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NUCLEAR ENGINEERING INTERNATIONAL

Deep Isolation, a Berkeley startup, believes that horizontal drilling offers a simple and safe means to dispose of nuclear waste
The following editorial is reprinted from *Nuclear Engineering International*, January 2019

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New life for burying nuclear waste

Deep Isolation, a Berkeley startup, has an approach it thinks could break the nuclear waste gridlock. Amid speculation that Yucca Mountain could once again move forward, **Rod Baltzer** and **Zann Aeck** discuss how public-private collaboration can help dispose of waste stockpiles that have already grown too big to fit into the USA's stalled repository

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ACCORDING TO THE INTERNATIONAL ATOMIC Energy Agency (IAEA), there is an estimated 250,000t of spent nuclear fuel in storage worldwide, and another 120,000t of reprocessed spent fuel. A global consensus exists across governments, regulators, scientists, and the nuclear industry that the safest option for the disposal of this waste is in geological repositories.

Despite this consensus, and after more than 40 years of study, planning and policymaking, there is not a single high-level waste (HLW) repository operating today. Construction licences have been granted in Finland and Sweden. The USA has federal commitments to take title to the waste, and its inability to make good on that is costing government, industry, ratepayers and taxpayers billions of dollars each year. And it is only getting worse.

Enter Deep Isolation

The idea for Deep Isolation grew out of Berkeley Earth, an environmental organisation working to address climate change through a triad of energy conservation, shale gas as a bridge fuel and nuclear power. Recent advances in oil and gas drilling technology inspired Deep Isolation's founders to solve the nuclear waste issue.

The father-daughter cofounders are CEO Elizabeth Muller and CTO Richard Muller. Elizabeth Muller is an expert in global warming, stakeholder engagement, strategy and communications. Richard Muller is a MacArthur Genius and a scientist, educator and author in nuclear physics.

The two believe that horizontal drilling offers a simple and safe means to place nuclear waste deep inside stable rock, in formations that have held volatile materials for millions of years. Compared to huge mined repositories, these smaller facilities could reduce worker exposure risk, because fewer workers would be needed to operate them. The drillholes could be located closer to existing waste stores to reduce transportation risks. Building several smaller facilities could reduce the burden on the public and share it more equitably. This could be accomplished at a fraction of the money already spent on mined repositories.

Mounting costs

Ratepayers in the USA have paid the federal government more than $40 billion since 1983 to site, construct and operate a permanent nuclear waste repository. The government, in turn, has spent $15 billion on developing and licensing a mined repository at Yucca Mountain. But taxpayers are still liable for up to $34 billion in court-ordered claims against the government, because government failed to meet statutory commitments to take possession and dispose of the estimated 80,000t of spent fuel in the USA.

All the while, nations around the world default to costly temporary storage at the power plants. The USA is spending around $3 billion dollars per year on temporary storage. The global figure per year is over $13 billion.

The current approach to disposal requires digging massive underground repositories and placing nuclear waste inside a network of tunnels. Yucca Mountain, for example, will ultimately involve a five-mile U-shaped main storage tunnel deep underground. Once completed, the facility will be maintained by a staff of 2000-2500 engineers and other personnel. The detailed study and international collaboration are paying off. Sweden and Finland are nearing completion of their first repositories. Canada is moving forward with its Adaptive Phased Management approach to facility siting. These national efforts, which appear to be on the path to success, are shaped and informed by previous attempts that failed.

Government budgets for delivering these huge engineering projects are equally massive. Across the USA, Canada and the UK, average disposal cost estimates run about $1.36 million per ton of spent nuclear fuel. At this rate, it would cost $145 billion to dispose of existing high-level waste in these three countries alone. To dispose of global waste inventories would cost upwards of $556 billion. Even so, we continue to generate spent fuel with no repository. That means those enormous disposal costs continue to climb.

By contrast, for over 20 years the oil and gas industry has drilled over 50,000 horizontal wells in the USA. We have the technology and experience to guide these wells with precision. Drillers can even target an old oilfield pipe and drill a new hole to intersect with it. They can also follow a specific geologic formation deep below the earth, not just target a specific depth and angle.

Drilling costs have come down dramatically so that horizontal wells are now a few million dollars each. Compare that to the billions invested in mined repositories and it reveals the potential attractiveness of Deep Isolation's solution, especially for smaller nuclear energy programmes in nations with less waste in storage.

Deep Isolation horizontal drillholes would be several thousand feet deep and drilled into or below a low-permeability geologic formation. A vertical drillhole would first be drilled, then it would turn horizontal and extend slightly upward for up to two miles. The holes could vary in diameter to accommodate a variety of waste canisters and sizes. Calculations to date estimate that two or three horizontal drillholes could safely store all of the waste produced over the lifetime of a typical nuclear power plant.

The canister will be made of corrosion resistant alloys. When these disposal canisters are used in a low oxygen environment they are expected to last for thousands of years.

