

Meltdown-or-Not Future for Nuclear Seen in Diminutive Reactors

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Nuclear engineer Jose Reyes jolted awake at 4:45 a.m. on March 11 when his son called to warn him that a massive earthquake had unleashed a tsunami that rocked Japan. Giant waves were heading for the Oregon coast, about an hour from Reyes's Corvallis office.

As news poured in during the next 12 hours that the cooling system at a Tokyo Electric Power Co. nuclear plant had been damaged, Reyes's anxiety grew. People were using the words "potential meltdown" with alarming frequency. Reyes, 55, who founded NuScale Power Inc. in 2007 to design a slimmed-down, 45-megawatt reactor, contemplated the blot on the already beleaguered nuclear industry -- and the prospects for his nascent company, Bloomberg Markets magazine reports in its May issue.

"We've been hard-pressed but not crushed," he says. "Stopping the progress being made would be a mistake."

Convinced that today's large nuclear projects are burdened by too much financial risk, NuScale is designing and testing a 60-foot-high (18-meter-high) reactor encased in a thermos-like metal sheath. It would cost about \$200 million and could be used to light and heat villages, desalinate ocean water or be strung together side by side to form a midsize power plant -- virtually free of carbon emissions. With some investors on board, Reyes plans to ask the U.S. Nuclear Regulatory Commission for a license in late 2012.

"More and more people see small nuclear as a green technology," he says.

Nuclear Revival

Decades after accidents at Three Mile Island and Chernobyl poisoned attitudes and the environment, Reyes and a cadre of scientists, engineers and investors have been betting that small-scale reactors can spark a nuclear revival.

Hyperion Power Generation Inc. in Santa Fe, New Mexico, is working on 25-megawatt, refrigerator-sized designs for \$50 million each that could power remote locations or be used in hospitals and factories. By 2020, Russian nuclear company Rosatom Corp. expects to sell seven barges equipped with twin 35-megawatt reactors for the Arctic and Africa. In Argentina, the government of President Cristina Fernandez de Kirchner is clearing ground in the central grasslands for a 25-megawatt prototype planned for 2014.

Microsoft Corp. (MSFT) co-founder Bill Gates is backing a more powerful, 500-megawatt reactor designed by TerraPower LLC in Bellevue, Washington. Its traveling-wave technology uses uranium-238 to fuel a reaction in what functions like a 13-foot-tall candle.

'Valuable Offering'

"If it works, it's hard to think of a more valuable offering in the energy space," says Izhar Armony, a partner at Waltham, Massachusetts-based Charles River Ventures, which invested in TerraPower.

As improbable as it may sound amid the devastation in northeastern Japan, the nuclear accident may increase the appeal of innovative, small-scale reactors, says Chris Gadowski, a Bloomberg New Energy Finance analyst in San Francisco.

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“We’re seeing a knee-jerk reaction saying, ‘get rid of nuclear,’ but that’s not going to happen in the long run,” he says. “There is no other good solution if you want to decarbonize the energy sector. As far as small reactors go, these events in Japan will strengthen their hand as opposed to weakening it.”

U.S. Energy Secretary Steven Chu, who won the Nobel Prize in physics in 1997 for using lasers to study atomic particles, has requested \$97 million for small-reactor development in fiscal 2012, which begins on Oct. 1. Chu said on March 16 that President Barack Obama’s administration will press ahead with efforts to expand loan guarantees for new reactors.

Nuclear and Coal

Maurice Gunderson, a partner at San Francisco-based CMEA Ventures, invested in NuScale four years ago. He predicts he’ll raise an additional \$200 million by June 1, even after the Japanese disaster.

Anti-nuclear sentiments inflamed by leaking radiation at the Fukushima plant may subside over time, he says. More crucial, he says, is that the world has few good options to replace the one-seventh of its electricity that’s produced by nuclear reactors.

“Powering a society as large as the one we have means using nuclear power and coal,” he says. “Nothing else we have at the present time is big enough to do it in a sustained way. And coal means lopping off mountaintops, air pollution and mining deaths. It’s tremendously hazardous.”

Burning petroleum spews carbon into the air, and rising prices ripple through the global economy. From Dec. 17, when riots erupted in Tunisia and spread to oil-rich nations in the region, Brent crude for May settlement surged 26 percent to \$115.70 a barrel in London on March 22.

