DEEP GEOLOGICAL REPOSITORY AS A TOOL FOR STRATEGIC RAW-MATERIAL AND ENERGY INDEPENDENCE: LEGAL AND TECHNOLOGICAL ASPECTS

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1. Introduction

A deep geological repository for radioactive waste (DGR), particularly for spent nuclear fuel, constitutes one of the most significant infrastructure projects of the coming decades, with direct implications for the energy security and sovereignty of the Czech Republic. Given the exceptionally long time horizon of the project, its technological complexity, and its societal sensitivity, it is essential that it be accompanied by a coherent and predictable legal framework.[1]

This article analyses the DGR as a strategic instrument of a modern and responsible approach to the management of high-level radioactive waste—both in terms of energy and resource self-sufficiency and from the perspective of the legal, regulatory, and institutional dimensions of its planning, construction, and operation. It outlines the current state of Czech legislation, including the newly adopted Act on Proceedings Related to the Deep Geological Repository, and situates it within the international context, with a particular focus on Central European states.

Particular emphasis is placed on the issue of potential future reuse of the stored fuel (*retrievability*) and on the manner in which this possibility is reflected in legal regulations and policy documents across jurisdictions. The article further addresses long-term legal challenges, such as securing public trust, ensuring transparency in decision-making processes, and enshrining safety principles within a legal order designed to operate on a time scale spanning multiple generations.

The objective of this contribution is to advance scholarly debate on how legal regulation can—and must—respond to the exceptional nature of nuclear waste projects, and how legislation can be employed to support technological responsibility and societal legitimacy of decisions whose implications extend far into the future.

The following sections examine the DGR both as a tool of energy sovereignty and as a legal and technological challenge, before situating the Czech experience in a broader Central European and international context.

[1] KAMENÍKOVÁ, T. Fáze hlubinného úložiště | SÚRAO [online]. 29. 6. 2020 [cit. 7. 9. 2025]. https://surao.gov.cz/hlubinne-uloziste/faze-hlubinneho-uloziste/

2. The Deep Geological Repository as a Tool of Energy Sovereignty in the Nuclear Fuel Cycle

In today's geopolitical and climate context, energy sovereignty ranks among the foremost strategic objectives of most states. Independence from fuel imports, technological self-reliance, and the capacity to autonomously govern the management of domestic resources and waste are increasingly central to legal and policy strategies in the energy sector. Against this backdrop, the DGR assumes a broader significance—not merely as an instrument for the safe disposal of high-level radioactive waste, but as a cornerstone of the infrastructure underpinning long-term state sovereignty over the nuclear fuel cycle.

By establishing a DGR on its own territory, the Czech Republic is moving toward a closed nuclear fuel cycle, encompassing all stages of nuclear material management—from energy generation to the safe and permanent disposal of waste. This step frees the state from dependence on international contractual mechanisms whose legal and political reliability is uncertain over the long term. The repository thereby emerges not only as an environmentally responsible solution, but also as strategically and legally critical infrastructure for preserving sovereign control over sensitive nuclear materials.

From a legal standpoint, the repository forms part of the state's security and self-sufficiency policy[2]. Spent nuclear fuel stored therein should not be regarded solely as waste, but also as a potential resource—capable of serving future generations of reactors or being reprocessed for renewed use[3]. Accordingly, the principle of *retrievability*, i.e., the possibility of recovering stored waste, is increasingly recognized in international legal instruments[4]. This flexibility is gradually becoming embedded in repository regulation and enhances their function as a strategic asset.

Although not yet explicitly codified in Czech law, this principle is reflected in policy instruments, most notably the *Concept of Radioactive Waste and Spent Nuclear Fuel Management*, which specifies that "*the repository shall be designed so as to allow, for a certain period, the removal of waste (retrievability), should future technological developments enable its further utilization*."[5]

Thus, the DGR has already outgrown its role as a mere terminal facility for nuclear waste. Within the framework of energy law and the governance of strategic raw materials, it constitutes a key instrument for safeguarding long-term security,

[2] Concept of Radioactive Waste and Spent Nuclear Fuel Management, p. 113.

