



A worker from Fuji Electric Co., holds a pocket-size radiation dose meter, mainly used in hospitals and universities, during a photo opportunity at an assembly factory in Tokyo May 20, 2011. **REUTERS/YURIKO NAKAO**

JAPAN'S NUCLEAR SOFTSPOT

Fukushima Daiichi ranked as one of the five most hazardous nuclear plants in the world for worker exposure to radiation, a Reuters investigation finds.

BY CHISA FUJIOKA AND KEVIN KROLICKI
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JAPAN'S FUKUSHIMA Daiichi nuclear plant ranked as one of the most dangerous in the world for radiation exposure years before it was destroyed by the meltdowns and explosions that followed the March 11 earthquake.

For five years to 2008, the Fukushima plant was rated the most hazardous nuclear facility in Japan for worker exposure to radiation and one of the five worst nuclear

plants in the world on that basis. The next rankings, compiled as a three-year average, are due this year.

Reuters uncovered these rankings, privately tracked by Fukushima's operator Tokyo Electric Power, in a review of documents and presentations made at nuclear safety conferences over the past seven years.

In the United States -- Japan's early model in nuclear power -- Fukushima's lagging safety record would have prompted more intensive inspections by the Nuclear

Regulatory Commission. It would have also invited scrutiny from the U.S. Institute of Nuclear Power Operations, an independent nuclear safety organization established by the U.S. power industry after the Three Mile Island accident in 1979, experts say.

But that kind of stepped-up review never happened in Tokyo, where the Nuclear and Industrial Safety Agency remains an adjunct of the trade ministry charged with promoting nuclear power.

As Japan debates its future energy policy after the worst nuclear accident since



Chernobyl, a Reuters review of the long-troubled record at Fukushima shows how hard it has been to keep the country's oldest reactors running in the best of times. It also shows how Japan's nuclear establishment sold nuclear power to the public as a relatively cheap energy source in part by putting cost-containment ahead of radiation safety over the past several decades.

"After the Fukushima accident, we need to reconsider the cost of nuclear power," Tatsujiro Suzuki, vice chairman of Japan's Atomic Energy Commission, told Reuters. "It's not enough to meet safety standards. The industry needs to search for the best performance."

In an illustration of the scale of the safety problems at Fukushima, Tokyo Electric had set a 10-year goal that insiders considered ambitious in 2007. The plan was to reduce radiation exposure for workers at Fukushima to bring the facility from near rock-bottom in the industry's global safety rankings to somewhere below-average by 2017, documents show.

"Severer management than before will be required," Tokyo Electric safety researcher Yasunori Kokubun and four other colleagues said in an English-language 2004 report. That report examined why Japan lagged other countries such as France and the United States in limiting radiation exposure for workers during plant maintenance.

The report came from an earlier period of corporate soul searching by Tokyo Electric, a politically powerful regional monopoly in Japan that ran the Fukushima power station and remains in charge of the clean-up work at the crippled plant expected to take a decade or more.

In 2002, the chairman and president of the utility were forced to step down after regulators concluded the company had routinely filed false reports during safety inspections and hid evidence of trouble at its reactors, including Fukushima. All 17 of Tokyo Electric's reactors were ordered shut down. The last of those did not restart until 2005.

COST-SAVING CULTURE

AS PART OF A BID TO win back public trust, the utility promised to repair a "safety culture" it said had failed in the scandal. Teams of newly empowered radiation safety managers were created and began to audit the company's nuclear operations, including Fukushima. They also reported back findings to other nuclear plant operators and regulators. None of the utility's safety managers who gave



RADIATION CHECK-UP: Four-year-old girl Saki Watanabe is tested for possible nuclear radiation at an evacuation centre in Koriyama, Fukushima Prefecture, northern Japan, April 8, 2011, located about 70 km (44 miles) from the tsunami-crippled nuclear reactor. **REUTERS/KIM KYUNG-HOON**

"IN NORMAL TIMES, RADIATION MONITORING WOULD BE LEFT TO THE PLANT OPERATOR, BUT THESE ARE NOT NORMAL TIMES."

those archived presentations responded to requests for comment for this report.

One problem, according to one of those early assessments, was that Tokyo Electric's managers on the ground tended to put cost savings ahead of a commitment to keep driving worker radiation doses "as low as reasonably achievable," the international standard for safety.

Take maintenance, for instance. Japanese plants are required to shut down every 13 months for almost four months at a time -- twice as long as the U.S. average. Tepco was slow to invest in the more expensive radiation safety precautions needed during maintenance, thus lowering the cost of operating Fukushima before the accident.

