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The Staggering Timescales Of Nuclear Waste Disposal

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High-level nuclear waste consists largely of spent fuel from nuclear reactors. Though it makes up a small proportion of overall waste volumes, it accounts for [the majority of radioactivity](#). This most potent form of nuclear waste, according to some, needs to be safely stored for [up to a million years](#). Yes, **1 million years** - in other words, a far longer stretch of time than the period since Neanderthals cropped up. This is an estimate of the length of time needed to ensure radioactive decay.

Yet existing and planned nuclear waste sites operate on much shorter timeframes: often **10,000 or 100,000 years**. These are still such unimaginably vast lengths of time that regulatory authorities decide on them, in part, based on [how long ice ages are expected to last](#). To some extent all of these figures are little better than educated guesses.

They're also such mind-bogglingly long periods that in 1981, the US Department of Energy established the Human Interference Task Force to devise ways to warn future generations of the dangerous contents of nuclear repositories. This was a challenging task then, and nuclear semiotics remains the stuff of science fiction. Written language has only existed for about [5,500 years](#), so there's no guarantee that Earth's inhabitants, tens of thousands of years from now, would understand any of the writing systems currently in use. The [meanings of visual signs also drift over time](#). The more whimsical ["ray cat solution,"](#) of genetically engineering cats to glow in the presence of radioactive material, is even less reliable.

Even stopping nuclear power operations is a necessarily drawn-out process. [Decommissioning a single nuclear reactor](#) typically takes about **20 years**. Most countries grappling with nuclear waste are planning for at least **40 to 60 years** just to [implement their repository programs](#).

After brief flirtations with amusingly bad ideas including [shooting nuclear waste into space](#), the consensus among nuclear scientists is that the best option for dealing with high-level nuclear waste is deep geological disposal. One of the International Atomic Energy Agency's [conditions for such a geological site](#) is low groundwater content,

which has been stable for at least **tens of thousands of years**, and geological stability, over **millions of years**. Thus, Japan, with its seismic instability, is unlikely to have any suitable candidates for deep geological disposal.

Like many countries, Japan is relying on interim storage of high-level waste while hoping that longer-term solutions will present themselves eventually. In fact, no country even has an operational deep geological repository for spent nuclear fuel. (The US has a deep disposal site in New Mexico for “transuranic” waste from nuclear weapons, which is [long-lived and intermediate-level waste](#) whose elements have higher numbers than uranium in the periodic table.)

It’s challenging to find a site that ticks all of the geological boxes (including relatively impermeable material with little risk of water infiltration), and that isn’t politically controversial. To take two notable examples, communities in Nevada, US and Bure, France have hotly opposed plans to establish repositories. Given the history of environmental justice globally, it’s likely that any future locations approved for nuclear waste dumps will be found in poor areas.

Only one country, Finland, is even building a permanent spent-fuel repository. Even in Finland, however, it’s estimated that a license won’t be issued until 2024. Similar licenses for other European countries scouting out possible locations likely wouldn’t be available until 2050 in Germany and 2065 in the Czech Republic. And these countries are outnumbered by those that don’t even have an estimated timeframe for licensing, as they’re so far back in the process of searching for a site.

Strategies remain worryingly short-term, on a nuclear timescale. Chernobyl’s destroyed reactor no. 4, for instance, was moved in July 2019 into a massive [steel and concrete “sarcophagus”](#) that will only last **100 years**. Not only will containers like this one fall short of the timescales needed for sufficient storage, but no country has allotted enough funds to cover nuclear waste disposal. In France and the US, according to the recently published [World Nuclear Waste Report](#), the funding allocation only covers a third of the estimated costs. And the cost estimates that do exist rarely extend beyond several decades.

Essentially, we’re hoping that things will work out once future generations develop better technologies and find more funds to manage nuclear waste. It’s one of the most striking examples of the [dangers of short-term thinking](#).

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