[3] OECD, Nuclear Energy Agency. Advanced Nuclear Fuel Cycles and Radioactive Waste Management. OECD, 2006, s. 13. https://www.oecd-nea.org/jcms/pl_14008

[4] Reversibility and Retrievability in Geologic Disposal of Radioactive Waste: Reflections at the International Level, p. 15.

[5] Concept of Radioactive Waste and Spent Nuclear Fuel Management, p. 113.

ensuring self-sufficiency, and fostering a responsible approach to the stewardship of nuclear fuel as a critical resource for both the present and the future.

3. The Deep Geological Repository: Significance, Technology, and Challenges

At the outset, it is important to clarify what a DGR actually is and why it is so significant for the Czech Republic.

In Czech legislation, the DGR is defined in Section 2 of Act No. 53/2024 Coll., on Proceedings Related to the Deep Geological Repository, as "*a nuclear installation intended for the permanent disposal of radioactive waste at a depth of at least 300 meters below the surface of the earth, located so as to meet nuclear safety requirements for the disposal of high-level waste*."

While most spent fuel is currently stored temporarily in interim storage facilities[6], the DGR is regarded as the only internationally recognized final solution. This approach is supported both by supranational organizations[7] and by national nuclear agencies[8].

A DGR is a facility designed for the permanent, safe, and geologically stable disposal of high-level radioactive waste, primarily spent nuclear fuel from nuclear power plants. This type of waste remains hazardous for tens of thousands of years and therefore planning a DGR is a process with an exceptionally long time horizon. The life cycle—from site selection, design, construction, operation, to gradual and final closure—may last over 100 years. Yet this is only a fraction of the period for which safety must be ensured. Geological formations and engineered barriers must perform their protective functions for hundreds of thousands of years, until the radioactivity of the waste decays to natural background levels.[9]

A fundamental principle of repository design is *passive safety*—safety guaranteed without reliance on human presence or technological oversight. This principle also accounts for possible social and civilizational changes over centuries. The multi-barrier concept—from container, to buffer materials, to the host rock—is the key safety feature. According to IAEA, the system must be robust enough to ensure radionuclide isolation even if one barrier fails.[10]

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[6] NOVOTNÁ, N. Dukovany repository | SÚRAO [online]. 6. 2. 2019 [cit. 25. 10. 2025]. https://surao.gov.cz/en/public/operational-repositories/dukovany-repository/

[7] Radioactive waste management [online]. Nuclear Energy Agency (NEA) [cit. 7. 9. 2025]. https://www.oecd-nea.org/jcms/c_12892/radioactive-waste-management

[8] This approach is being implemented in several European countries—e.g., Finland (Onkalo project), France (Cigéo), Sweden (Forsmark), and Switzerland.

[9] Moving forward with geological disposal of radioactive waste: a collective statement by the NEA Radioactive Waste Management Committee (RWMC). Paris, France: Nuclear Energy Agency, Organisation for Economic Co-operation and Development, 2008, p. 3.

[10] IAEA Safety Standards Disposal of Radioactive Waste. https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf

4. The Deep Geological Repository in Czech Republic

For the Czech Republic, the construction of a domestic repository is of fundamental importance, as it will enable closure of the entire cycle of radioactive waste management without dependence on foreign solutions. It is thus not only a matter of nuclear safety, but also of strengthening the state's energy sovereignty and self-sufficiency.

At the same time, it is a technologically highly demanding project with a long time horizon—the planned commissioning in the Czech Republic is currently projected around the year 2050[11]. By its very nature and scale, the DGR may be described as one of the largest infrastructure projects of the present era.

The Czech strategy, as expressed in the *Concept of Radioactive Waste and Spent Nuclear Fuel Management*, builds on this consensus and defines the repository as a key and indispensable element of national nuclear energy infrastructure. The document also stresses the need for planning with regard to interdisciplinary development, research, and openness to revising approaches should more effective solutions emerge in the future[12].

