Japan's Fukushima site is an ongoing morass

The world-scale nuclear disaster needs to be addressed by worldwide expertise, critics say.

An underground cryogenic barrier is Japan's latest tack to stanch the flow of groundwater into the contaminated Fukushima Daiichi nuclear power plant. The plan has been met with criticism—as has much of the government's and the effectively nationalized Tokyo Electric Power Company's (TEPCO's) response to the multifaceted disaster brought on by the magnitude-9 earthquake and tsunami on 11 March 2011.

"They have got it wrong from A to Z," says Paris-based international energy consultant Mycle Schneider. "The wrong tanks [for storing contaminated water], the wrong materials, the wrong site preparation and monitoring. A big worry is that a new earthquake would destroy one or more tanks or a reactor building with its spent fuel pool and we'd get massive releases into the environment." The most pressing issues are dealing with the contaminated water—400 000 tons and counting—and ensuring that the reactor cores and the 15 093 fuel-rod assemblies onsite are kept under water. A failure to cool the fuel could lead to a buildup of decay heat, spontaneous combustion of the fuel cladding, and uncontrolled release of radioactivity.

Disaster zone

The six boiling water reactors at the Fukushima Daiichi power plant all suffered structural damage in the Great East Japan Earthquake and tsunami and the several reactor hydrogen explosions that followed. When backup generators flooded and failed, the cores of the three reactors that were working at the time melted through their primary containment vessels. Two and a half years later, some 400 tons of groundwater becomes contaminated daily as it flows into the site; pumping it out expands the onsite storage farm, currently around 1000 tanks, by two tanks every five days. And tons of radioactive water leaks into the Pacific Ocean each day. The government now admits this, says Mitsuhei Murata, a former ambassador to Switzerland. "And there is no immediate solution in sight."

At the time of the accident, Reactor 4 was down for maintenance, with spent fuel in its fourth-floor cooling pool. If that reactor collapses, says Murata, people would have to evacuate, "or die on the spot." The other two reactors were closed for refueling when the disaster struck. In September Prime Minister Shinzo Abe told TEPCO that like the others at the Fukushima Daiichi plant, they should be decommissioned. Extrapolating from the 1979 meltdown at Pennsylvania's Three Mile Island puts the decommissioning cost at about $1 billion per reactor, according to Daniel Aldrich, a political scientist from Purdue University who has focused on nuclear power and disaster recovery for more than a decade. Others say it will cost more.

Remediation at Fukushima is much more complicated than the entombment carried out after the 1986 Chernobyl nuclear meltdown in Ukraine. "It's high time for a real consciousness about the level of complexity of this site," says Schneider. "It's not another Three Mile Island. It's not another Chernobyl. The difficulties go far beyond just a nuclear accident. It's a disaster zone."

TOKYO ELECTRIC POWER COMPANY

Standing atop Reactor 4 is a group from the US Nuclear Regulatory Commission during a visit last year to the Fukushima Daiichi nuclear accident site.

The complexity of the site on Japan's northeastern coast stems from the many unknowns about the conditions of the reactors; the risk of further fallout if a strong enough earthquake, tornado, or fire occurs or the power goes—as when a rat gnawed through a cable last March; and the discharge of radioactive water into the Pacific Ocean. Untrained laborers are recruited to clean up and monitor the site. "The most dangerous characteristic is that you don't know where the hot spots are," says Schneider. He recounts stories of people shielding their dosimeters to extend their employment and of workers in raincoats fastening bolts near toxic gushing tank leaks.

"Human error"

Add to that the host of humanitarian problems that have arisen in the wake of the accident: Tens of thousands of evacuees remain in temporary lodgings; farmers and fishermen can no longer make a living because people are wary about contamination from fish and from land crops; people worry about the possibility of developing illness from exposure to radioactivity; in areas where the radioactivity is elevated but not enough to get government assistance, people are scared to stay but have nowhere to go. Suicide, divorce, and depression rates have risen in communities affected by the disaster, says Aldrich.

"The area was not prepared ahead of time. The evacuations were done poorly. The government and TEPCO do not share information with the public. Communities have been destroyed. The Fukushima site has been mismanaged," says Aldrich. "These are all layered problems. And the base anxiety is related to them. The earthquake and tsunami were beyond human control, but what has happened since is human error."

The physical and technical complexities are exacerbated by the management of the remediation, which so far has been TEPCO's responsibility, and by the breakdown of public trust in TEPCO and the government. In his research, Aldrich found that public trust in the government and national authorities plummeted from 85% in 2010 to 8% some three months after the March 2011 disaster. The distrust is the "biggest problem," says Schneider. He and others note that it's unrealistic to expect TEPCO, a utility

company, to have the know-how to deal with a nuclear accident.

"My complaint is that TEPCO should have overdesigned," says Dale Klein, chair of a five-member committee that advises the company on nuclear safety. "Their safety assessments should have been more robust. A few years ago, their own engineers said a hypothetical tsunami could be 16 meters high—the tsunami [on 11 March 2011] was 14 meters. They should have thought about what they would have done if hit by a larger-than-expected tsunami—things like making watertight battery compartments."

"I am advocating that TEPCO create a special unit only charged with decommissioning," says Klein, a former head of the US Nuclear Regulatory Commission. He also agrees that communication needs to be better: "TEPCO presents information without context. A lot of good work they are doing gets buried when they have poor communications and misinformation."

PEACE BOAT

Protesters demonstrate against nuclear power in Yokohama, Japan, in January 2012.

