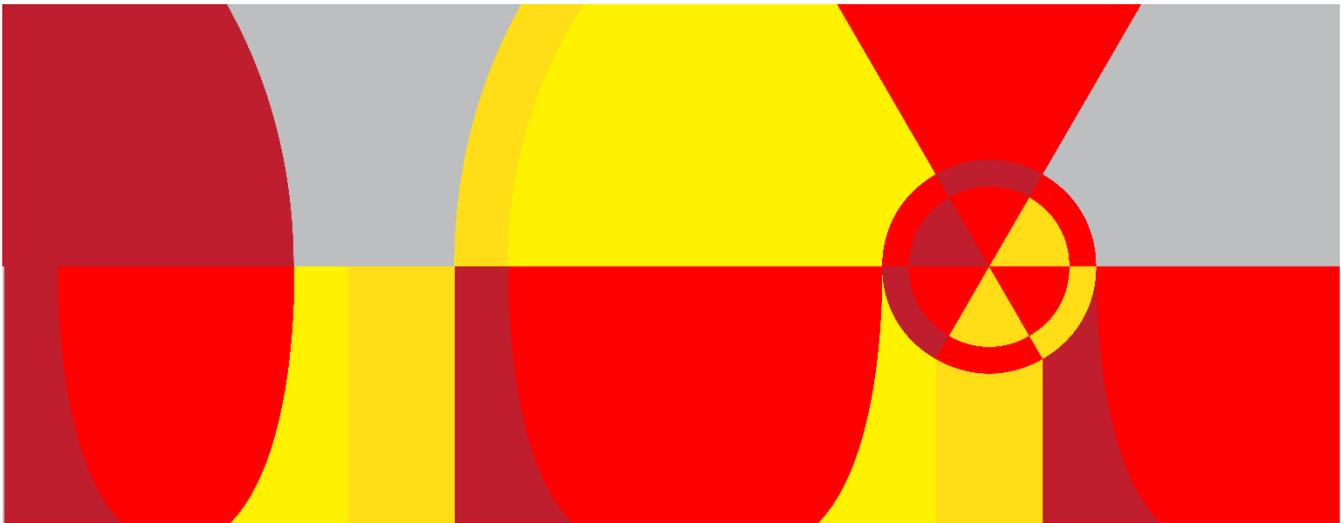


Feature—After Fukushima, EPRI Deepens Engagement in Japan



All Nuclear Utilities Participate in R&D to Advance Plant Safety

By Brent Barker

On March 11, 2011, EPRI Fellow Rosa Yang awoke to the news that a major earthquake had struck Japan, sending a 60-foot tsunami flooding across the northeastern shore of Honshu Island. Tens of thousands were feared dead or missing, entire towns washed away, and Tokyo Electric Power Company's (TEPCO) nuclear reactors at Fukushima were believed to be in trouble. It was an uneasy coincidence for Yang, scheduled that day to fly to Japan to meet with some of the country's top nuclear officials. "This was to be my first major trip to Japan in my new role as EPRI's nuclear technical lead in Asia," she recalled. "Our new country manager, Michio Matsuda, advised me to come, explaining that there were no pressing hazards in Tokyo, and it was important for me to be here to offer any help."

