Sea-Based Nuclear Waste Solutions

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Sea-based approaches to the disposal of nuclear waste make it hard for terrorists, rebels, or criminals to steal for use in radiological weapons or in nuclear bombs. The enormous volume of water in the world's oceans also has a vastly greater dilutive capacity than any single land site in the event of unintended leaks. And seawater itself contains a variety of radionuclides, so treating it as a domain in which there is no natural radioactivity runs counter to fact.

Even proponents of land-based geological storage sites of radioactive waste must recognize that, without a great deal of additional investment and endless political arguments, these sites will not have the capacity to store all the waste that will be generated in future decades. So studying sea-based solutions makes eminent sense.

Four sea-based approaches recommend themselves.

Sub-Seabed Disposal in Stable Clay Formations

First proposed in 1973, the concept of **burying nuclear waste in stable clay formations** under the seabed was investigated by international teams of scientists for many years. A substantial scientific literature details the various modalities, associated risks, and geological conditions. The large undersea plain some 600 miles north of Hawaii, stable for some 65 million years, received special attention.

Researchers found that the clay muds in such sub-seabed formations had a high capacity for binding radionuclides, so that any leakage would be likely to remain within the clay for millions of years, by which time radioactive emissions would decline to natural background levels.

However, for bureaucratic reasons, in 1986 the U.S. Department of Energy cut off funding for research on sub-seabed and other nuclear waste disposal options in favor of pursuing the Yucca Mountain one. Even though Congress established an Office of Subseabed Disposal Research within the Department of Energy, the Congress soon changed its mind, and the Office spent allocated funds on other projects.

From the outset, environmentalists voiced hostility to the concept of subseabed disposal, though it is clear that some failed to make the elementary distinction between casual dumping and the planned burial of nuclear waste in secure containers either in deep boreholes under the seabed or in a prepared subseabed geological repository. Also, it must be noted that some environmentalists oppose all specific proposals for nuclear waste disposal as a way of putting an end to nuclear technology entirely. Given the determination of quite a few governments around the world to pursue nuclear technology, however, this stance may prove unrealistic, unhelpful, and ultimately dangerous to the environment itself. At the very least, such environmentalists should state that they oppose all solutions when objecting to any specific one.

The London Dumping Convention prohibits dumping nuclear waste at sea. It is not clear whether this applies to a sub-seabed geological disposal solution. Moreover, the Convention will be coming up for renewal in the not-too-distant future. Other countries have tended to follow the U.S. lead thus far, but this situation might change as nuclear waste disposal becomes an ever more pressing problem and land-based solutions appear inadequate.

At a minimum, funding further research into sub-seabed disposal makes sense. Since the abandonment of research, fundamental changes have occurred. The danger of terrorists or others gaining access to nuclear waste and using it in radiological weapons looms far larger now than in the 1980s. New technology for containing storage reduces the threat of early leakage. And bottom-crawling submarines are now available that can effectively insert canisters of waste deep into the sub-seabed.

Restarting investigation into sub-seabed disposal in stable clay formations is a commonsensical way to develop a fallback alternative to geological disposal on land. The possibility of creating an international consortium that would ensure that all high-level nuclear waste from every country in the world would be buried in a single sub-seabed storage area seems very promising.

Burial in Subduction Faults

A second sub-seabed option has received almost no attention but deserves careful consideration: burying canisters of nuclear waste in **Subduction Faults** that would carry the waste downward toward the Earth's mantle. This approach possesses the virtue of being very permanent--the reverse of shooting the waste with rockets into the Sun, except much more practical. As the subduction fault would carry the canisters down at a rate of, say, 10 cm per year, the chances of any release of radionuclides into the biosphere would become increasingly remote.

A single California firm, Permanent RadWaste Solutions, has pursued the technology for this option. In addition to the bottom-crawling submarine for digging the holes and delivering the waste, this company has developed a canister technology that becomes more tightly sealed and resistant as the outside pressure increases during the descent of the canister toward the mantle. Some observers object that earthquake or volcanic activity could cause the canister to leak, and the radioactive waste would spew into the sky or onto the surface. However, it is possible to place the canisters in the parts of a subduction zone where there is no volcanic activity, so that they will take millions of years to migrate to less stable parts, at a time when their level of radioactivity will no longer surpass that of the natural background.

