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The Waste Isolation Pilot Plant's salt beds hold radioactive materials from US nuclear-weapons labs.

NUCLEAR POLICY

US seeks waste-research revival

Radioactive leak brings nuclear repositories into the spotlight.

BY JEFF TOLLEFSON

A radiation leak has raised questions about the safety of the United States' only deep nuclear-waste repository, and has given fresh voice to scientists calling for more research into underground waste storage.

On 14 February, radioactive plutonium and americium leaked out of the Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico, where thousands of drums of contaminated material from the US nuclear-weapons programme are stored in salt beds more than half a kilometre below the surface. The health and environmental impacts seem to be minor, but 13 employees have tested positive for low-level contamination. The Department of Energy (DOE) and its contractors are still working on a plan to re-enter the WIPP and find out what caused the leak.

The incident also brings renewed attention to a problem that policy-makers have been avoiding: what to do with a mounting stockpile of spent fuel from commercial reactors, which is currently stored at reactor sites. In 2010, the DOE mothballed plans to develop Yucca Mountain in Nevada, which since 1987 had been designated as the future site of an underground repository (see *Nature* **473,** 266–267; 2011). Researchers at the DOE and universities want to explore a variety of alternatives. But they say that they have been hobbled by small budgets and the Nuclear Waste Policy Act, which prevents the DOE from investigating any specific site apart from Yucca Mountain.

"Basically, all of the old ideas have come back out of the woodwork," says Michael Driscoll, a nuclear engineer at the Massachusetts Institute of Technology in Cambridge. "But the first thing we need is Congress to wrestle with this and revise the Nuclear Waste Policy Act."

For now, researchers are pursuing generic repository science that does not conflict with the law. In one large proposed experiment, DOE scientists wanted to assess whether salt beds at the WIPP could store radioactive waste that is hotter than the material they currently hold. In 2011, the team began developing a US$31-million experiment that would have tested how the salt deforms when it is heated, and how water moves through it.

Other researchers are investigating the concept of dropping cylinders of nuclear waste into 5-kilometre-deep boreholes in hard rock such as granite. Sandia National Laboratories in Albuquerque, New Mexico is leading a consortium of researchers and companies seeking to drill an experimental borehole costing approximately $25 million. The hot-salt and borehole proposals are now competing for funding within the DOE's relatively small $15-million annual budget for this kind of research. "Big tests like either of those would completely overwhelm the current budget," says Peter Swift, who heads the DOE's nuclear-waste science programme at Sandia.

In Europe, scientists have developed expertise with other types of rock. Finland and France have homed in on proposed underground repositories in granite and shale, respectively. Germany has buried low- and medium-level wastes in underground domes of salt, and it is evaluating the terrain for a controversial high-level waste repository.

International collaboration gives researchers access to the basic science on all of these environments, says Jacques Delay, secretary-general of the Implementing Geological Disposal of Radioactive Waste Technology ▶

Platform in Bure, France, a consortium that guides a roughly €10-million (US$14-million) joint research programme under the European Commission. "What is tricky is to make the link between the academic science and our projects," he says.

But basic research can go only so far, because the scientific assessment of repository safety is specific to local geology. After choosing a site, researchers must study the density, porosity and heat conductance of the rock there, and characterize any fractures and groundwater movement. Modelling and experiments help to determine how the rock will respond to the heat generated by the nuclear waste.

The United States spent more than $15 billion on Yucca Mountain before then-energy secretary Steven Chu pulled the plug, saying that the site was not a "workable option" — broadly interpreted to mean that it was doomed politically, if not technically. The United States has evaluated few alternatives. The city of Carlsbad, which hosts the WIPP, is politically inclined to expand its nuclear-waste portfolio. But few other communities have shown interest in storing nuclear waste.