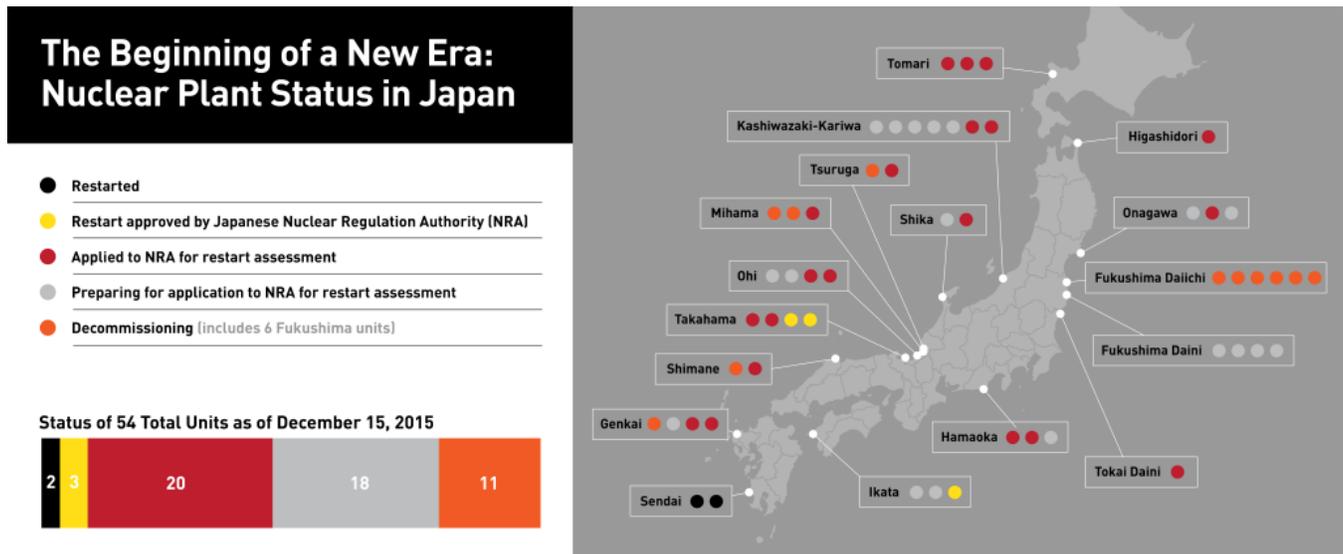
Yang arrived the next day. "The airport was chaotic, Tokyo frantic," she said. "My appointment with TEPCO's chief nuclear officer, a former classmate of mine, was cancelled, but I spent the next two days with another old friend, Shunichi Suzuki, TEPCO's R&D manager, which turned out to be fortunate."

Some might say fateful. A few days after Yang returned home, Suzuki called her about a crisis unfolding in Fukushima's damaged reactors. Cooling water contaminated with radioactive fission products, mostly cesium, was collecting faster than TEPCO could store it. Plant personnel had to find a way to remove the cesium before the rainy season started in two months. Otherwise, the rains would flood the reactor basements and carry the contaminated water into the ocean. TEPCO was seeking EPRI's help.

"I remembered an EPRI technical report published on the subject three months earlier," said Yang. "With Matsuda's help, we made calls and contacts, and EPRI's liquid waste processing and low level waste management expert, Lisa Edwards, was put on the first plane to Japan." TEPCO selected a technology identified in the EPRI report, then gave the specifications to the developer, Kurion, with a nearly impossible deadline. Kurion came through—designing, building, and shipping a first-of-a-kind system in time. "The outcome was extraordinary," said Matsuda. "TEPCO was able to remove more than 99.9% of the cesium before the rainy season started."

“This is testament to the value of R&D,” said Yang. “If we hadn’t done the R&D, we wouldn’t have been able to help them solve an extremely urgent problem. The benefit was not just to TEPCO but to Japan and the world, preventing significant contamination of the ocean.”

“Relationships are crucial in Japan,” said EPRI Nuclear Vice President Neil Wilmshurst. “The Japanese remember people who help them when they are in trouble. This certainly played a role in sustaining and growing Japan’s engagement with EPRI in a time of great financial hardship.”



This graphic depicts the status of nuclear plants in Japan.

Surge in Japanese Participation with EPRI

Recognizing the importance of risk—especially the risk of very low-probability, high-consequence events such as the Fukushima accident—the Japanese nuclear utilities have expanded their participation in EPRI R&D.

Full participation in EPRI nuclear research programs began with TEPCO in 2002, followed by Chubu (Japan’s third largest utility) in 2006. Participation by other utilities grew after Fukushima. For example, Chugoku and Shikoku came on board with full participation in 2013, and Kansai (second largest utility) joined in 2014. Currently, all 11 Japanese nuclear utilities participate in EPRI research. Five have elected full membership, participating in all 17 EPRI nuclear programs—which range from maintenance and inspection techniques to materials integrity, risk management, and fuel reliability. The entire suite is focused on enhancing nuclear plant reliability, performance, and safety and on reducing the risk of a severe accident in the future.

The scope of EPRI research related to the Fukushima accident now includes evaluation of root causes, improvements in severe accident management, and risks from seismic events and flooding. In joining EPRI’s Risk and Safety Management Program, Japan’s nuclear utilities are helping to establish a more risk-informed framework for nuclear safety. The program is providing them with rigorous training in probabilistic risk assessment. “First, we had educational presentations for chief nuclear officers and a one-day course for middle management,” said Matsuda. “Then we had six one-week training sessions for engineers working at the various headquarters and power plant sites.”

