

# How do we tell future generations about highly radioactive nuclear waste repositories?

March 19 2024, by Thomas Keating and Anna Storm

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In Europe, increasing efforts on climate change mitigation, a sudden focus on energy independence after Russia's invasion of Ukraine, and reported breakthroughs in [nuclear fusion](#) have sparked renewed interest in the potential of nuclear power. So-called [small modular reactors](#) (SMRs) are increasingly under development, and familiar promises about nuclear power's potential are being revived.

Nuclear power is routinely portrayed by proponents as the source of "[limitless](#)" amounts of carbon-free electricity. The rhetorical move from speaking about "[renewable energy](#)" to "fossil-free energy" is increasingly evident, and telling.

Yet nuclear energy production requires managing what is known as "spent" nuclear fuel where major problems arise about how best to safeguard these [waste materials](#) into the future—especially should nuclear energy production increase. Short-term storage facilities have been in place for decades, but the question of their long-term deposition has caused [intense political debates](#), with a number of projects being [delayed](#) or [cancelled entirely](#). In the United States, work on the Yucca Mountain facility has [stopped completely](#) leaving the country with 93 nuclear reactors and no long-term storage site for the waste they produce.

Nuclear power plants produce three [kinds of radioactive waste](#):

- Short-lived low- and intermediate-level waste;
- Long-lived low- and intermediate-level waste;
- Long-lived and highly radioactive waste, known as spent nuclear fuel.

The critical challenge for nuclear energy production is the management

of long-lived waste, which refers to nuclear materials that take thousands of years to return to a level of radioactivity that is deemed "safe".

According to the US [Nuclear Regulatory Commission](#) (NRC), in spent fuel half of the radiation in strontium-90 and cesium-137 can decay in 30 years, while it would take 24,000 years for plutonium-239 to return to a state considered "harmless." However, exactly what is meant by "safe" and "harmless" in this context is something that [remains poorly defined](#) by international nuclear management organizations, and there is surprisingly little international consensus about the time it takes for radioactive waste to return to a state considered "safe" for organic life.

## **'Permanent' geological repositories**

Despite the seeming revival of nuclear energy production today, very few of the countries that produce nuclear energy have defined a long-term strategy for managing highly radioactive spent fuel into the future. Only Finland and Sweden have confirmed plans for so-called "final" or "permanent" geological repositories.

The Swedish government [granted approval](#) for a final repository in the village of Forsmark in January 2022, with plans to construct, fill and seal the facility over the next century. This repository is designed to last 100,000 years, which is how long planners say that it will take to return to a level of radioactivity comparable to uranium found in the earth's bedrock.

Finland is well underway in the construction of its [Onkalo high-level nuclear waste repository](#), which they began building in 2004 with plans to seal their facility by the end of the 21st century.

The technological method that Finland and Sweden plan to use in their permanent repositories is referred to as [KBS-3 storage](#). In this method, spent [nuclear fuel](#) is encased in cast iron, which is then placed inside

copper canisters, which are then surrounded by clay and bedrock approximately 500 meters below ground. The same or similar methods are being considered by other countries, such as the United Kingdom.

Sweden and Finland have described KBS-3 as a world-first nuclear-waste management solution. It is the product of decades of scientific research and negotiation with stakeholders, in particular with the communities that will eventually live near the buried waste.

Critical questions remain about the storage method, however. There have been widely publicized concerns in Sweden about the [corrosion of test copper canisters](#) after just a few decades. This is worrying, to say the least, because it's based on a principle of passive safety. The storage sites will be constructed, the canisters filled and sealed, and then everything will be left in the ground without any human monitoring its safe functioning and with no technological option for retrieving it. Yet, over 100,000 years the prospect of human or non-human intrusion into the site—both accidental or intentional—remains a serious threat.

## **The Key Information File**

Another major problem is how to communicate the presence of buried nuclear waste to future generations. If spent fuel remains dangerous for 100,000 years, then clearly this is a time frame where languages can disappear and where the existence of humanity cannot be guaranteed. Transferring information about these sites into the future is a sizeable task that demands expertise and collaboration internationally across the social sciences and sciences into practices of nuclear waste memory transfer—what we refer to as [nuclear memory communication](#).

In a project commissioned by the Swedish Nuclear Waste Management Company (SKB), we take up this precise task by writing the "Key Information File"—a document aimed at non-expert readers containing

only the most essential information about Sweden's nuclear waste repository under development.

The Key Information File has been [formulated](#) as a summary document that would help future readers understand the dangers posed by buried waste. Its purpose is to guide the reader to where they can find more detailed information about the repository—acting as a "key" to other archives and forms of nuclear memory communication until the site's closure at the end of the 21st century. What happens to the Key Information File after this time is undecided, yet communicating the information that it contains to future generations is crucial.

The Key Information File we will publish in 2024 is intended to be securely stored at the entrance to the nuclear waste repository in Sweden, as well as at the National Archives in Stockholm. To ensure its durability and survival through time, the plan is for it to be [reproduced in different media formats and translated into multiple languages](#). The initial version is in English and, when finalized, it will be translated into Swedish and other languages that have yet to be decided.

Our aim is for the file to be updated every 10 years to ensure that essential information is correct and that it remains understandable to a wide audience. We also see the need for the file to be incorporated into other intergenerational practices of knowledge transfer in the future—from its inclusion into educational syllabi in schools, to the use of graphic design and artwork to make the document distinctive and memorable, to the formation of international networks of Key Information File writing and storage in countries where, at the time of writing, decisions have not yet been made about how to store highly radioactive long-lived nuclear waste.

## **Fragility and short-termism: a great irony**



In the process of writing the Key Information File, we have discovered many issues surrounding the efficacy of these strategies for communicating memory of nuclear waste repositories into the future. One is the remarkable fragility of programs and institutions—on more than one occasion in recent years, it has taken just one person to retire from a nuclear organization for the knowledge of an entire program of memory communication to be halted or even lost.

And if it is difficult to preserve and communicate crucial information even in the short term, what chance do we have over 100,000 years?

International attention is increasingly fixated on "impactful" short-term responses to environmental problems—usually limited to the lifespan of two or three future generations of human life. Yet the nature of long-lived nuclear waste requires us to imagine and care for a future well beyond that time horizon, and perhaps even beyond the existence of humanity.

Responding to these challenges, even partially, requires governments and research funders internationally to provide the capacity for long-term intergenerational research on these and related issues. It also demands care in developing succession plans for retiring experts to ensure their institutional knowledge and expertise is not lost. In Sweden, this could also mean committing long-term funding from the [Swedish nuclear waste fund](#) so that not only future technical problems with the waste deposition are tackled, but also future societal problems of memory and information transfer can be addressed by people with appropriate capacity and expertise.

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