Nukes: A Solution for Nuclear Waste?

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1. Introduction

I've posted several of my "Nukes…" papers lately, and everyone in this industry seems to agree that there is currently no solution to dispose-of or recycle high-level nuclear waste (mainly from spent nuclear fuel). Or maybe there is. Your author recently came across a local Bay Area company that believes they have the technology to solve this problem. This post is about that company and their proposed solution.

There is settled consensus across Governments, regulators and technical experts around the world that deep geological disposal is the preferred safe and sustainable long-term solution for nuclear waste. However, the costs of delivering a traditional mined repository are extremely high, and local communities are often resistant to hosting such a facility. Moreover, in the European Union, new regulations introduced on January 1, 2023 make clear that investment in new nuclear power can help meet EU climate and environmental objectives – but only if Member States have an operational disposal facility for high-level radioactive waste by 2050.[1]

Deep Isolation delivers the benefits of deep geological disposal in compliance with the new EU investment guidelines, but with significant additional benefits that make it a practical, lower-cost and safe option to a traditional mined repository for high-heat generating waste streams.

Deep Isolation's solution places canisters containing spent nuclear fuel or other high-level waste in deep borehole repositories located 1-3 kilometers underground in suitable rock isolated from the biosphere. The waste can then be retrieved for several decades or left permanently and safely (i.e. disposed of). And this can be done at or near the nuclear power plants that produce the waste, rather than in a large centralized facility.

2. Benefits

Deep Isolation brings innovative technology that is altering the way governments around the world think about nuclear waste. Our solution is:

***Safe:** We offer the advantages of a mined geological disposal facility (GDF) and are fully in line with the political, regulatory and scientific consensus in favor of deep geological disposal. We offer borehole repositories in multiple configurations with patented new processes and technologies that ensure safety through natural geologic isolation as well as engineered barriers.*

***Far more affordable:** The cost of disposing of nuclear waste using Deep Isolation is significantly less than a mined repository. This is in part because the diameter of our boreholes is less than 10 percent the size of shafts used in mined repositories. Also, our regionally distributed model can reduce or even eliminate the costs and political sensitivities of transporting nuclear waste through communities to a central facility.*

[1] Deep Isolation, "An introduction for Nuclear Waste Policymakers around the world," June 2023, https://www.deepisolation.com/wp-content/uploads/2020/05/Deep-Isolation-White-Paper-Introduction-for-policymakers.pdf

Author's comment: In our current situation, high-level waste like spent reactor fuel elements is stuck at the reactors where it was created. If the reactor is still operating, the spent fuel elements continue accumulating. They are also stuck at many retired reactor sites.

Thus, moving this waste to nearby suitable deep geological storage, would substantially increase its safety by isolating it from our biosphere, and also virtually eliminating the possibility of third-party diversion.

Flexible: *Our solution offers great siting flexibility, because directional drilling can be used to access safe, isolated rock formations in a much greater range of locations, geologies and depths than is possible for mined geologic disposal facilities. And the modular nature of boreholes enables governments to choose between centralized and distributed models of disposal.*

Simple and phased implementation: *The modularity of the Deep Isolation solution allows for a staged pathway to disposal. A phased approach can be taken, beginning with a single borehole and adding boreholes as required. And our implementation times are much shorter than the many years required to construct a mined repository.*

Better for citizens and communities: *Our research suggests communities find a Deep Isolation repository more equitable than a large mined repository. Our solution offers the potential for a win-win. We can take waste being stored above ground and put it deep underground. The significantly lower costs that result from this offer the opportunity to share savings with participating communities.*

2.1. The Problem's Solution

Since the EBR-I reactor in Idaho generated the first nuclear-powered electricity in 1951, more than 500 additional nuclear power plants have followed.[2] Together, these contribute more than 10 percent of the world's electrical power[3]. While nuclear power plants have no carbon emissions, they create radioactive waste that can remain hazardous to the environment and human health for tens of thousands of years.