Remediation

In early September the Japanese government announced that it would foot the bill for an ice wall and water filtration equipment proposed by TEPCO. Pipes to carry cooling fluid will be installed underground to freeze the soil and keep groundwater away from the four damaged reactors. The ice wall will be roughly 1.5 km long and up to 30 m deep. A decision on the final depth will be based on the results of geological surveys and other tests, says Hirokazu Yamaguchi, TEPCO general manager of corporate reform. "We will confirm that the soil can be frozen to bedrock by conducting operation tests."

At an estimated $320 million, the ice wall is about a third to half the cost of a subterranean steel barrier that was rejected earlier as too pricey. Of the options considered by TEPCO and the government, says Tatsujiro Suzuki, vice chairman of the Japan Atomic Energy Commission, "ice is the fastest, [initially] cheapest way to stop the water, but it's only been used on a small scale." A prototype will get under way soon, he says. "They think this is almost zero-percentage penetration. But they have already started thinking about backup plans." Critics note that even if the technique works on the large scale, vast amounts of electricity will be needed to keep the soil frozen. "It can't be a permanent solution," says Murata.

The filtration system will cost about $150 million and will remove the radioactive isotopes of cesium, strontium, and other elements from water. Tritium cannot be removed.

This month TEPCO begins moving the spent fuel from Reactor 4 to a ground-level common pool. Transferring all 1533 assemblies is expected to take about a year. Later, the fuel will be put in dry casks of concrete and steel for long-term storage.

Global wisdom

In mid-August TEPCO revealed that a storage tank had spewed out 300 tons of contaminated water—about one-eighth the volume held by an Olympic swimming pool. It was not the first leak, and it's impossible to know exactly how much escaped or where it went; moreover, many of the water storage tanks are bolted, not welded, together, and the vast majority do not have volume gauges installed. A few weeks later Abe assured the International Olympic Committee that the Fukushima site is "under control"—and Japan won its bid to host the 2020 summer Olympics. That claim was followed by a seemingly contradictory statement by TEPCO. Such events have put a new spotlight on the crippled Fukushima nuclear site. "The renewed attention is where I am a bit hopeful," says Schneider.

"The only tiny little blinks of good news were a couple of statements about needing international advice. But for the time being, the result is zero—the international input they are announcing is either bilateral or individual. This is far from good enough," he says. To be sure, the Japanese government and TEPCO have consulted experts from outside the country. But, says Schneider, "If they bring in only people that are perceived as nuclear proponents, that is a problem. For technical issues, I don't care whether the experts are pro nuclear or not. But there needs to be expertise that is independent of state and corporate interests." He first floated the idea for an international task force in 2011, just weeks after the accident. But, he says, "you cannot push from the outside if no one pulls from the inside."

"The government should get more involved, and should create a system to utilize global wisdom for the site," says Suzuki. "Unfortunately that process seems slower than expected."

"The nuclear accident cannot be solved by a single state or company," says Murata. "If the world does not learn the lessons of Fukushima, this tragedy will take place again." Still, he points to a few positive developments. The formation last year of the Nuclear Regulation Authority as a separate government body may lead to better oversight of nuclear power plants. And an official at the Ministry of Economy, Trade and Industry shares the "sense of crisis," says Murata. "Many ideas are sleeping. If a real task force is established, the Fukushima crisis will become more manageable."

Klein says he "would like to see the Japanese government have a robust monitoring system so the public can feel assured and trust that their fish supply is safe. They need a massive educational program to convince people that it's okay to eat the fish." Based on his involvement with Fukushima, he adds, "I have no problem eating fish when I am in Japan." But South Korea, for example, recently announced that the country will not import fish from certain areas of Japan.

Japan's nuclear future

Not surprisingly, a majority of Japanese citizens want to phase out nuclear power. But in a reversal from the previous government, which was in charge at the time of the Fukushima accident, the current Abe government favors

nuclear power. Restarting nuclear reactors is a higher priority than cleaning up the Fukushima site, critics say. Playing into the discussion about the future of nuclear power in Japan is debate over whether the meltdowns at Fukushima were caused by the earthquake or the tsunami. For nuclear power proponents, the tsunami is the more comfortable answer, since huge tsunamis are rarer than large earthquakes.

Last year saw the launch of Mayors for a Nuclear Power Free Japan. The group now has nearly 90 members, some from areas near the Fukushima site, where economies have traditionally depended on the nuclear power plants. "If this body continues to grow," says Akira Kawasaki of the activist group Peace Boat, "it will have good political and even financial power to counter measures by the national government."

Pressure continues to mount: In early October, former prime minister Junichiro Koizumi announced that he now opposes nuclear power. And his son Shinjiro Koizumi, who has criticized the handling of the March 2011 disaster and is an advocate for its victims, was recently appointed one of four parliamentary secretaries in charge of reconstruction.

According to Aldrich, it's unlikely that Japan will phase out nuclear power. But given public opposition, he predicts that "four to seven reactors will be as good as it gets." Before the Fukushima disaster Japan had around 50. Kawasaki notes that Tokyo survived the hot summer without nuclear power. "The case that Japan needs plants is not persuasive anymore," he says. The government is due to submit a broad energy policy by the end of this year.

Toni Feder

Geoengineering researchers ponder ethical and regulatory issues

With interest in artificial climate intervention heating up, advocates and foes agree on the need for a governance regime to sanction experimental trials.

As part of a research project exploring stratospheric particle injection to possibly mitigate global warming, a team of UK scientists and engineers in 2011 readied an experiment to spray water through a hose tethered to a balloon 1 km above Earth's surface. Although the experiment's environmental impacts would have been nil, leaders of the research ultimately called it off.

In 2012 the indigenous Haida people of British Columbia contracted to dump 100 metric tons of iron sulfate into waters off the west coast of Canada in hopes of stimulating phytoplankton growth and restoring a salmon fishery. Such ocean fertilization also has been