Research Report

GA1

Establishing legal frameworks for long term radioactive waste management

Ridima Niranjan

(Deputy Chair)

Introduction

The management of long term radioactive waste is an extremely complex challenge faced by the international community. Nuclear technologies in realms such as energy production, medical applications, and industrial uses, generate radioactive by-products that can remain hazardous up to hundreds of thousands of years. More specifically, high-level waste (HLW) contains long-lived radionuclides (unstable atoms that spontaneously decay and emit ionising radiation) and subsequently generates heat, which makes its management a necessity. The way these hazards become embedded into surroundings and endure for millenia requires extremely robust institutional solutions that can span beyond typical regulatory timelines. As nuclear technology continues to develop - both through traditional power plants or newer uses like small modular reactors (a type of nuclear fission reactor) - the amount of radioactive waste steadily increases. This growth makes it even more important for countries to establish legal frameworks that can manage these materials safely over the long term.

Several international agreements have looked at nuclear safety, including the 1997 Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management, which are overseen by the International Atomic Energy Agency (an intergovernmental organisation that aims to strengthen the global nuclear safety and security framework). However, there is still no single and binding global system that governs how countries should deal with long-term radioactive waste. Each country is responsible for creating its own policies, and their approaches differ widely due to their own technical capacities and available funding. Some states like Finland have been able to move forward with the construction of deep geological repositories (a secure underground facility, typically several hundred meters deep, designed for the permanent disposal of hazardous waste). Others have made little progress because of public opposition and limited resources. The challenge is made even more difficult by the fact that radioactive contamination does not stop at national borders. Poor management in one country can create serious risks for its neighbours, which reinforces the importance of a more multilateral approach to tackling this issue.

Definitions of Key Terms

1. Radioactive Waste - a radioactive material which does not have any foreseen use but still contains or is contaminated with radionuclides.
2. Spent Nuclear Fuel (SNF) - used fuel removed from a nuclear reactor that is no longer efficient for energy production but remains highly radioactive.
3. High-level waste (HLW) - highly radioactive waste that generates heat and requires cooling and shielding, usually from spent fuel or reprocessing.
4. Geological repositories - engineered underground facilities designed to isolate radioactive waste hundreds of meters below the surface using natural and engineered barriers.
5. Transboundary movement: the movement of resources, such as hazardous waste, water, or air pollution, across national political boundaries
6. Polluter Pays Principle - the concept that those who produce radioactive waste are financially responsible for its management and disposal.

General overview

The long term management of radioactive waste is a challenging issue because of how long radionuclides remain hazardous. For example, plutonium-239 has a half-life of almost 24,000 years as its radiotoxicity decays extremely slowly (World Nuclear Association). This is an example of a case where the containment strategies implemented need to function far beyond both human lifespans and political cycles due to how enduring these materials are. On an international scale, the stockpile of spent nuclear fuel (SNF) is already threateningly large, and according to the Stimson Center, approximately 400,000 metric tonnes of SNF is stored across hundreds of sites in dozens of countries. This global inventory only grows - by roughly 11,300 metric tonnes per year (Stimson Center, *Spent Nuclear Fuel Storage and Disposal*). These numbers highlight how important it is to transition from interim storage to long-term disposal solutions at an urgent pace.

The IAEA estimates that through 2016, states have generated roughly 390,000 tonnes of spent nuclear fuel from the beginning of commercial nuclear electricity production (IAEA, Global Overview of Radioactive Waste and Spent Fuel Management). The majority of this still remains in interim storage such as by being submerged in cooling pools or placed in dry cask systems, which is due to permanent deep geological repositories not yet being widely

available. Furthermore, many of these storage sites were never intended to serve as permanent facilities in the first place, which raises long-term safety concerns as the infrastructure ages. (Stimson Center, Spent Fuel: High Above, On the Ground, and Far Below). Relying indefinitely on interim storage is not without risk. As facilities age, the likelihood of structural degradation, leakage, or accidents increases. The Sellafield site in the United Kingdom illustrates these dangers: a leaking structure at the facility has raised concerns about contamination and environmental safety, demonstrating how poor long-term management can create risks (The Guardian, Revealed: Sellafield nuclear site has leak that could pose risk to public). Radioactive contamination is also indifferent to national borders. Groundwater movement, geological fractures, or atmospheric dispersion could allow radionuclides to migrate from one country to another - which complicates the legislative process and highlights the importance of regional cooperation to tackle this issue.