5. Comparison of Approaches to Nuclear Energy and Radioactive Waste Management in Central Europe

A comparative perspective illustrates how different Central European states approach nuclear energy and waste management. The following overview highlights key differences in legislative frameworks, institutional arrangements, and strategies

5.1 Czech Republic

The Czech Republic operates six nuclear units (Dukovany, Temelín) and plans further expansion by 2036. In line with a closed fuel cycle, it is preparing a DGR, though without legal provisions for retrievability. Waste is currently stored in interim facilities. Planning of the repository: site selection without proper legal anchoring of the process; Act No. 53/2024 Coll. on procedures related to the repository. The permitting procedure includes rights for municipalities and the public.

5.2 Poland

Poland does not yet operate any nuclear power plants but is intensively preparing for the construction of its first AP1000 reactor, planned for commissioning between 2033–2040. Until 1961 it operated the Różan surface repository for LILW, and it is preparing a new state facility (NSPOP) to be opened by 2033. Polish legislation includes the *Atomic Law* (2000), updated in 2023 by special nuclear legislation

[11] Concept of Radioactive Waste and Spent Nuclear Fuel Management, p. 50.

[12] Concept of Radioactive Waste and Spent Nuclear Fuel Management, p. 57.

that simplifies the permitting process for NPPs and SMRs. Reprocessing is not conducted; the country operates an open fuel cycle.

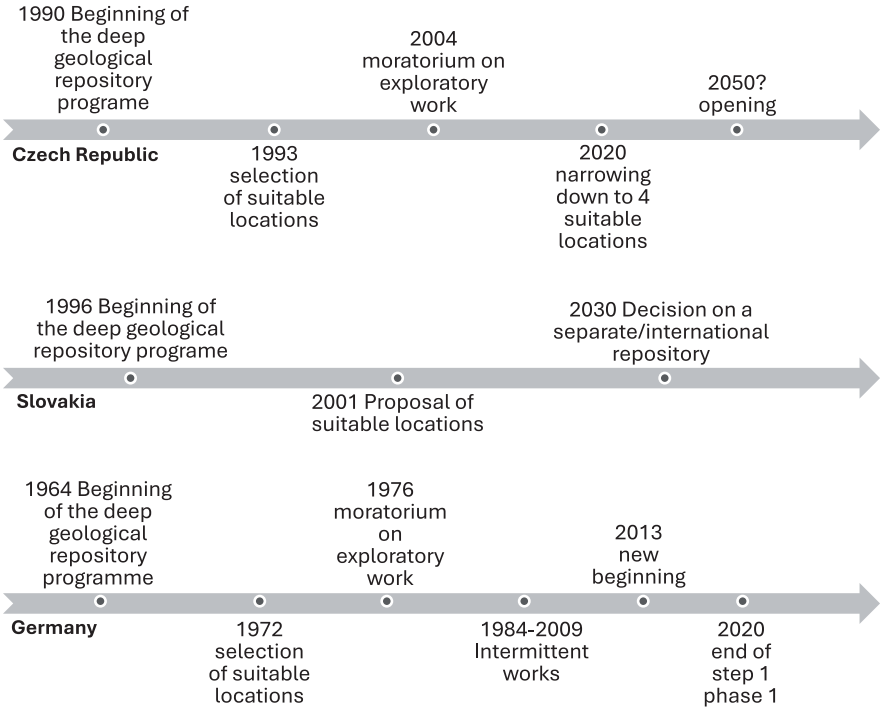
5.3 Slovakia

Slovakia operates five (almost six) reactors (Bohunice V2, Mochovce). Radioactive waste is stored in interim facilities, and a LILW repository is in operation at Mochovce. DGR is under preparation; strategic approaches were confirmed by the IAEA ARTEMIS mission (2023), which supported the DGR development. Legislatively, amendments were adopted within the EIA framework, and in December 2024 an EU committee requested a plan for recycling and decommissioning. Reprocessing is no longer practiced.

5.4 Germany

Germany shut down all nuclear power plants by 2022. Nevertheless, it continues its DGR project. The *Site Selection Act* (*StandAG*), adopted in 2017 and amended in 2024, reflects the principle of safety for millions of years and guarantees retrievability for 500 years. A state agency, BGE, was established for DGR operation, with independent oversight by BASE. Reprocessing is carried out abroad; retrievability is enshrined both legislatively and institutionally.