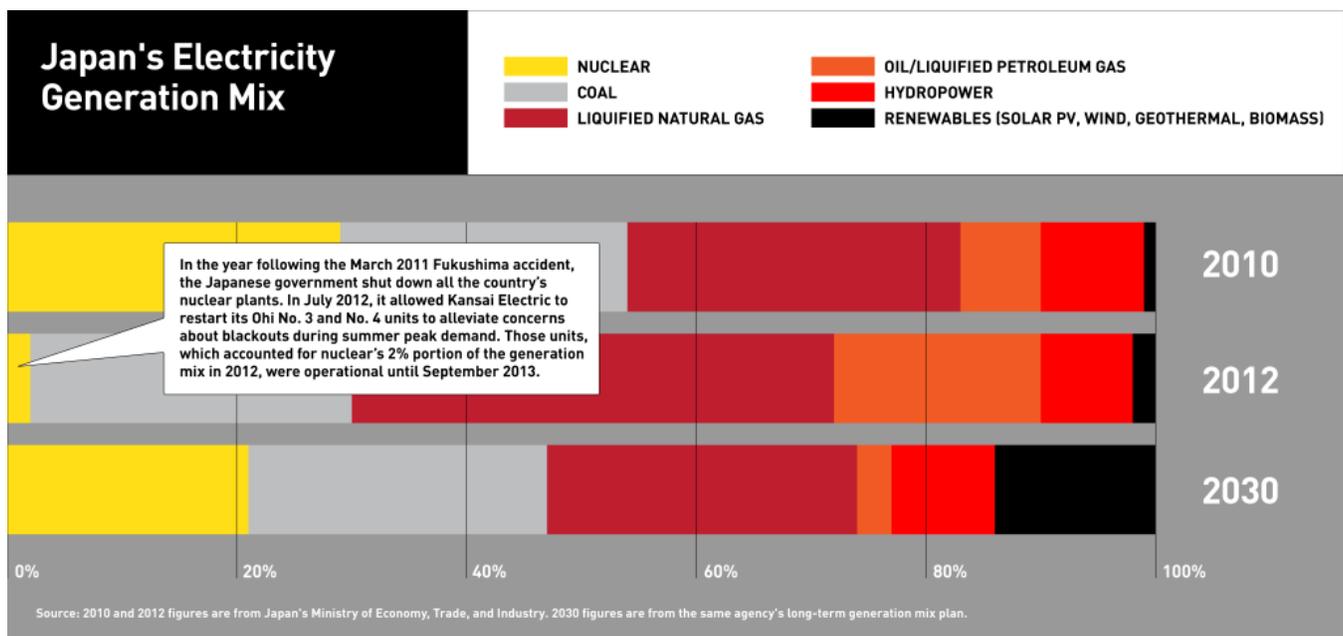
Changing Nuclear Landscape

Before Fukushima, nuclear represented 30% of the country’s power generation and was on course to become 50% by 2030, according to the government’s Basic Energy Plan 2010. Following the accident, the government shut down the nation’s reactors and refocused power generation on fossil and renewables. Imports of coal,

natural gas, and oil soared by more than \$35 billion per year. To help offset these costs, utilities increased electricity prices by 20% for residential customers and by 30% for industrial facilities.

At least 11 nuclear units, including the six at Fukushima Daiichi, will be shut down permanently and fully decommissioned. For the remaining units, utilities are evaluating the costs and benefits of restarting after making significant safety modifications, which include increased tsunami and seismic protection. Many plants have submitted applications for restart licenses, while operators of some older units will seek license extensions beyond 40 years. Safety enhancement for restarts has already reached \$30 billion.

The pace and scale of Japan's nuclear resurgence is uncertain due in part to a skeptical public and local lawsuits, but the national government remains committed to nuclear power to help meet its target to reduce CO₂ emissions 26% by 2030 relative to 2013 levels. Government guidelines for the 2030 generation mix call for 20–22% nuclear, 20–24% renewables, 26% coal, and 27% natural gas (see chart).



Advancing EPRI's Severe Accident Software

Shortly after the accident, the Japanese government began funding enhancements of EPRI's Modular Accident Analysis Program (MAAP) to assist in Fukushima decommissioning. Based on its long experience with MAAP, Toshiba's nuclear division recommended to the Ministry of Economics, Trade and Industry (METI) that it support the program's further development.

The uses of MAAP are diverse and growing. "MAAP was used since the early hours of the Fukushima accident to help understand what happened," said Yang. "Initially, we had to use generic numbers because we didn't have exact plant data. As data became available—how much water was put in the reactor and when, and equipment conditions during the accident—our understanding has grown. In time, the enhancements funded by the Japanese will help us unravel the full sequence of events." The improvements are also expected to provide insights on the location of highly radioactive core debris in the three damaged units.

