► 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.

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.” ■

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

TOMAS MUNI/ATNY TIMES/REDUX/EYEVINE

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. ■

FUKUSHIMA: THE LEGACY

The region around the Fukushima Daiichi nuclear power plant is still subject to exclusion zones that roughly mirror the areas of greatest contamination. This map shows the perimeters and radioactivity 1 metre above the ground in September 2013.

CANCER RISKS
Radiation exposure in Fukushima poses only a negligible cancer risk. For example, a study last month showed that residents in the worst-affected residential areas, including Tamano, have only a 1% higher lifetime risk of developing solid cancers.

OFFSHORE RADIATION
In December 2013, the International Atomic Energy Agency found that the level of caesium-137 in the ocean around the Fukushima plant was 1 becquerel per litre (Bq L⁻¹). World Health Organization guidelines state that the maximum level of caesium-137 in drinking water should be 10 Bq L⁻¹.

OCEAN POLLUTION
The radiation levels farther offshore, between 2 and 20 kilometres from the port, are now mostly below 0.1 Bq L⁻¹ for caesium-137. Even farther out, the levels are close to what they were before the disaster: 0.001–0.003 Bq L⁻¹ for caesium-137.

RADIATION DOSES
According to the World Health Organization, residents living in the hardest-hit areas of Fukushima prefecture were subject to radiation levels of 12 to 25 millisieverts (mSv) in the first year. That is equivalent to two or three medical CAT scans.

EXCLUSION ZONES
Officially, 154,000 people have been evacuated from their homes near the plant. None have yet been allowed to return permanently, but over the next two years up to 30,000 may be allowed back.

- Air radiation rates** (microsieverts per hour)
- >19
 - 9.5–19
 - 1.0–9.5
 - 0.2–1.0
- Exclusion zones**
- No public access
 - Restricted access
 - Free movement, no overnight stays

SLEEPING GIANT

In 2010, Japan was the world's third largest producer of nuclear power and had big plans to increase its output by 2030. The Fukushima disaster in 2011 has resulted in all of its reactors being turned off, and its expansion plans are on hold, although the current government may change that.

● Japan ○ World

48
434

Reactors operable February 2014

3
70

Reactors under construction February 2014

9
173

New-build reactors approved as of Feb 2014

3
310

New-build reactors proposed as of Feb 2014

IN THE MIX

Before the Fukushima disaster, Japan had planned to produce about 50% of its electricity from nuclear power by 2030.