How do you leave a warning that lasts as long as nuclear waste?



Enlarge / Ominous looking skies you've got there…
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In January 1997, the crew of a fishing vessel in the Baltic Sea found something unusual in their nets: a greasy yellowish-brown lump of clay-like material. They pulled it out, placed it on deck and returned to processing their catch. The next day, the crew fell ill with serious skin burns. Four were hospitalized. The greasy lump was a substance called yperite, better known as sulfur mustard or mustard gas, solidified by the temperature on the sea bed.

At the end of the World War II, the US, British, French and Soviet authorities faced a big problem—how to get rid of some 300,000 tonnes of chemical munitions recovered from occupied Germany. Often, they opted for what seemed the safest, cheapest and easiest method: dumping the stuff out at sea.



Enlarge / Scenes from a nuclear waste memory shoot, located in Bure, France, taken in May 2019.

Estimates are that at least 40,000 tonnes of chemical munitions were disposed of in the Baltic Sea, not all of it in designated dumping areas. Some of these locations are marked on shipping charts but comprehensive records of exactly what was dumped and where do not exist. This increases the likelihood of trawler crews, and others, coming into contact with this dangerous waste.

The problem isn’t going to go away, especially with increased use of the sea floor for economic purposes, including pipelines, sea cables and offshore windfarms.

The story of those unlucky fishermen illustrates two points. First, it is difficult to predict how future generations will behave, what they will value and where they will want to go. Second, creating, maintaining and transmitting records of

where waste is dumped will be essential in helping future generations protect themselves from the decisions we make today. Decisions that include how to dispose of some of today’s most hazardous material: high-level radioactive waste from nuclear power plants.

Down, down

The red metal lift takes seven juddering minutes to travel nearly 500 meters down. Down, down through creamy limestone to reach a 160-million-year-old layer of clay. Here, deep beneath the sleepy fields and quiet woods along the border of the Meuse and Haute-Marne departments in north-east France, the French National Radioactive Waste Management Agency (Andra) has built its underground research laboratory.

The laboratory’s tunnels are brightly lit but mostly deserted, the air dry and dusty and filled with the hum of a ventilation unit. Blue and grey metal boxes house a series of ongoing experiments—measuring, for example, the corrosion rates of steel, the durability of concrete in contact with the clay. Using this information, Andra wants to build an immense network of tunnels here.

It plans to call this place Cigéo, and to fill it with dangerous radioactive waste. It is designed to be able to hold 80,000 cubic meters of waste.



Enlarge / A graphic showing the lift shaft to the underground lab, in the visitors' center at Andra.
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We are exposed to radiation every day. Public Health England estimates that in a typical year someone in the UK might receive an average dose of 2.7 millisieverts (mSv) from natural and artificial radiation sources. A transatlantic flight, for example, exposes you to 0.08 mSv; a dental X-ray to 0.005 mSv; 100 grams of Brazil nuts to 0.01 mSv.

High-level radioactive waste is different. It is, primarily, spent fuel from nuclear reactors or the residues resulting from reprocessing that fuel. This waste is so potent that it must be isolated from humans until its levels of radiation, which decrease over time, are no longer hazardous. The timescale Andra is looking at is up to one million years. (To put this into some sort of context, it's just 4,500 years ago that Stonehenge was constructed. Around 40,000 years ago,

modern humans arrived in northern Europe. A million years ago, the continent was in the middle of an Ice Age. Mammoths roamed the frozen landscape.)

Some scientists call this long-lived waste “the Achilles heel of nuclear power”, and it’s a problem for all of us—whatever our stance on nuclear. Even if all the world’s nuclear plants were to cease operating tomorrow, we would still have more than 240,000 tonnes of dangerously radioactive material to deal with.



Enlarge / Inside the underground testing lab at Andra.
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Currently, nuclear waste is stored above ground or near the surface, but within the industry this is not considered an acceptable long-term solution. This kind of storage facility requires active monitoring. As well as regular refurbishment it must be protected from all kinds of hazards, including earthquakes, fires, floods and deliberate attacks by terrorists or enemy powers.

This not only places an unfair financial burden on our descendants, who may no longer even use nuclear power, but also assumes that in the future there will always be people

with the knowledge and will to monitor the waste. On a million-year timescale this cannot be guaranteed.

So, after considering a range of options, governments and the nuclear industry have come to the view that deep, geological repositories are the best long-term approach. Building one of these is an enormous task that comes with a host of complex safety concerns.

Finland has already begun construction of a geological repository (called Onkalo), and Sweden has begun the licensing process for its site. Andra expects to apply for its construction licence within the next two years.

If Cigéo goes into operation it will house both the high-level waste and what is known as intermediate-level long-lived waste—such as reactor components. Once the repository has reached capacity, in perhaps 150 years' time, the access tunnels will be backfilled and sealed up. If all goes according to plan, no one will ever enter the repository again.

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