The spent nuclear fuel in this configuration can be retrieved for decades after disposal. The canisters are designed with latching mechanisms to reconnect with drilling equipment for removal if it becomes desirable to do so. Even after the drillhole is backfilled and plugged, canisters filled with waste can be retrieved by re-drilling the original hole.

The fact that canister recovery cannot be done quickly adds to security against terrorist removal. After the disposal drillhole has been sealed, it would take a large drilling rig over a week to re-drill the hole. A specialised drilling crew would then need to find and retrieve the disposal canister. So, while retrievability is built into the design, it is not something that can be done swiftly or by covert means.

Much work remains, but the solution appears to be straightforward. Deep Isolation believes that the creation of a first deep geologic disposal site, using horizontal drillhole technology to dispose of the waste from a 1GW nuclear reactor, is possible in as little as three years. The primary challenges lie not in the technical realm, but in the political will and public acceptance.

The geologic formation and depth are the ultimate geologic barriers that prevent the waste from reaching the biosphere. Additionally, the drillholes will be backfilled and plugged with materials and in a manner to ensure there are no pathways to the surface. This results in a safer disposal with built-in redundancy for long-term performance and better protection of people and the environment.

A unique aspect of the deep drillhole disposal concept is the ability to place waste at or very near a nuclear reactor site or other location that already stores nuclear waste. In this way there is no need to transport the spent fuel.

Engineered barriers

The technology appears promising, but needs adequate funding and government R&D support. Testing and data collection to support potential licensing could require millions of dollars and a handful of years, but that remains a bargain by comparison. The real obstacles to horizontal drillhole repositories are twofold: policy and legislation; and public acceptance.

The Muller team knew they would face considerable doubts. So, they brought in experts in nuclear physics, geology, government affairs, stakeholder engagement and business development. The team settled on a public-private partnership model to form a cleantech startup with a focus on community engagement. Private sector innovation and drive, backed by government resources and accountability, can be a powerful combination.

Community engagement is a core value for Deep Isolation. Safe and secure waste disposal becomes a solution to be offered to communities, not imposed on them. The real difference comes through earning and maintaining trust and confidence in the communities. Finding an amenable host community and state can be difficult. Deep Isolation is working with the government and communities to provide a sound and lasting foundation.

Political and legal challenges are the primary impediment to finishing the repository at Yucca Mountain. Nevada is spending $3.5 million per year in legal fees to prevent the facility from ever being used to hold nuclear waste.

Past efforts clearly demonstrate that proper and effective community engagement is essential. A recent pilot test in the USA for an alternative disposal concept alarmed the community and the project was cancelled, even though the tests themselves would not involve any radioactive material. Local people did not trust the government claims that these sites would never be used to dispose of nuclear waste. Poor community engagement can doom a project before it has begun.

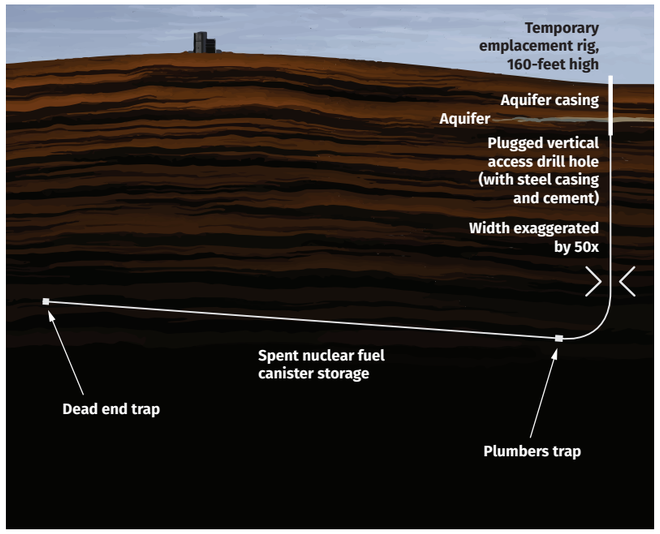
Deep Isolation will engage people and communities at all levels and do it early. The time for answering questions and building relationships is long before the workers and equipment come rolling into town.

We've done this before

Deep Isolation believes that combining private sector innovation with public sector resources and accountability along with community support can break the international nuclear waste gridlock.

Government and industry have come together before to revolutionize the economy and improve lives. For instance, a US legislative change allowed FedEx to revolutionise shipping. And government purchasing power allowed SpaceX to dramatically reduce costs and pave the way for progress in the highly regulated space industry. This kind of partnership can also solve the nuclear waste challenge.

Deep Isolation's solution can offer a simpler, safer and more cost-effective resolution to nuclear waste gridlock on its own, or to supplement mined repositories such as the oversubscribed Yucca Mountain project. Through a refined community engagement-first approach, communities might play a bigger role in local decisions. ■



Below: **Depiction of the Deep Isolation disposal solution**

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