Today the software is used by more than 70 organizations in 17 countries. MAAP can be used to help evaluate potential safety benefits of plant design, equipment, operations, and maintenance changes. It can also be used to evaluate potential plant uprating (higher power levels), life extensions, and restarts in Japan and elsewhere.

During a severe accident, MAAP can be used to help predict the timing of key events, to guide evaluations of the effectiveness of operator actions, and to support efforts to predict the release of fission products. With high-powered computing, it can assist operators as they evaluate many possible scenarios and uncertainties during a crisis.

Decommissioning Teams

The cleanup at Fukushima Daiichi will likely take 40 years or more and be extremely costly because of the extensive damage and high radiation fields in the plant. At the government's request, two advisory committees have been formed—both with EPRI participation—to help guide the process. The International Expert Group offers technical advice to TEPCO's decommissioning team, and EPRI's Yang is one of six members.

Yang also sits on the government's Nuclear Damage Compensation and Decommissioning Facilitation Corporation (NDF). This four-person advisory committee will tap into international expertise and provide mid-to-long-term strategy, identifying alternative decommissioning approaches and critical, unaddressed R&D needs. Priorities include retrieving fuel debris and managing highly radioactive materials.

"Asking Rosa to sit on both advisory committees reflects the government's recognition of EPRI's value and Rosa's expertise, as well as the esteem in which they hold her in Japan," said Wilmshurst.

Nuclear Power's Future in Japan

Nuclear power appears to be starting a new chapter in Japan. Eighteen units are seeking government approval to restart (see map). Kyushu's Sendai Unit 1 restarted in August, and Unit 2 restarted operations in October. The Japanese Nuclear Regulation Authority (NRA) has approved restarting Kansai's Takahama Units 3 and 4, pending related court rulings. The NRA has granted safety approval to Shikoku's Ikata Unit 3, and local communities and municipalities generally favor restarting the plant. "The Japanese government's support of nuclear plant restarts comes from its commitment to addressing climate change," said Matsuda.

The ability for nuclear plants to withstand major earthquakes and tsunamis remains a central concern. Geologists consider the area about 125 miles south of Tokyo as the region most vulnerable to tsunamis. Along that shoreline, a one-mile concrete wall has been built to shield the three Hamoaka nuclear units. At 70 feet, it rises 13 feet higher than the Fukushima tsunami. A wave similar in magnitude to Fukushima's may be likely in this region in the next 30 years, according to geologists.

CRIEPI's Role in Collaborative R&D

Japan's Central Research Institute of the Electric Power Industry (CRIEPI) is a collaborative R&D organization funded by a kilowatt-hour charge on electricity generation. Similar to the U.S. national energy laboratories, it focuses on basic scientific research and is recognized for its expertise in materials science. In 2011, EPRI and CRIEPI signed a joint R&D agreement focusing on fundamental mechanisms for materials aging.

EPRI's Commitment to Nuclear Safety

EPRI's credibility and technical leadership in Japan have been bolstered through its work on Fukushima decontamination and decommissioning, severe accident software applications, risk assessment, and more. Its leadership has deepened with the full participation of five utilities in EPRI's nuclear programs.

"We're fully committed to enhancing the future of nuclear safety in Japan and around the world," said Wilmshurst at the Asian Nuclear Power Council meeting in Kyoto in June. It was a signature meeting, co-hosted by the council's Japanese members and attended by 110 nuclear industry representatives. The many chief nuclear officers in attendance, as well as the CEO of the World Association of Nuclear Operators, recognized EPRI's critical role in Fukushima. EPRI's R&D network represents more than 75% of the world's commercial reactors, and its collaboration with Japanese nuclear utilities opens the door for them to engage with the world's best nuclear safety R&D.

Key EPRI Technical Experts

Rosa Yang, Michio Matsuda

Deregulation of Japanese Utilities

In 2013, the Japanese government unveiled a plan through 2020 to deregulate the electricity industry, unbundling the vertically integrated utilities established for each of the country's 10 traditional regions. In 2015, Japan established an interregional power grid control system similar to the independent system operators in the United States. In 2016, efforts to deregulate the retail markets will begin. Meanwhile, the power industry is closely watching TEPCO's proposed unbundling model with separate thermal/fuel, transmission/distribution, and retail companies under a holding company. The nuclear units will remain an integral part of the holding company.