There is clear global consensus across governments, regulators, scientists and the nuclear industry that the preferred solution for the long-term disposal of this high-level nuclear waste (HLW) is through deep geological disposal. As the International Atomic Energy Agency puts it:

There is presently a broad consensus among technical experts that the preferred method of ensuring long term safety for high level waste (HLW) is isolation in a deep geological disposal facility. Geological disposal facilities for long-lived waste, if properly sited and constructed, provide passive, multibarrier isolation of radioactive materials. Emplacement in carefully engineered structures buried deep within suitable rock formations provides the long-term stability typical of a stable geological environment. At depths of several hundred meters, in a tectonically stable region, processes that could disrupt the disposal facility are so slow that the deep rock and groundwater system remain practically unchanged over hundreds of thousands or even millions of years."

[2] The International Atomic Energy Agency reports in their latest survey that there are 395 operating nuclear power reactors around the world, and an additional 155 shutdown reactors in decommissioning.
[3] Source: World Nuclear Association

While many countries have yet to decide long-term policies for disposal of high-level nuclear waste, every country that has identified a complete solution has included deep geological disposal based in a traditional mined repository. Despite that clear consensus, no country in the world has yet succeeded in fully implementing this approach.

As discussed below, two key barriers are hampering progress: high costs and the difficulty of obtaining community consent.

2.2. Mined Repositories Are Complex and Expensive

A number of leading nuclear nations have published their budgets and plans for delivering these huge engineering projects. Table 1 below gives the costs for deep geological disposal that have been published by the Canadian, Swedish, UK and US government authorities

Cost of a mined repository[4] in 2020 US dollars

Canada	*$19.8 billion*
Sweden	*$6.2 billion*
United Kingdom	*$23.9 billion*
United States	*$122.2 billion*
Cost per tonne in an average mined repository	*$1.24 million*
Typical time to market	*1 year from regulatory approval to start of construction, 8.3 years for construction.*

As Table 1 shows, planned expenditure on deep geological disposal in these four countries alone amounts to $172 billion in 2020 prices – not including the costs of interim storage. And in view of the long lead times needed to construct a mined repository and emplace waste, significant interim storage costs need to be factored in for countries looking to build such a repository. Extrapolating these budget figures to a global level, means that the total bill for disposing of the world's nuclear waste through individual national mined repositories could cost more than $667 billion.

These very high costs have meant that most governments are not currently investing in mined repositories. Instead, they keep incurring the costs of temporary storage for nuclear waste – often in above ground or near-surface facilities which, in many countries, are being extended significantly beyond their original planned lifespan.

[4] Note that the budget estimates for the four countries date from different years. Canadian, UK and Swedish figures have been converted to US dollars using average exchange rates for the relevant year from ofx.com, and all figures have been updated to 2020 values using inflation calculators published by the relevant national monetary authorities.

2.3. Unpopular with Local Communities

Cost is by no means the only barrier to deep geological disposal in a mined repository. Most governments are committed to a policy of community consent for such an underground repository. Deep Isolation welcomes and supports that policy; we believe no sustainable and equitable solution for nuclear waste disposal is possible if the host community does not willingly fully participate in the decision-making process and agree with the decisions that are made. But finding a community that will consent to hosting nuclear waste from all around the country is challenging. Over the years, many governments have tried and failed to do so, due to local opposition at becoming "the nation's nuclear waste dump." So far, only Finland, France and Sweden have successfully completed a site selection process.

2.4. The Deep Isolation Solution

Founded in 2016, Deep Isolation includes a team of scientists, engineers, environmentalists and entrepreneurs committed to creating the world's safest and most cost-effective solution for the permanent disposal of nuclear waste.