But that focus on costs also kept Tepco from developing a more active commitment to worker safety that could have helped it navigate the March disaster, officials now say.

After the earthquake, contract workers at

Fukushima were sent in without radiation meters or basic gear such as rubber boots. Screening for radiation from dust and vapor inhaled by workers was delayed for weeks until experts said the testing was almost meaningless. At least 39 workers were exposed to more than 100 millisieverts of radiation, five times the maximum allowed in a normal year.

Fukushima Daiichi, built in a poor region on Japan's Pacific Coast to supply power to Tokyo, was pushed into crisis by the massive March 11 earthquake and the tsunami that hit less than an hour later. The backup power systems meant to keep its radioactive fuel cool were disabled, leading to meltdowns, explosions and radiation spewing into the environment, forcing the evacuation of more than 80,000 residents.

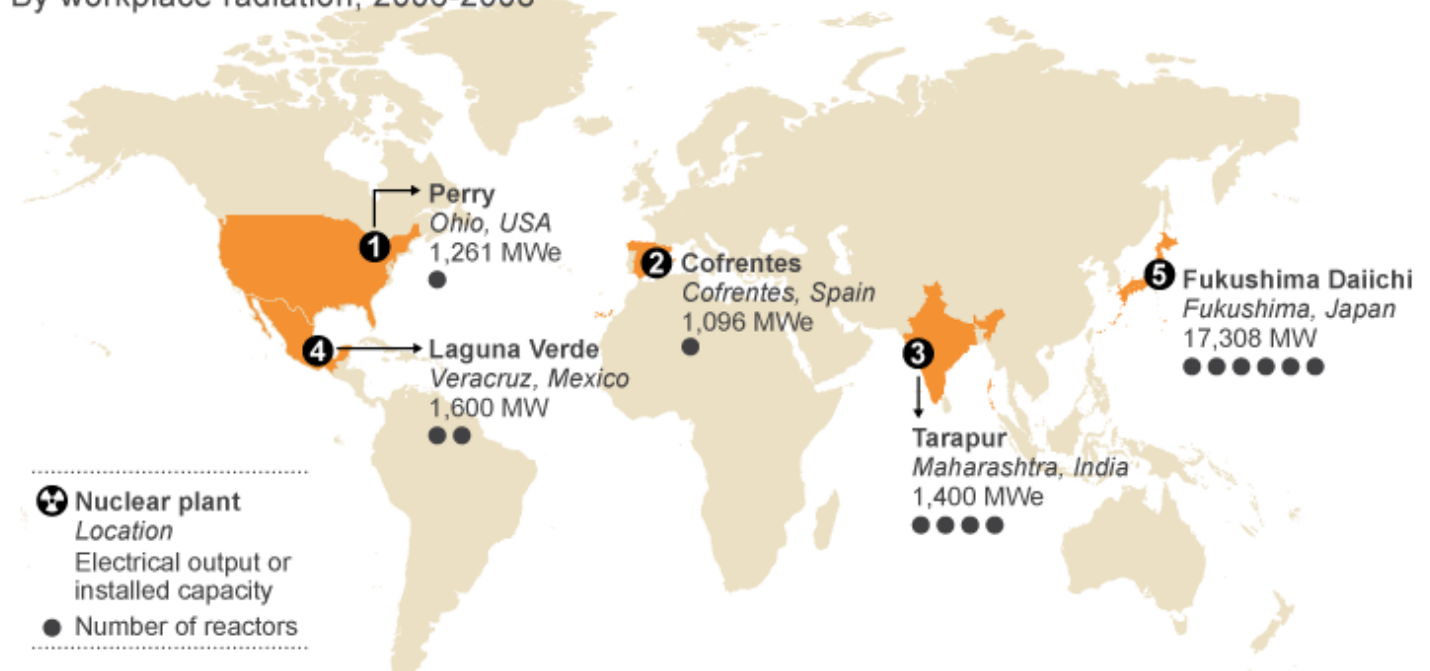
Goshi Hosono, the government minister appointed to coordinate Japan's response to the Fukushima crisis, said he was not aware of the details of Fukushima's radiation safety record before March 11 and declined to comment on that basis.

But he said the utility had failed to protect workers in the chaos that followed the accident, prompting a reprimand from government officials and a decision by regulators to take charge of radiation health monitoring at the plant.

"In normal times, radiation monitoring would be left to the plant operator, but these are not normal times," Hosono told Reuters.

