Committee: International Atomic Energy Agency (IAEA)

Agenda Item: Ensuring the proper management and disposal of nuclear waste in all member states.

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Introduction

The management of nuclear waste, especially in its storage and disposal, represents one of the most paramount challenges of the 21st century. Many nations around the world are shifting toward nuclear power, frequently posited as a reliable, effective, and secure source of energy. As dependence on nuclear energy strengthens to mitigate the effects of climate change and to meet other sustainable development goals (SDGs) effectively, the proper management of nuclear waste has been rendered one of the critical global concerns.

A major concern in this area is the completion of the nuclear cycle that involves proper management of storage and disposal of low and high-level nuclear waste. While progress in the area of storage and disposal has improved nuclear safety, poor management of nuclear waste continues to pose long-term environmental risks and health effects.

The nuclear power industry, just like any other industry, generates waste. The most important difference is that all nuclear waste is regulated so that none is allowed to cause pollution. Much time and resources are needed to manage and dispose of nuclear waste properly; to achieve this, almost all radioactive waste is managed through some form of burial.

Others are reprocessing or transmutation of nuclear wastes, which is a process that changes its properties to reduce or eliminate radiotoxicity, and vitrification, where the nuclear waste is incorporated in glass.

With the development of nuclear energy use, especially in those developing nations with limited infrastructure, there is an increasing call from the international community to develop strong international safeguards and support systems for the effective adoption of standards for safety and sustainability. In this regard, review of the present framework is necessary for identifying the areas for improvement.

The nuclear sector belongs to one of innovation, collaboration, and sustainable practices. Stability in the world and empowerment of youth require joint international efforts in the area of risk mitigation posed by nuclear waste, including initiatives that will engage young innovators developing safe and more sustainable solutions for nuclear energy. Delegates are called on to analyze past approaches while advocating innovative and inclusive measures to ensure safe management of nuclear waste for future generations.

Definition of Key Terms

Nuclear Waste: Radioactive material for which no further use is foreseen but still contains, or is contaminated with radionuclides. Nuclear waste can be in gas, liquid, or solid form

Radioactivity: The phenomenon whereby atoms undergo spontaneous random disintegration, usually accompanied by the emission of radiation.

Characterization: Determination of the nature and activity of radionuclides present in a specified place.

Low-Level Waste (LLW): Radioactive waste that is above clearance levels, but with limited amounts of long-lived radionuclides. Low-level waste requires robust containment and isolation for periods typically of up to a few hundred years and is suitable for disposal in engineered near-surface disposal facilities.

High-Level Waste (HLW): Radioactive waste with levels of activity concentration high enough to generate significant quantities of heat by the radioactive decay process or waste with large amounts of long-lived radionuclides that need to be considered in the design of a disposal facility for such high-level waste. Disposal in deep, stable geological formations usually several hundred meters or more below the surface is the generally recognized option for the disposal of high-level waste.

Spent Fuel: Nuclear fuel removed from a reactor following irradiation that is no longer usable in its present form because of depletion of fissile material, poison buildup, or radiation damage.

Regulatory Body: An authority or a system of authorities designated by the government of a State as having legal authority for conducting the regulatory process, including issuing authorizations, and thereby regulating nuclear, radiation, radioactive waste, and transport safety.

Containment: Methods or physical structures designed to prevent or control the Release and dispersion of radioactive substances.

Storage: The holding of radioactive sources, radioactive material, spent fuel, or radioactive waste in a facility that provides for their/its containment, with the intention of retrieval.

Dry Storage: Storage in a gaseous medium, such as air or an inert gas. Dry Storage facilities also include facilities for the storage of spent fuel in casks, silos, or vaults.

Wet Storage: Storage in water or in another liquid.

Disposal: Emplacement of waste in an appropriate facility without the intention of retrieval.

Disposal Facility: An engineered facility where waste is emplaced for disposal.

Near-Surface Disposal Facility: A facility for radioactive waste disposal located at or within a few tens of meters of the Earth's surface.

Geological Disposal Facility: A facility for radioactive waste disposal located underground (usually several hundred meters or more below the surface) in a stable geological formation to provide long-term isolation of radionuclides from the biosphere.

