Nuclear waste: the intractable problem

Scientists the world over agree: we must store nuclear waste with long-life, high-level radioactivity deep under the ground. However, not a single nation has in fact started doing so. This uncertainty is disturbing to most, but it does not seem to worry nuclear engineers. They believe the problem will be solved if it is given enough time.

by Yves de Saint Jacob

The matter is of an almost philosophical nature. Can Man, haunted since the beginning of time by his own finite lifespan, commit to a long-term future for the planet measured in thousands, tens of thousands, hundreds of thousands or even a million years? Humans may have mastered science, but can they guarantee that the Earth will safely harbour in its bosom, for centuries, radioactive material they have buried there? Can they ensure that the nuclear reactors or systems they have designed to store waste will resist earthquakes, global warming or cooling, or other global shake-ups we know nothing about yet?

Low and high radioactive disposal storage facility of Covra in Borssele, The Netherlands. Photo by: Michiel Wijnbergh/Hollandse Hoogte

It is this questioning of the limits of Man's power and conceit, which is at the core of the dispute between "pro" and "anti" nuclear activists. 'Demonstrably we can manage things for several centuries because we have already proven this. However, we can't say we can manage this waste for millions of years as the lack of experience is obvious,' admits Professor Jacques Foos, a 30 year veteran professor of nuclear physics at the National Conservatory of Arts and Sciences.

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The safety issue surrounding nuclear energy has various aspects. First, there is the risk of serious accidents, as illustrated by the Chernobyl tragedy. A new catastrophe would destabilise the sector, but the technological evolution of reactors is constantly improving their safety performance. The current "3rd generation" of reactors is recognised by most experts as being safer than the previous one. The objective set for the designers of different types of nuclear power plants was clear, says Bertrand Barré, scientific adviser for the Areva group. 'If the reactor core melts, there should be no environmental contamination and no people should have to be evacuated.' Hence a long series of measures were taken, the most visible being the presence of an "ashtray" that will collect and contain melting materials.

Secondly, there is the question of slow and unseen leaks. Nuclear scientists consider this to be more a problem of communication than a real safety problem – and in their opinion, the media blow any incident, however insignificant, well out of proportion. They are adamant that nuclear power is one of the safest and least polluting industrial sectors. A coal-burning power plant emits more radioactivity than a nuclear power plant, due to the uranium and thorium contained in fly-ash. Unfortunately, the general public does not perceive it that way.

Thirdly, the proliferation and use of civilian nuclear knowledge or materials for military purposes is an important issue, though more of a diplomatic than a technical nature.

Football field

And then there is the problem of what to do with the radioactive waste. 'We can't just snap our fingers and get rid of it,' states Professor Jacques Percebois, one of the most highly respected academics in favour of nuclear development. When a neutron triggers fission of a heavy nucleus, the latter breaks apart into two unequal pieces, releasing considerable energy. These fission fragments rarely originate from stable nuclei: being radioactive, they disintegrate fairly quickly into other nuclei, which are themselves somewhat radioactive. The processes take varying periods of time, ranging from a few seconds to several million years.

Two criteria are generally used to classify fission products: the degree of activity and the lifespan. The most pressing problem is of course that of the high-level, long-lived radioactive waste. This category represents less than 1% of the total waste by volume. Waste with "medium" or "low" activity but a long life, over 30 years, is a little less problematic, but nonetheless we need to find long-term storage solutions for it. This material represents roughly 10% of waste. Currently, the best solution envisaged for these two categories of waste is to bury it in deep geological layers.

Every year, the 27 Member States of the EU produce around 85,000 m3 of radioactive waste, or the equivalent of a truncated pyramid 10 m high, with a base the size of a football field. The 1% of high-level, long-lived waste can be contained in a cube measuring 10 metres on each side. The other long-life waste has a volume of around 100,000 m3. As for the short life waste, there is just under a million cubic meters of it that is slowly returning to normality.

