Collective inspiration

End of the road for Yucca Mountain

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To many opponents of a renewed nuclear future, the lack of a coherent long-term plan to manage waste is the biggest stick to beat the industry with. The announcement late last year that the US had abandoned its plans for a deep geological storage repository at Nevada's Yucca Mountain - a much vaunted solution - has only created an atmosphere of uncertainty.

There are four types of nuclear waste, ranging from the very low level waste that can be disposed of commercially to the high level waste (HLW), primarily spent fuel, which is of the greatest concern.

The nuclear industry would argue that the volume of HLW is small, but to the layman the numbers will seem quite staggering. At present there are some 270,000t of HLW around the globe, stored in storage pools at the reactor sites. Each year another 3,500t is added that burden.

In terms of radioactivity, HLW is the major issue, arising from the use of nuclear reactors to generate electricity. Highly radioactive fission products and transuranic elements are produced from uranium and plutonium during reactor operations, and are contained within the used fuel.

Where countries have adopted a closed cycle and utilised reprocessing to recycle material from used fuel, the fission products and minor actinides are separated from uranium and plutonium and treated as HLW (uranium and plutonium is then reused as fuel in reactors). In countries where used fuel is not reprocessed, the used fuel itself is considered a waste and therefore classified as HLW.

The HLW also generates a considerable amount of heat and requires cooling. It is vitrified into borosilicate (Pyrex) glass, encapsulated into heavy stainless steel cylinders about 1.3m high and stored for eventual disposal deep underground. This material has no conceivable future use and is unequivocally waste.

France has two commercial plants to vitrify HLW left over from reprocessing oxide fuel, and there are also plants in the UK and Belgium. The capacity of these western European plants is 2,500 canisters (1,000t) a year, and some have been operating for three decades.

If used reactor fuel is not reprocessed, it will still contain all the highly radioactive isotopes, and then the entire fuel assembly is treated as HLW for direct disposal. It too generates a lot of heat and requires cooling. However, since it largely consists of uranium (with a little plutonium), it represents a potentially valuable resource and there is an increasing reluctance to dispose of it irretrievably.

Either way, after 40-50 years the heat and radioactivity have fallen to one thousandth of the level at removal. This provides a technical incentive to delay further action with HLW until the radioactivity has reduced to about 0.1 per cent of its original level.

Direct disposal of used fuel has been the preferred method of Sweden as well as the USA, although evolving concepts lean towards making it recoverable if future generations see it as a resource. This involves allowing for a period of management and oversight before a repository is closed.

50 years of waiting

A period of grace has existed for the nuclear industry; for 50 years HLW has been kept at nuclear facilities 7m deep ponds - allowing 3m above the fuel in order to shield it. However, that age of grace is over, as 50 years of heat and radioactivity reduction have now allowed encapsulation for indefinite storage or disposal. The current industry has inherited the E F requirement to come up with a viable storage plan that will satisfy the regulators and the public alike.

The Yucca mountain site in Nevada is situated 100 miles north west of Las Vegas, adjacent to the Nevada Nuclear Test Site. The 1987 Nuclear Waste Policy act designated it as the national repository for HLW. The Department of Energy (DoE) was to begin accepting spent fuel there in 1998, but a series of delays and legal challenges made that impossible.

In 2009 President Barack Obama announced that the site was no longer an option and proposed to eliminate all funding for the project. This decision signals the death knell for the costly project, and raises a question as to whether it was ever a viable option.

One man who believes that it was doomed from the start was Steve Frishman, a geologist and head of the Agency for Nuclear Projects office at the Office of the Governor of the State of Nevada.

If nuclear waste was to leak from a facility such as Yucca Mountain, the catalyst for that would be water. Because the site is about 800m above the water table that was not originally considered a problem, but because the area is prone to heavy, short bursts of rain and the rock itself is heavily fractured, the authorities soon realised that their assumption may have been wrong.

Delaying tactics

'The question then becomes not whether Yucca Mountain will start to leak, but how fast it will begin to leak,' Frishman says. 'This is the basis of the current argument. Once the DoE discovered that water could move very rapidly through the systems we used their own models and discovered that it could actually reach the water table in less than 1,000 years.

'The department's response to that, instead of saying 'new information has told us this is not workable' they went looking for ways to delay the release. They began looking for a metal container to hold the waste, which has high corrosion resistance.'

In essence these were delaying tactics. The DoE was aware that any cask, and they had selected a nickel alloy, would corrode, but it was a matter of how quickly. The DoE tests claimed several thousands of years, while others, including the State of Nevada, set the figure at below 1,000 years.

The next move from the DoE was to specify drip shields, made from titanium, that would move any dripping water away from the casks, but again this tactic was fraught with difficulties. Not least installing the shields in the first place.

'So instead of relying on the geology of the system to maintain isolation they were going to use a metal alloy to delay the release,' Frishman explains. 'All that happens with that delay is that you allow for the decay of fission products like stronium 90 and cissium 137 - these would be gone to all intents and purposes in 300-500 years anyway. But the rest of the actinides are still there.

'The original idea for deep geological disposal is that you need very long isolation in order to deal with isotopes such as plutonium, which has a half-life of about 25,000 years. And that's the real danger. It's the very long-lived isotopes we're worried about.'

Alternative solutions

Eventually, it seems that the US has seen the light and will look elsewhere for its long-term storage options. 'I think the most important thing to understand is exactly what the geological and hydrological conditions that we looking for are,' Frishman says. 'Being a geologist I'm still of the belief that I held 30 years ago that we can find a geological setting where we can have pretty good confidence in isolation. However, the way the US have gone into this is to find a site that they thought they could force people to accept it even if they didn't want it.

'That line of argument has failed worldwide and we're the last example of failure. Others learned quicker. If we're going to get anything out of this programme at all in the US, it will be to take what we have learned in terms of hydrology, geology and chemistry and look for a geologic setting ignoring the idea of whether any state wants it or not.'

Further information:

Read *E&T*'s interview with Nevada geologist Steve Frishman in full