Nuclear Transmutation: The conversion of one chemical element or an isotope into another chemical element, with the final objective of reducing radiotoxicity or increasing the final capacity of repository facilities.

Processing: Processing includes the collection and sorting of nuclear waste; reducing its volume and changing its chemical and physical composition, such as concentrating liquid waste; and finally, its conditioning so it is immobilized and packaged before storage and disposal.

Vitrification: A mature technology used to immobilize high-level nuclear waste, by incorporating them into glass for safe, long-term storage or disposal.

Major Actors Involved

International Atomic Energy Agency (IAEA): The International Atomic Energy Agency covers a wide range of nuclear waste management topics and sets international compliance criteria for countries to adhere to while setting their national policies regarding the matter. The IAEA promotes the establishment of long-term and environmentally conscious solutions such as the adoption of geological disposal for high-level waste, reprocessing technologies, and safe storage solutions for low-level waste.

United Nations Environmental Programme (UNEP) It handles many issues related to nuclear waste management. Even though UNEP usually focuses on the effects of improper waste disposal on the environment, its work is essential to understand the long-term environmental impact of this issue and take effective action accordingly.

European Atomic Energy Community (EURATOM): The European Union's members have a unified approach to nuclear waste management, particularly through the European Atomic Energy Community (EURATOM). Of course, national policies and attitudes towards nuclear waste management vary.

Union of Concerned Scientists: The Union of Concerned Scientists (UCS) is a nonprofit organization focused on using science to address global issues such as nuclear waste management. They advocate for scientifically sound solutions to ensure the proper management and disposal of nuclear waste, and they critique the risks of long-term storage at nuclear power plants, where waste can remain for decades. The organization also calls for greater public transparency and accountability in the development of nuclear waste disposal strategies.

For example, **Germany** is committed to phasing out nuclear power by 2038 and has a strong policy of ensuring that nuclear waste is safely stored. Germany's Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) has a subdivision called the Federal Office for the Safety of Nuclear Waste Management (BASE), with plans to convert a former iron mine called Schacht Konrad into a nuclear disposal facility.

On the contrary, instead of prioritizing renewable energy sources, **France** remains heavily dependent on nuclear energy for its electricity needs, which significantly increases the amount of toxic nuclear waste in the country. Despite negative comments on their nuclear waste management approach, the French government is operating an underground laboratory in the territory of Bure to study deep geological formations in which radioactive waste can be stored. France also attaches great importance to scientific developments in nuclear waste reprocessing.

Due to its pioneering work and leadership in developing long-term solutions for nuclear waste disposal, **Finland** is a significant player in the nuclear waste management arena. Finland hosts the world's first permanent deep geological repository for nuclear waste, Onkalo, designed to store high-level nuclear waste for up to 100.000 years. The Finnish government also allocates funding to research projects and advisories in the field of nuclear energy and waste safety.

USA: The United States of America is one of the largest nuclear energy, therefore nuclear waste, producers in the world, with over 90 operational nuclear reactors. The U.S. has developed many nuclear waste storage facilities, with the most controversial one being Yucca Mountain. The project was designed to be a permanent geological repository but due to political delays, the country still relies on storage facilities such as the Waste Isolation Pilot Plant (WIPP) in New Mexico.

UK: The UK's extensive history in nuclear energy and weapons production has given it numerous opportunities to operate sophisticated nuclear decommissioning programs, with the Sellafield site playing a central role in managing and processing nuclear waste. The UK also directly collaborates with the IAEA to develop innovative technologies such as small modular reactors (SMRs) and implement long-term, sustainable solutions to dispose of its high-level nuclear waste.

Russia: Russia's nuclear waste management system operates on a closed fuel cycle, allowing the recycling of nuclear waste and reducing the volume of high-level waste. Russia's waste reprocessing plants at Mayak and Zheleznogorsk handle large-scale reprocessing operations and the government is actively involved in developing deep geological repositories to ensure the long-term containment of nuclear waste.

China: China is rapidly expanding its nuclear energy capabilities to keep up with demand, alongside implementing nuclear waste management strategies that adhere to international standards. China focuses on centralized storage for nuclear waste and plans to construct more deep geological repositories in the long term. The Beishan site in Gansu Province is a strong contender for the construction of a geological repository.