As with the stable clay approach, it would be possible to bore deep holes into the subduction faults in order to get the waste as deep as possible, even though the danger of leakage upward to the seafloor appears to be minimal. Radionuclides are heavier than water, so there is also no reason why they should migrate upward to the ocean's surface, especially since there is no evidence that bottom-dwelling marine species are concentrated upward into a food pyramid that leads to the surface.

Engineered Island Disposal

The notion of burying nuclear waste on remote, unpopulated islands has been investigated, but one must question how thoroughly. The Yucca Mountain Project Website lists the reasons why this option was not pursued: 1) risks of ocean transport, especially bad weather; 2) earthquake and volcanic activity; 3) penetration of island foundations by seawater and fresh water, leading to leakage; and 4) the opposition of nearby countries.

Many of these objections could be overcome by constructing a remote island in a place in the ocean where the depth is not great. While constructing the island would cost a lot of money, so do all other geological disposal solutions. In this case, the island itself would be the disposal site. One could use rock with optimal barrier properties and select a location far from other islands, the mainland, and areas with seismic activity. Building an Engineered Island would best be done as an international effort, perhaps spearheaded by several countries with no other attractive options.

Objection #1 (risks of ocean transport) does not deter the shipment of nuclear waste now, and it can be reduced by various technical and procedural means, including monitoring by an authorized international body. Engineered Island disposal is an option that deserves more research, especially since the human-made island approach has tended to be overlooked thus far.

Seawater Uranium Cycling

The presence of uranium in seawater at 3 parts per billion suggests a fourth and final sea-based nuclear waste solution. Technology already exists to separate this uranium from seawater, but currently its cost far exceeds the cost of conventional uranium mining. Nonetheless, the potential for such seawater uranium extraction holds considerable interest for countries like Japan where other sources of energy are lacking.

One way to lower the cost would be to combine the extraction of uranium with related activities. The most obvious would be to extract other valuable minerals such as gold at the same time. A second such activity would consist of performing the extraction of uranium and other minerals using the water flowing through an Oceanic Thermal Energy Conversion (OTEC) plant, which in turn would make OTEC technology more economically attractive.

And there is still another activity that can be combined with seawater uranium extraction, if one considers that every atom of uranium extracted reduces the natural level of radioactivity of the ocean. In a process called "Seawater Uranium Cycling" (SUC), an international monitoring body could grant to a company engaged in seawater uranium extraction a license to return to the ocean an amount of radionuclides from high-level waste equivalent in radioactivity and potential chemical toxicity to the uranium extracted. This would permit the company to dispense in a very diffuse way from a ship traversing vast expanses of sea a tiny trickle of precisely the long-lived radionuclides like americium that cause such difficulties when concentrated into High-Level Waste because of their very long decay times.

SUC would begin in a small way, perhaps with one or two companies handling only a small amount of uranium and waste radionuclides each year. Over time, however, improvements in technology for extracting uranium and other minerals would attract more firms and increase the importance of this method for disposing of the most troublesome radionuclides, while preserving the natural radioactivity of the ocean instead of diminishing it. The total amount of uranium in the ocean is immense (4,300,000,000 metric tons), so SUC could operate for a very long time. While many people might feel consternation at the image of simply pouring radionuclides into the water, a correct scientific view shows this image to be very misleading. The gigantic volume of the ocean and the careful dispersal carried out in accordance with international monitoring would make SUC an admirably safe method. It would also provide incentives for the development and deployment of seawater uranium extraction, while lessening the environmental impact of opening new uranium mines on land.

Conclusion

While objections can--and surely will--be raised to each of these sea-based approaches to nuclear waste disposal, it is much harder to oppose them as a bundle. Even though they compete with each other, they also support each other in terms of reinforcing the general concept of carefully investigating methods of sea-based disposal.

Since the U.S. Government appears to lack the political will to pursue such approaches, other governments, companies, foundations, and NGOs need to begin to support research on them. Relying, as we now do, on dozens of nuclear countries each to develop and maintain secure geological disposal sites for nuclear waste is a thoughtless and dangerous approach. The ultimate goal should be to devise a nuclear waste solution (not necessarily a sea-based one) that will win international acceptance and become the long-term one for all High-Level Waste, and perhaps for Low-Level Waste as well.