressing different aspects of the long-term management of all types of radioactive waste management and spent fuel.

While the science is solid, progress on developing DGRs requires deliberate and time-intensive work to engage public stakeholders in the decisions made regarding nuclear waste disposal.

Overall, there is widespread reporting of lessons learnt from both failures and successes in communicating technical information to non-technical audiences at an international level or by various international organisations. While certain areas where more research is needed have been identified (e.g. training in risk communication, public outreach techniques and the use of new tools such as social media), there is a need to continue developing approaches for effective dialogue. The NEA Forum on Stakeholder Confidence has been at work on this question for more than a decade and the NEA launched a new two-year initiative in 2019 to further investigate the key elements needed for effective regulator-implementer dialogue when developing geological disposal facilities.

What should policy makers do?

Policy makers should:

- Adopt an open, transparent and broadly participatory approach to managing radioactive waste.
- Use the time for dialogue with all stakeholders to address any remaining long-term technical and social uncertainties.
- Foster international dialogue at the strategic and policy levels to facilitate the exchange of existing experiences and approaches.

Today the greatest challenge in many countries to developing high-level radioactive waste disposal repositories is achieving public support and confidence. In countries with advanced DGR projects, both governments and the nuclear industry have invested a tremendous effort in building up a collective awareness on uncertainties and benefits of radioactive waste disposal facilities.

In modern societies, the implementation of any major, new technological project, despite the technical merits and proven safety, must satisfy societal and political requirements, which has been a particular challenge to geological disposal in many countries. Thus, while the choice to construct a deep geological repository have been made in several countries, others have experienced much slower progress, and in some cases progress has come to a standstill as options are further reviewed or put on hold while experience is further developed internationally.

In many countries, a more open, transparent and broadly participatory approach to managing radioactive waste is being adopted. A cautious and flexible step-wise decision process that offers the flexibility to reverse decisions when new knowledge becomes available is a common trend. Whether, when, and how to move towards geological disposal are decisions for each country. The decision process will be lengthy. Countries should therefore use the time for dialogue with all stakeholders with a view to addressing the long-term technical and social uncertainties.

International co-operation can help achieve national solutions – by sharing information, co-ordinating policies, conducting joint research, and developing a consensus on international standards. Over the years, technical and scientific co-operation have already been intensive. However, international dialogue at the strategic and policy levels can facilitate the exchange of existing experiences and approaches. In developing co-operation, it would be beneficial for national organisations to take an integrated and holistic view to assure safety and security for pre-disposal facilities and disposal repositories, both in the implementation of HLW management policies, programmes and in their regulatory oversight.

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Further reading

NEA (2015), *Fostering a Durable Relationship Between a Waste Management Facility and its Host Community*, OECD Publishing, Paris.

NEA (2010), *Radioactive Waste in Perspective*, OECD Publishing, Paris.

NEA (2009), *Considering Timescales in the Post-closure Safety of Geological Disposal of Radioactive Waste*, OECD Publishing, Paris.