India: India has an ambitious nuclear program, with a concentration on thorium-based reactors, which generate less high-level waste than uranium reactors. It pursues a closed fuel cycle policy, which involves reprocessing spent fuel to recover plutonium for future use. India emphasizes the importance of scientific innovation in nuclear waste management and is looking into options for long-term storage solutions, including deep geological repositories while guaranteeing compliance with the safety criteria set.

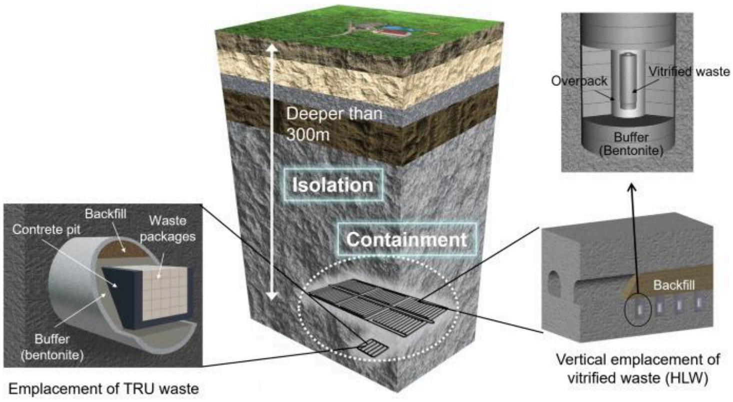
General Overview of the Issue

Nuclear waste management and disposal is one of the most contentious global issues of the twenty-first century. As nuclear energy has steadily emerged as one of the prominent sources of the global energy mix, concerns associated with its safe disposal of radioactive by-products have also mounted. The mismanagement of nuclear waste poses considerable environmental and health hazards if it is not properly disposed of, hence calling for a very elaborate management strategy. This process involves the navigation of complex technological, political, economic, social, and cultural factors. Effectively managing nuclear waste requires not only the identification of appropriate technologies but also strong international cooperation, well-established regulatory frameworks, and long-lasting commitments to safety.

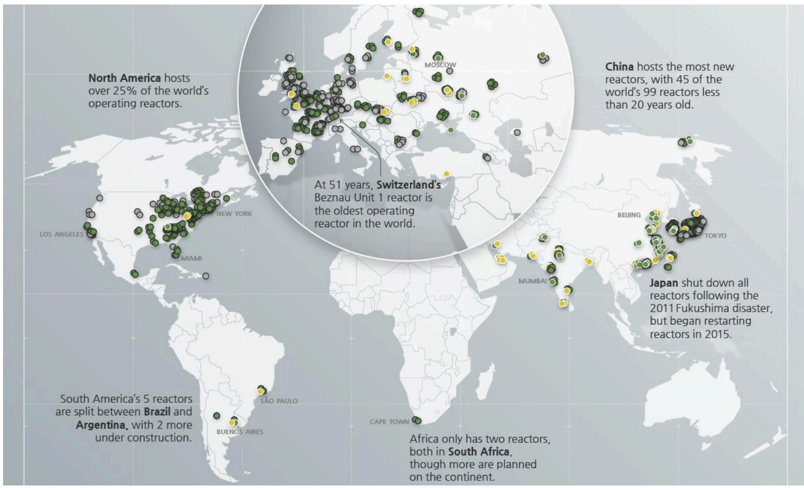
The development of nuclear technology in the mid-twentieth century brought both opportunities and challenges. Nuclear power has provided many countries with a relatively clean and efficient source of energy; however, it has also created a growing need to dispose of the waste generated in the process of using nuclear power. This became especially relevant when the wider use of nuclear reactors for electricity generation started in the 1950s.

The dangerous character of nuclear fission byproducts became clear when the first generation of reactors produced radioactive waste that could be dangerous for thousands of years.