The timelines below illustrate the progression of selected countries in planning DGR. They demonstrate that, although Germany has the longest-standing repository program, it currently finds itself in a comparable position to the Czech Republic and Slovakia. The principal cause lies in inadequate public communication, which provoked sustained opposition and ultimately necessitated a full restart of the German project. In the Czech Republic, site-selection activities were likewise suspended due to public protests; however, the overall program was not discontinued and, upon its resumption, has proceeded with a significantly stronger emphasis on public participation. In Slovakia, by contrast, the process of identifying a suitable site is accompanied by an ongoing discussion as to whether establishing an international repository at the most geologically appropriate location might offer a more efficient solution.



6. Legal Framework and Institutional Arrangements for the Deep Geological Repository in the Czech Republic

The establishment of a DGR is an exceptionally complex process that requires a stable and predictable legal framework. The legal and institutional framework for the Czech DGR has gradually evolved, relying on three core instruments: the Act. No. 263/2016 Coll, the Atomic Act, its implementing decree No. 375/2016 Coll., and the newly adopted Act No. 53/2024 Coll, on Procedures Related to the Deep Geological Repository.

The Atomic Act and related regulations

The Atomic Act, sets out the framework conditions for managing radioactive waste, including the obligations of operators and state institutions. It also specifies requirements for nuclear safety, supervision, and the long-term protection of public health and the environment.

Implementing Decree No. 378/2016 Coll. further details requirements for exploration, site selection, and site assessment for the repository, including geology, hydrogeology, and risk analysis.

Act on procedures related to the repository, which was adopted to create a special procedural framework for repository-related proceedings. This law strengthens the consultative role of the public and affected municipalities in selecting the final site, conducting surveys, and defining protected zones.

Planning and preparation process

The planning of the repository proceeds in several stages. Following initial geological assessment comes the designation of the exploration area under the special act, then the selection of the preferred site. The Government of the Czech Republic confirms the final site, which opens the way for environmental impact assessment (EIA), engineering and preparatory works, zoning, and building permits.

After construction comes the operational phase, which includes long-term monitoring. An important principle here is gradual closure of the repository, which maintains flexibility in the first decades of operation—and thus the possibility of retrieving stored waste (*retrievability*).

Role of the state and key institutions

The Radioactive Waste Repository Authority (*SÚRAO*) plays the central role, as a state organization responsible for preparation, construction, operation, and closure of the repository. SÚRAO also prepares strategic documents and manages public information campaigns.

The State Office for Nuclear Safety (*SÚJB*) oversees nuclear safety, approves safety documentation, and issues licenses for each stage of preparation and operation.

The Ministry of the Environment (*MŽP*) plays a crucial role as the authority responsible for the EIA process and as the contact point for cross-border environmental assessments.

Together, these institutions form a multi-level system of governance intended to balance safety oversight, environmental protection, and public accountability.

This comprehensive system enables the Czech Republic to meet demanding safety and environmental requirements for radioactive waste disposal while simultaneously strengthening strategic control over the nuclear fuel cycle as an element of national sovereignty.

7. Retrievability

DGR is not only a key element of strategic energy independence, but also a long-term and responsible method of managing high-level waste. An important component of modern repository concepts is the possibility of future retrieval (*retrievability*) and re-use of stored waste if technical or energy conditions require it.[13]

[13] NEA. *Reversibility and Retrievability in Geologic Disposal of Radioactive Waste: Reflections at the International Level*, p. 13.

Retrievability represents an important element of both technological and legal flexibility. With the development of reprocessing technologies and Generation IV reactors, retrievability may become a key instrument of energy self-sufficiency. The Czech Republic has the technical capacity and strategic documents addressing this option, but clear legislative anchoring is missing.

Comparative experience shows that this principle is increasingly reflected in international instruments and national policies, where it serves as a means of preserving flexibility in light of future technological developments. Enshrining retrievability in Czech law would therefore align domestic regulation with emerging international standards and strengthen the legitimacy of the repository project by demonstrating openness to innovation and responsible long-term stewardship of nuclear materials.