World's most dangerous nuclear plants

By workplace radiation, 2006-2008*



*Plants using boiling water reactors (BWR) only; based on rolling average, person/sv per reactor.

Two of Tarapur's reactors are pressurized heavy water reactors.

Sources: Tokyo Electric, Nuclear Power Corp. of India, Consejo De Seguridad Nuclear, NRC, World Nuclear Assoc, Reuters.



Reuters graphic/Christine Chan

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HIGHER RADIATION IN OLD PLANTS

IN A JUNE REPORT TO the International Atomic Energy Agency, Japanese officials said basic design failures, a fatal underestimation of tsunami risk and a chaotic decision-making process had contributed to the disaster. But they also said Tokyo Electric's "safety culture" had failed it again.

Outside experts agreed. "The main root causes of this man-made disaster can be found in (Tokyo Electric's) ineffective -- exemplary poor -- safety practices and track record," said Najim Meshkati, an engineering professor at the University of Southern California and former U.S. government science advisor.

In response to questions about the radiation safety record at Fukushima, Tokyo Electric said that radiation exposure for each individual worker at the plant had been kept below the regulatory standard. The overall radiation level remained relatively high because the plant's six reactors were all between 30 and 40 years old at the time of the accident, the utility said.

"Because it was an older plant it required longer maintenance periods and more



intensive repair work," Tokyo Electric spokeswoman Ryoko Sakai said. "For that reason, the overall radiation exposure was higher than our other plants."

The General Electric-derived design of the reactors at Fukushima posed a particular safety challenge during routine shutdowns because radioactive steam is allowed to circulate through the power-generating turbine. That means that large parts of the power plant pose a radiation risk during repairs, experts say.

But even compared to other boiling water reactors, Fukushima stood out for its risks. At the start of the decade, each of its reactors had exposed workers to 2.5 times the amount of radiation they would have faced in an average U.S. reactor of the same design. By 2009, that gap had narrowed, but exposure at Fukushima was still 1.7 times the U.S.

average and equivalent to subjecting workers on the site to a collective 1,500 full-body CT scans each year.

Because of Fukushima's high radiation, Tokyo Electric brought in thousands of workers each year, often to work just a few days on the most hazardous jobs. The utility employed almost 9,000 contract workers annually on average at the plant over the past decade, according to records kept by Japan's trade ministry.

Those workers were needed in part to allow Tokyo Electric to meet the international safety standard Japan had committed to in 2001. Under that standard, workers were limited to 20 millisieverts of radiation exposure in an average year, equivalent to getting two CT scans at work.

But even with its extraordinary work force, the average contract worker at Fukushima was exposed to 73 percent more radiation than the average nuclear worker at other plants in Japan over the past decade, according to a Reuters review of data from Japan's trade and industry ministry. The same worker was also exposed to almost three times the amount of radiation that



SHIELDS UP: A worker stands near a temporary shield screen that will be used to block radiation from the Unit 2 reactor at Fukushima Daiichi Nuclear Power Station in Fukushima prefecture, in this handout picture taken June 21 and released June 23, 2011. **REUTERS/TOKYO ELECTRIC POWER CO/HANDOUT**

Tokyo Electric's own staff faced. The average radiation dose ran almost a third higher than for U.S. workers at similar plants.

The number of Fukushima workers near the annual limit for radiation also remained troublingly high. Over the past five years, each Fukushima reactor exposed almost 300 workers to between 10 and 20 millisieverts of radiation, the Reuters review of the data showed. The comparable figure for U.S. reactors of similar design was just 22 workers per reactor with those kinds of exposure levels.

'THIS SITUATION IS THE WORST'

PART OF THE REASON was that Fukushima maintenance work took almost three times longer than comparable jobs at U.S. plants -- more than four months on average. But American utilities have also spent heavily as a group on steps to reduce worker exposure, including building mock-up reactors so workers could rehearse dangerous jobs almost as commandos would.

"We are ready and willing to spend money to reduce worker doses," said John Bickel, a nuclear safety expert who has consulted for the NRC and the IAEA. "I would characterize that there is an intense competition in the U.S. to be the lowest."

By contrast, critics of the Japanese nuclear industry cite records showing how Tokyo

Electric and other utilities shifted the health risks of operating nuclear plants to a group of relatively poor and sometimes homeless day laborers desperate for a quick payday.

"Nuclear power is based on discrimination, a system in which the people who are working to protect nuclear safety end up on the streets and are given the cold shoulder by society.