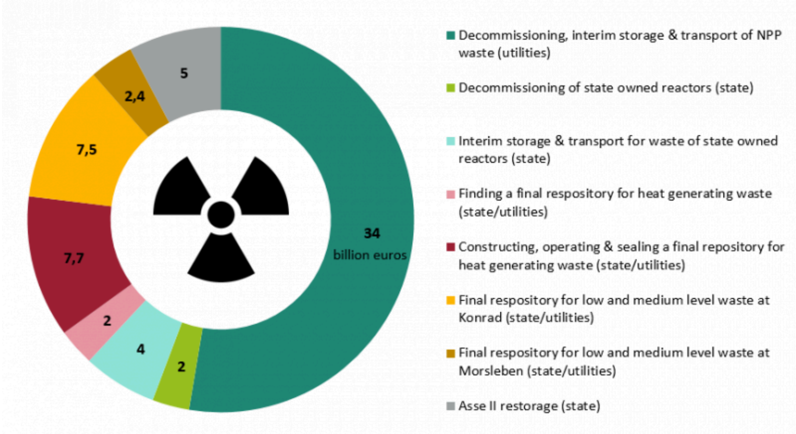
As the nuclear power industry grew, so did the urgency of the problem of waste disposal. Governments, scientists, and environmentalists began to realize the long-term dangers of nuclear waste. More recently, a number of strategies have emerged to address these difficulties, including the reprocessing of nuclear waste and the use of deep geological repositories (DGRs). Despite several decades of research and development, progress has been slowed by political and social opposition to disposal sites in many countries.



Geological disposal is considered the most feasible alternative to date by most experts in the disposal of high-level nuclear waste. In this method, the wastes are isolated from the surface of the Earth for thousands of years underground. Reprocessing will be the next big step; this will include the chemical treatment of nuclear waste to separate components like plutonium and uranium for reuse in reactors.



Nuclear Reactors Around The World



Nuclear Waste Disposal Costs

This approach not only reduces the total volume of waste but also lowers demands on newly extracted uranium. However, reprocessing raises concerns about nuclear proliferation as well as the environmental impact of the reprocessing operation itself. Vitrification, a process in which radioactive waste is immobilized by being combined into glass, is another such technique under research. Despite this technological advancement, long-term safety in nuclear waste management remains the greatest concern. Though geological disposal is considered to be a safer method compared to alternative approaches, it is not without risk—possible issues include container failure, groundwater contamination, and seismic activity. Further, the opposition of the public to facilities sited close to their homes aggravates these problems because communities clearly voice their fear about the potential health and environmental consequences.

The financial burden of the development and operation of the disposal facilities is quite considerable, which makes nuclear waste management an expensive undertaking. Long-term solutions pose special challenges for many nations to finance; those developing nuclear energy projects face even bigger challenges compared to richer countries with more resources to handle such expenses. This financial pressure is compounded by the ever-increasing quantity of nuclear waste. As reactors approach the end of their operational life span, decommissioning will increase the amount of radioactive waste.

Joint Convention on the Safety of Nuclear Waste Management

Public perceptions greatly influence regulations surrounding nuclear waste management. A country's attitude toward nuclear power often defines its approach to managing its by-products. Other countries continue to invest in nuclear power because it is seen as a reliable source of energy, but other countries refuse to use it because it poses an environmental hazard—this creates an ongoing debate on how best to manage nuclear waste. Cultural factors also play a big role in how national policies on nuclear waste are put in place. Generally speaking, regions with a tradition of environmentalism or nuclear failures are more resistant to the development of nuclear power. Countries with high needs in energy may view nuclear power as being critical to energy security, thus the desire to continue on this path and ensure efficient disposal mechanisms for the generated wastes.

Strong international cooperation must come forth to meet the global challenge of nuclear waste. Because nuclear waste does not respect national borders, countries are forced to work together to ensure safe and effective disposal mechanisms are implemented with international safety standards. This is very instrumental with the help of the International Atomic Energy Agency, setting international safety standards, offering technical assistance to nations, and facilitating intergovernmental communication. Through such cooperation, the IAEA promotes transparency and allows knowledge sharing on the advances in nuclear waste management.

In conclusion, although technological advancements have improved some aspects of nuclear waste management, major challenges persist without solutions. The interplay of economic constraints with public perception, cultural attitudes, and international cooperation will shape future approaches to this critical challenge, especially as the world's reliance on nuclear energy is expected to grow. In working towards sustainable solutions that put safety and environmental protection first, ongoing dialogue and cooperation will be critical to addressing the challenges of nuclear waste management for the twenty-first century.