Ever since the industry began to produce nuclear waste, only temporary solutions have been put in place. It is stored, but not buried. All the countries are still studying permanent storage. The first ones to do so might be Sweden and Finland, beginning in 2020. France is aiming for 2025. 'Finland started in 2003-04 to excavate an underground laboratory in order to study the feasibility of a waste repository within a granite formation', explains Gérald Ouzounian, Director of International Affairs of the French National Radioactive Waste Management Agency (Andra). 'Today, the access ramp has reached a depth of 300m and, if everything works according to schedule, the repository should be operational by 2020.'

In France, the construction of the Underground Research Laboratory at Bure, in the east of the country, began in 2000, and experiments are under way 490 metres underground in clay formations. 'A licence application will be submitted in 2015 with a view to commissioning the repository in 2025', says Ouzounian.

Ouzounian believes clay formations have an advantage over granite formations in Sweden and Finland. 'Since water is the only means through which radioactivity can be dispersed, it constitutes the major threat for the waste. Clay offers two major advantages in that regard. First, it is highly impermeable, due to its swelling power in the presence of water. Second, it has special chemical properties, such as being able to retain dissolved elements. At the depths involved, there is no oxygen and most materials are non-soluble. In case of infiltrations, the small amount of materials that may be carried away by water is retained by the clay and prevented from dispersing. Both Finland and Sweden have already planned to include a clay barrier around their waste packages.'

All that, however, is still some years away. The head of Greenpeace's anti-nuclear campaign in France, Frédéric Marillier, notes ironically: 'Thirty years of research and huge investments have not really resulted in much. Today, we still have nothing even remotely resembling a good solution to the major risks of pollution and proliferation'.

The nuclear industry sees things a little differently. It would of course give us peace of mind to know what we have to do, but many French scientists believe that we shouldn't make hasty decisions about storage. Hervé Nifenecker, a physics engineer who launched a movement of pro-nuclear scientists called Sauvons le climat ("Save the climate"), believes that 'current waste can be stored on the surface or at subsurface level with no consequences as yet observed for public health'. The waste will be monitored by teams of engineers whose knowledge regarding nuclear development is constantly improving. The waste should cool down for a period ranging from a few dozen to a hundred years before being placed in a final storage place. 'Therefore, we have time to develop new technologies, and safety will only improve over time.' In many countries, the law has introduced the concept of "reversibility": the possibility of bringing back to the surface, at least for a period of 100 years, packets of waste stored in deep geological layers. In fact, with less haste, the concept of "waste" itself could even become more flexible. If a use is found for the radioactive waste, it won't be waste anymore.

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Mox

One way of reducing the amount of waste is by reprocessing it. In France, spent fuel is processed in order to recover uranium and plutonium, which are then re-used to manufacture a fuel called Mox. The rest – 1/30th by weight, roughly speaking – is vitrified in giant glass cubes. The Russians, Japanese and Indians also do this. Others, such as Germany, Switzerland and Belgium have their waste reprocessed elsewhere, especially in France. The US, the UK, Sweden and the Ukraine have abandoned reprocessing in favor of direct storage, but some are considering returning to reprocessing. Still others (Canada, Korea, Taiwan) have never engaged in reprocessing and have, from the very beginning, opted for direct storage.

Although reprocessing greatly reduces the volume of waste to be stored, the spent Mox is even more radioactive than the other waste. The existence of large stores of the plutonium-containing Mox is also a nuclear proliferation risk. 'Six to ten kilos of plutonium is all it takes to make a bomb with the power of Hiroshima,' says Marillier.

Ironically, the best use for the spent Mox may be to reprocess it in new, 4th generation nuclear reactors – an argument in favour of continuing with the development of nuclear power. Nuclear physicists often argue that reprocessing today can never be truly justified unless we commit to new reactors in the future. For anti-nuclear activists, though, reasoning such as this puts us on a collision course with disaster. ■