At the same time, it is crucial that the scope of retrievability be carefully limited in time. A repository cannot remain indefinitely accessible without undermining its primary function as a final disposal solution. Extended or unlimited retrievability would create long-term safety risks, increase the vulnerability of the facility, and delay the eventual closure that is essential for intergenerational responsibility. A legal framework that guarantees retrievability for a defined period—sufficient to allow for potential reuse or reprocessing should viable technologies emerge—while simultaneously setting a clear end point for closure, would best reconcile the competing objectives of flexibility, safety, and legal certainty.

Such an approach would allow the Czech Republic to fulfil the principles of responsible and sustainable management of strategic materials and to align with European standards in nuclear policy. Examples include national waste management programs of Finland, France, Germany, and Switzerland.

Anchoring retrievability in law would therefore not weaken but rather reinforce the DGR's role as a pillar of both safety and sovereignty.

8. Legal and Regulatory Challenges of the Project

The planning of DGR represents not only a technical and scientific challenge, but also a legal and regulatory task unparalleled in other areas of infrastructure. One of the key aspects is the time horizon extending over tens to hundreds of thousands of years, far exceeding the lifespan of ordinary legal, political, or economic systems.

In my opinion, from a legal perspective, it is necessary to ensure that:

- decisions are sufficiently reasoned and documented for future generations,
- mechanisms of oversight and review are established even in the long-term perspective (*post-closure oversight*),
- the possibility of interventions remains as long as technically feasible, e.g. through retrievability.

The legitimacy of decisions concerning radioactive waste management cannot rest solely on technical expertise or legal compliance; it must also be grounded in public trust. For this reason, public participation is not merely a procedural formality but a substantive element of governance in the nuclear field.

A deliberative model of participation provides the most promising framework. Under this approach, affected communities and the broader public are engaged from the earliest stages of decision-making and are granted meaningful opportunities to contribute throughout the planning, siting, and licensing processes. Participation is conceived not as a right of veto but as a right of involvement—ensuring that societal concerns are heard, debated, and reflected in outcomes, while ultimate responsibility remains with the competent authorities. Unlike purely consultative or adversarial models, deliberative participation fosters a shared responsibility between the state and the public, while maintaining the state's ultimate decision-making authority.

Embedding such a model in the Czech regulatory framework would strengthen both transparency and societal legitimacy. Early and continuous engagement fosters informed dialogue, reduces the likelihood of entrenched opposition, and enables the balancing of technical, environmental, and ethical considerations. Moreover, it reflects the intergenerational nature of nuclear waste governance: decisions taken today will affect citizens for centuries to come, and it is therefore imperative that those citizens perceive the process as fair, inclusive, and responsive.

9. Conclusion

DGR's are not only a technical solution for radioactive waste management, but also a strategic instrument of national energy sovereignty. The Czech Republic faces the challenge of establishing a stable legal framework, ensuring technological safety, and strengthening public trust. Experience from European countries shows that the success of such projects depends on the combination of scientific expertise, legal certainty, and transparent communication. If these three pillars are effectively integrated, the Czech DGR can serve not only as a safe disposal facility, but as a symbol of technological responsibility, legal foresight, and democratic legitimacy for generations to come.

Literature

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Abstract

This article examines the deep geological repository for radioactive waste (DGR) as a strategic instrument of energy sovereignty and technological responsibility in the Czech Republic. It situates the DGR within the broader nuclear fuel cycle, emphasizing its role not only as a safe and sustainable solution for the disposal of high-level radioactive waste, but also as critical infrastructure for safeguarding long-term national sovereignty over sensitive nuclear materials.

The paper outlines the current Czech legal framework, including the recently adopted Act No. 53/2024 Coll., and compares national approaches in Central Europe, with particular reference to Poland, Slovakia, and Germany. Special attention is devoted to the principle of *retrievability*, which reflects the potential future reuse of spent nuclear fuel and the tension between technological flexibility and the imperative of final disposal.

Finally, the article discusses long-term legal and regulatory challenges, highlighting the need for transparent governance, intergenerational responsibility, and a deliberative model of public participation. It argues that Czech legislation must evolve to embed both safety and legitimacy within a legal order capable of operating across time horizons spanning multiple generations.

Keywords

Deep geological repository (DGR); radioactive waste; nuclear fuel cycle; energy sovereignty; retrievability; Czech law; legal framework; Central Europe; public participation; intergenerational responsibility