***A form of deep geological disposal** – so it is fully aligned with the global political and scientific consensus in favor of deep geological disposal as the optimum means for disposing of nuclear waste.*

***Better for local communities** – significantly mitigating the major political and social barriers which hamper siting for a traditional large mined repository.*

***Designed with the participation of environmental groups** – Deep Isolation has long been engaging with environmental groups and is continually incorporating their input into current plans, helping earn trust and confidence.*

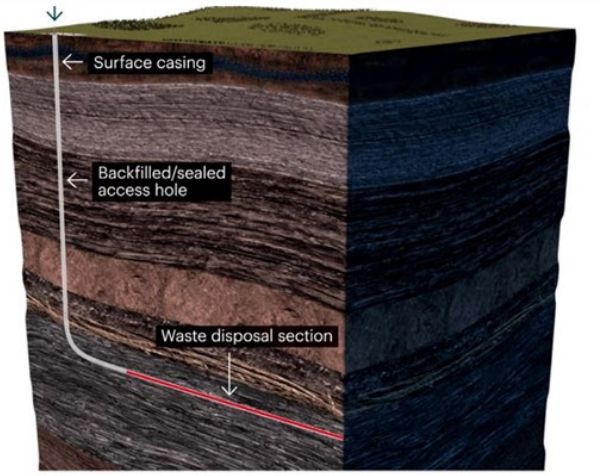
***Dramatically less expensive** than a mined repository that requires engineering capable of safeguarding the humans needed to work deep underground in such repositories.*

The following subsections describe this solution in more detail, starting with a description of how all aspects of it are deeply rooted in a set of values that have driven Deep Isolation since its creation.

2.5. Technology

Deep Isolation's solution places waste canisters in boreholes deep underground in stable geological formations that have been out of contact with the biosphere for millions of years. We either drill vertically deep down into crystalline basement, or construct horizontal repositories in a wide range of sedimentary, igneous, and metamorphic host rocks using proven directional drilling technology.

As illustrated right, our principal reference architecture involves horizontal geometry, because this is likely to give the optimum balance of performance and cost considerations for a typical inventory in a wide range of potential geologies. Such boreholes offer an ideal isolation environment for many types of nuclear waste. The waste is emplaced in canisters, then lowered down the borehole at a typical depth of one kilometer or more and placed end-to-end into the encased horizontal section of the borehole.



When ready for permanent sealing, the vertical portion of the casing is removed, then backfilled with rock, bentonite, and other materials. The radioactive waste is effectively isolated from the human environment by the depth of the repository and the thick, protective natural barrier system above it. This is the heart of geological waste disposal.

All our borehole designs allow for decentralized disposal of the waste at or near its current location depending on local geology. Alternatively, multiple boreholes can safely be constructed at central or regional locations. For some countries, deep borehole disposal will provide a complete solution for geological disposal; for others – with more varied inventories – they may still need a traditional mined facility for some larger waste forms, but can reduce the overall scale and cost of this by putting high-heat generating wastes at much greater depth using a "mined plus boreholes" approach.

Final author's comment: Deep Isolation has much more information in their approach and company through reference 1. To your author, this seems to be a thorough, well-developed solution for all stake-holders.

Also, I mentioned that Deep Isolation is a SF Bay Area Company. On their "Our Story" Page they say: "*Deep Isolation has a global presence with offices in Berkeley, CA, Richland, WA, and the United Kingdom…"*

I'm no longer surprised to see a nuclear firm in the SF Bay Area (or even in Livermore, therein, where I live), because our region (especially Berkeley and Livermore) were major foundation sites for the nuclear industry during and immediately after WWII. Also, the SF Bay Area has several National Labs, including Lawrence Livermore National Lab (LLNL), Berkeley (LBNL), Sandia (SNL) – Livermore Campus, and SLAC National Accelerator Lab ("SLAC" was originally for Stanford Linear Accelerator Center).

Since I worked at GE Vallecitos Nuclear Center (VNC, Vallecitos is an adjacent valley to the Livermore Valley and means "valleys" in Spanish), I was able to view the reactor that had US Commercial Reactor License #1 (VBWR or Vallecitos Boiling Water Reactor), up close. This reactor has recently been decommissioned and taken "back to grass"[5] (eventually, to be followed by the rest of VNC).

[5] https://www.world-nuclear-news.org/Articles/Vallecitos-reactor-removal-complete Note that this site has an old video with a newsreel from when VBWR was commissioned.