Some DOE researchers favour a serious exploration of borehole disposal, in part because no one has tested the idea, which dates back to the 1970s. Swift estimates that just 800 boreholes would take care of the existing US waste stockpile, as well as spent fuel from current reactors until about 2050. There is suitable rock at various depths across the country. "You could spread these things out, and you wouldn't have to put all of your money on one site," says Patrick Brady, a geochemist at Sandia who is part of the lab's borehole consortium.

"Basically, all of the old ideas have come back out of the woodwork"

Drilling constraints might limit these boreholes to less than 50 centimetres in diameter, so spent fuel rods, currently stored in large canisters, would need to be repackaged. However, a hole that size would be perfect for a major source of waste that the DOE is trying to dispose of: 2,000 highly radioactive capsules containing caesium and strontium from the Hanford Site, a decommissioned plutonium-production facility in Washington state. These capsules are 52–56 centimetres long and up to 9 centimetres in diameter, and they contain 38% of Hanford's radioactivity. Swift says that they could all fit into a single borehole.

With research worldwide concentrating on underground repositories, Swift says that it is time to try a new concept: "If we make a borehole, it will be the one that the rest of the world comes and looks at." ■

TOMAS MUNITA/NY TIMES/REDUX/EYEVINE

An abandoned train line in Namie, Japan, inside the restricted area around the Fukushima Daiichi plant.

ENERGY POLICY

Japan caught up in energy dilemma

As the third anniversary of the Fukushima disaster nears, the nation is faltering in its resolution to shun nuclear power.

BY DAVID CYRANOSKI

Three years after a tsunami led to reactor meltdowns at Japan's Fukushima Daiichi nuclear power station, the country is at a crossroads in terms of energy policy. A draft law released last week suggests that, despite the previous government's promise of a 'zero-nuclear' future in the wake of the disaster, the current administration is ready to re-embrace the technology. Yet the announcement came just weeks before the opening of a ¥10-billion (US$98-million) renewable-energy research centre in Fukushima prefecture that aims to be at the forefront of green technology. Which way will Japan turn?

The reformist wave that swept Japan after the 2011 disaster included proposals to supply all of the country's energy from renewable sources. Nowhere is taking this more seriously than Fukushima prefecture, which plans to use an array of giant solar panels, biomass plants and windfarms to supply all of its energy by 2040. Two floating, 7-megawatt wind turbines, the world's largest, are scheduled to come online in the next year.

The opening of the Fukushima Renewable Energy Institute in April will bolster the prefecture's vision. The institute is in Koriyama, 60 kilometres west of the stricken nuclear plant, and has been established by the Tsukuba-based National Institute of Advanced Industrial Science and Technology (AIST). It has attracted interest from electronics companies such as Panasonic and Sharp, and foreign collaborations are also in the pipeline, including one with the Fraunhofer Institute for Solar Energy Systems in Freiburg, Germany. Inside, about 100 researchers will work across areas including solar, hydrogen, wind and geothermal power.

Deputy director Tetsuo Munakata says that the institute will expand on the long-running research programmes of AIST, and he points to concrete goals such as reducing the thickness of silicon wafers for solar cells to 80 micrometres in seven years.

But some see the institute as a showpiece with little chance of success. Critics point out that Japanese solar-panel makers are already struggling to compete with the lower costs of Chinese manufacturers. Tetsunari Iida, head of the Institute for Sustainable Energy Policies in Tokyo, says that the Fukushima institute lacks experienced hands and will get bogged down with ministerial bureaucracy. "I don't think we can expect much in terms of practical results," he says.

Sceptics also point to what seems to be a government move towards nuclear energy. Despite continued leaks of radioactive water stored at Fukushima Daiichi, and extensive exclusion zones remaining around it (see 'Fukushima: the legacy'), the draft energy plan says that the government will push to restart Japan's 48 operable reactors, all of which were closed after the earthquake that triggered the disaster. The plan is expected to be approved in the spring.

But Munakata says that the new institute also underlines the government's commitment to renewable energy. "There's no way it isn't going to keep investing in renewables," he says. ■