Timeline of Important Events

Date:	Event:
2 December 1942	First controlled nuclear chain reaction occurs at the University of Chicago
1 March 1957	The National Academy of Sciences publishes recommendations on radioactive waste disposal
21 February 1989	The Nuclear Regulatory Commission certifies the TRUPACT-II for shipping TRU waste
1 November 1990	The U.S. Department of Energy issues a record of decision to carry on the development of the Waste Isolation Pilot Plant
18 May 2004	The Environmental Protection Agency approves DOE characterization plans for remote-handled TRU waste disposal at WIPP
9 January 2012	DOE authorizes the resumption of waste emplacement at WIPP

31 January 2022	The U.S. government announces plans to resume efforts on the Yucca Mountain repository program in Nevada for high-level waste disposal
12 March 2023	IAEA releases updated guidelines on nuclear waste management practices globally.

Related Documents

https://www-pub.iaea.org/MTCD/Publications/PDF/cnpp2022/pages/index.htm: The IAEA Country Nuclear Power Profiles

https://www-pub.iaea.org/MTCD/Publications/PDF/IAEA-NSS-GLOweb.pdf: The IAEA Nuclear Safety and Security Glossary

https://books.google.com.tr/books?id=_hy3DwAAQBAJ&lpg=PP1&dq=Ensuring%20the%20proper%20management%20and%20disposal%20of%20nuclear%20waste%20in%20all%20member%20states.&lr&pg=PP1#v=onepage&q&f=true: “Nuclear Waste Management Strategies: An International Perspective” by Mark C. Sanders and Charlotta E. Sanders

https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf: The IAEA Safety Standards for Protecting People and the Environment

Past Solution Attempts

Most of the attempts made towards nuclear waste management have failed due to major obstacles. Early solutions, such as temporary storage in cooling pools at reactor sites, were unsafe for a long period and led to the generation of more waste without its final disposal. The Yucca Mountain Project in the U.S. had the objective of a geological repository; however, it was put to a stop because of political opposition and public safety concerns, showing the challenges of community acceptance for such facilities.

The Olkiluoto repository in Finland is on course to be commissioned, but the uniqueness of the technical uncertainties involved has raised skepticism about its long-term reliability. Reprocessing programs, as in France and Japan, aimed to recover spent fuel but again presented proliferation risks and the environmental concerns associated with reprocessing itself. Deep borehole disposal is a conceptual solution, but it is untested on a large scale and has not been deployed. In sum, public perception, political will, and technical feasibility complexities have defeated the implementation of most nuclear waste management solutions that were successful in the past.

Possible Solutions

Several solutions have been suggested toward nuclear waste management, each having different advantages and challenges. Deep Geological Disposal (DGD) is considered the most promising long-term option: high-level radioactive waste is placed in stable geological formations where it will be isolated for millennia; however, public opposition and political barriers have stopped the project at Yucca Mountain in the U.S. Reprocessing and recycling of spent nuclear fuel reduce the volume of waste but are considered to promote nuclear proliferation and environmental impacts.

Vitrification is effective at "fossilizing" waste in glass form but is expensive and difficult to implement. Transmutation promises the possibility of converting long-lived isotopes into shorter-lived ones, yet it remains largely experimental and impractical for current waste. Phased Geological Disposal offers retrievable storage before final disposal, but only with full planning and community engagement. Lastly, many countries rely on interim storage solutions for spent fuel, which, while providing temporary relief, highlight the urgent need for permanent solutions as capacities become strained. Each of these strategies underscores the multifaceted challenges of achieving effective nuclear waste management amid varying public perceptions and regulatory frameworks.

Useful Links

https://www.ucsusa.org/resources/nuclear-waste: The Union of Concerned Scientists (UCUSA) on nuclear waste

https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-waste/radioactive-waste-management: The World Nuclear Association on nuclear waste management

https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-waste/storage-and-disposal-of-radioactive-waste: The World Nuclear Association on nuclear waste storage and disposal

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=LEGISSUM%3Al27048: Summary of EU legislation on the topic of management of spent nuclear fuel and radioactive waste

https://www.iaea.org/topics/processing: The IAEA on nuclear waste processing

https://www.iaea.org/services/united-nations-environment-programme: The IAEA's collaboration with UNEP on the topic

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