Major parties involved

1. Finland: Widely recognised as a global leader in long-term radioactive waste management. The country is constructing the Onkalo deep geological repository, designed to isolate spent nuclear fuel hundreds of meters underground in stable bedrock.
2. France: France generates one of the largest volumes of radioactive waste in Europe. The national waste management agency, ANDRA, is developing the Cigéo repository, a deep geological facility that focuses on high-level and long-lived intermediate-level waste.
3. The USA: The USA has accumulated a large stockpile of spent nuclear fuel but lacks a permanent repository. The Yucca Mountain project in Nevada, which was meant to be a deep geological repository, has been stalled due to political opposition and legal challenges.
4. The International Atomic Energy Agency (IAEA): The IAEA plays a central role in establishing international safety standards and creating cooperation among states, such as through the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.

Timeline of Key Events

- 1990: IAEA Code of Practice on Transboundary Movement of Radioactive Waste - the IAEA established guidelines regulating the international shipment of radioactive waste.
- 1997: Adoption of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management - adopted to create a legally binding international framework. It obliges states to report on national programs and undergo peer review.
- 2010-2025: Development of Repositories - Finland's Onkalo repository construction began, while France advanced its Cigéo project, and other countries like Sweden, Germany, and Canada conducted extensive geological studies.
- 2023: Sellafield Leak Report - A leak at the UK's Sellafield site highlighted the ongoing risks associated with older storage facilities and the importance of regulatory oversight.

Previous attempts to solve the issue:

1. IAEA Joint Convention: The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, adopted in 1997, was the first legally binding international agreement focused specifically on nuclear waste. It requires countries to submit regular reports on their waste management programs and participate in peer reviews conducted by other member states. This approach promotes transparency and knowledge-sharing, but compliance with it is largely voluntary because the convention lacks strong enforcement mechanisms.

2. National Frameworks: Finland and Sweden have advanced deep geological disposal programs, France operates the national agency ANDRA (which is developing the Cigéo repository for high-level and long-lived waste), and Germany created the KENFO fund to finance long-term disposal.

Possible solutions

- Deep Geological Repositories (DGRs): Placing waste in deep, stable rock formations remains the most widely accepted solution. These technologies should be developed and implemented across countries, akin to Finland's Onkalo repository, in order to reduce long-term risks.

- Strong International Legal Frameworks: Existing agreements like the Joint Convention promote transparency but lack enforcement. Binding rules and clear penalties for noncompliance can improve accountability and ensure safety across borders

Further Readings

1. World Nuclear Association. *Radioactive Waste Management.* World Nuclear Association, 2025. https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-wastes/radioactive-waste-management.aspx
2. OECD Nuclear Energy Agency (NEA). *Regulating the Long-Term Safety of Geological Disposal.* OECD Publishing, 2016. https://www.oecd-nea.org/jcms/pl_23244/regulating-the-long-term-safety-of-geological-disposal
3. The Guardian. "Revealed: Sellafield Nuclear Site Has Leak That Could Pose Risk to Public." *The Guardian*, 5 Dec. 2023. https://www.theguardian.com/business/2023/dec/05/sellafield-nuclear-site-leak-could-pose-risk-to-public
4. Stimson Center. *Spent Nuclear Fuel Storage and Disposal.* Stimson Center, 2020. https://www.stimson.org/2020/spent-nuclear-fuel-storage-and-disposal/

Bibliography

C G. "Spent Nuclear Fuel Storage and Disposal • Stimson Center." *Stimson Center*, 17 June 2020, www.stimson.org/2020/spent-nuclear-fuel-storage-and-disposal/?utm_source=chatgpt.com. Accessed 16 Nov. 2025.

"Home." *Nuclear Energy Agency (NEA)*, 2025, www.oecd-nea.org/jcms/pl_23244/regulating-the-long-term-safety-of-geological-disposal. Accessed 16 Nov. 2025.

IAEA. "Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management | IAEA." *Iaea.org*, 25 July 2014, www.iaea.org/topics/nuclear-safety-conventions/joint-convention-safety-spent-fuel-management-and-safety-radioactive-waste.

Isaac, Anna, and Alex Lawson. "Revealed: Sellafield Nuclear Site Has Leak That Could Pose Risk to Public." *The Guardian*, The Guardian, 5 Dec. 2023,

www.theguardian.com/business/2023/dec/05/sellafield-nuclear-site-leak-could-pose-risk-to-public?utm_source=chatgpt.com Accessed 16 Nov. 2025.

Solimini, David. “Spent Nuclear Fuel: High Above, on the Ground, and Far below • Stimson Center.” *Stimson Center*, 24 Sept. 2021, www.stimson.org/2021/interactive-spentfuel-above-and-below/

World Nuclear Association. “Radioactive Waste Management - World Nuclear Association.” *World-Nuclear.org*, World Nuclear association, 25 Jan. 2022, world nuclear.org/information-library/nuclear-fuel-cycle/nuclear-waste/radioactive-waste management.