All of us who use electricity are responsible for this system," said Yuko Fujita, a former physics professor at Keio University who has campaigned for nuclear worker safety in Japan for over 20 years.

To be sure, Tokyo Electric had taken steps to reduce the amount of radiation workers faced. It changed the chemistry of water piped through the reactors to reduce corrosion in pipes. It developed robots and remote-controlled probes to inspect hazards rather than sending in workers. And it used radiation shields such as lead "blankets" wrapped around pipes during maintenance to limit radiation in places workers had to be.

Those measures had reduced the overall radiation exposure for workers at Fukushima to a third of the 1978 peak by the start of the past decade, the records show.

But by 2006, Tokyo Electric safety managers had decided that they had to take on a tougher problem to make any more progress. They needed to reform the



NO TO NUCLEAR: An anti-nuclear protester takes part in a rally in front of Tokyo Electric Power Co (TEPCO)'s headquarters in Tokyo April 15, 2011. **REUTERS/YURIKO NAKAO**

basic organization of the utility, where maintenance managers faced no pressure to meet targets for reducing radiation exposure for the thousands of contractors and day laborers, two reports show.

The only more dangerous plants from 2003 to 2005 on that basis had been the Tarapur nuclear plant in India, where two reactors shared the basic Fukushima design, and the Perry nuclear plant on Lake Erie outside Cleveland, Ohio.

Perry, which is operated by FirstEnergy Corp, was cited by the Nuclear Regulatory Commission for a series of safety mistakes during a maintenance period in April. In that incident, regulators said four workers were exposed to high levels of radiation after being sent to retrieve a radiation monitor near the reactor's core. The plant has been the target of NRC safety inspections for more than three years because of what U.S. regulators call "human performance" issues in safety management.

COMPLACENCY SETS IN

TOKYO ELECTRIC DID NOT come to terms with its own management and organizational problems related to safety until recent years, the record shows.

Shiro Takahira, a Tokyo Electric manager in charge of radiation safety, showed a

conference in October 2006 a chart depicting Fukushima Daiichi as the third-worst nuclear plant in the world in terms of worker exposure to radiation.

"This graph could be a good driving force to improve our process," Takahira told the radiation safety conference in Niigata, Japan, according to remarks posted by the organizer. Takahira said Tokyo Electric had traditionally "put more weight on cost effectiveness" than the need to keep driving radiation exposure down. "There has been no standard mechanism to promote (the standard of 'as low as reasonably achievable') systematically and continuously," he said.

By late 2006, radiation safety managers such as Takahira had won a seat at the table in planning repair jobs at nuclear plants including Fukushima. By 2007, the company set a goal of getting the annual radiation at each Fukushima reactor to about 2.5 sieverts, a more manageable dose equivalent to about

250 CT scans for workers. That would mean Fukushima was still lagging the industry but by a narrower margin.

The full-year radiation for 2008 and 2009 came in just below 2.5 sieverts of exposure per reactor, just under the goal managers had set in 2007. On a three-year rolling basis, the exposure was 2.53 sieverts per reactor between 2007 to 2009.

"We had largely reached our target by 2009," said Tokyo Electric's Sakai.

At that point, some of the urgency behind the safety campaign appeared to drain. "We'll continue to try to reduce occupational exposures by every possible measure after cost performance evaluations," Shunsuke Hori, a Tokyo Electric safety manager, said at a September 2009 conference in Aomori, Japan.

Hori was one of two Tokyo Electric safety managers who published what amounted to a declaration of victory after the nascent

effort to improve radiation safety.

"The reliability of Japanese nuclear plants is now quite high," Hori and another Tokyo Electric manager, Akira Suzuki, wrote in a radiation health journal. "The Japanese nuclear industry has over 40 years of radiation protection experience, and it is believed that more radiation control will be possible in the future using this experience."

The upbeat assessment was published in a little-read scientific journal, Radiation Protection Dosimetry, on April 26, 2011, the 25th anniversary of the Chernobyl disaster.

On the ground in Fukushima that day, white smoke was still steaming off three of the reactors, and residents to the northwest had started a wider round of evacuations.

(Additional reporting by Scott DiSavino in New York and Eileen O'Grady in Houston)



PRAYER TIME: Evacuees and a Buddhist monk (L) wearing radiation protection suits take part in a memorial service for the victims of the March 11 earthquake and tsunami during their brief visit to their hometown of Namie, Fukushima prefecture, near the crippled Fukushima Daiichi nuclear power plant in this picture taken by Kyodo on May 26, 2011. **REUTERS/KYODO**

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