No Pumps, External Power

Reyes says his preliminary data show that his reactor would have survived the Japanese earthquake -- and held up under one that shook the ground even harder. NuScale’s reactor core is housed inside a vessel that’s 10 times stronger than the one in Japan, he says, and that’s placed in a pool of water and buried underground.

More important, his design doesn’t require pumps or external power to cool the reactor. Fukushima Dai-Ichi reactors, of which Toshiba Corp. (6502) was among the builders, overheated when power sources failed and pumps couldn’t deliver cooling water.

NuScale’s design relies on so-called passive safety systems that take advantage of natural circulation created by the heating and cooling of water inside and outside the reactor. NuScale’s design, which uses about 5 percent of the amount of fuel of the big models, produces less heat after it’s idled.

“Keep your core covered with liquid -- that’s the rule of thumb,” Reyes says.

Last Bit of Hope

The accident in Japan is hurting Toshiba. The company’s shares have dropped 17 percent in the days after the earthquake and tsunami to 406 yen on March 22. On March 16, China suspended approval of new nuclear projects and said it would conduct safety inspections of all plants under construction. China has chosen the AP1000 from Toshiba’s Westinghouse unit as its flagship, with the first one set to go online in 2013.

Mykle Schneider, a Paris-based nuclear industry analyst who has advised the governments of Belgium, France and Germany on atomic energy, says small reactors would have been vulnerable to the twin forces of Japan’s earthquake and tsunami.

“The industry has lost the last remaining bit of hope,” he says. Nuclear proponents can’t recover by painting rosy views of a carbon-free atomic future, Schneider says. “This was a big one for the nuclear industry,” he says.

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Consuming Nuclear Waste

New reactor models will arrive too slowly to make a dent in global warming, while used fuel stored in pools of water is a prime terrorist target and safety risk, he says. Permanent waste disposal solutions mean digging into granite or salt and leaving radioactive material for thousands of years.

In the face of such dire predictions, nuclear power has been growing as countries strive to slake mankind's appetite for energy.

The world has 441 reactors, including those at Japan's Fukushima Dai-Ichi facility, with a total of 375,000 megawatts of capacity, the United Nations International Atomic Energy Agency said in September 2010. That provided about 14 percent of the world's power last year. Another 60 reactors are in the works, and output may reach 445,000 megawatts by 2020, the IAEA says.

By 2025, the world could add 36 small reactors, each with 400 megawatts of capacity or less, according to the IAEA. Of the 38 reactors of this size operating today, 34 were built before 1990 and use traditional technology rather than new designs.

TerraPower

TerraPower, the company Gates is backing, aims to build a sodium-cooled reactor by 2020. It would consume spent fuel from conventional plants and generate less waste of its own, addressing a problem that has dogged the industry. TerraPower has spent tens of millions of dollars on research and will need several billion dollars more for a prototype, CEO John Gilleland says.

Toshiba is planning a 10-megawatt model that, if approved, may supply the Alaskan village of Galena. Older, larger Toshiba reactors overheated amid the earthquake when backup systems failed to keep them cool. Toshiba declined to comment on the impact of the accident on its small-scale program.

Babcock & Wilcox Co., Reyes's main competitor in small models, has lined up a customer -- a crucial step before seeking NRC approval for its technology. The Tennessee Valley Authority, a federally owned utility in seven states, may build six small Babcock reactors to provide power for 4,800 Department of Energy researchers in Oak Ridge, Tennessee, says Andrea Sterdis, TVA senior manager for nuclear expansion. Terry Johnson, a TVA spokesman, says it's too soon to say how the Japanese accident may affect small-scale reactor development.

Babcock and TMI

Babcock, which supplied boilers for New York's first subways, also built the reactor for the stricken Three Mile Island nuclear facility near Harrisburg, Pennsylvania. In 1979, a commission appointed by U.S. President Jimmy Carter criticized the company for, among other things, failing to notify customers that the kind of coolant valve that caused the Pennsylvania accident had already failed nine other times. Babcock declared bankruptcy in 2000 as a result of legal claims for exposure to asbestos in its power-generating equipment. The company emerged from bankruptcy six years later.

Babcock's new, 125-megawatt reactors would cost about \$500 million each and become available as early as 2018, says Christofer Mowry, CEO of Babcock's B&W Modular Nuclear Energy unit. He declined, through a spokesman, to comment on the Fukushima accident.

'Icing on the Cake'

Ben Landy, an analyst at Baltimore-based T. Rowe Price Group Inc., says that Babcock already builds reactors for the U.S. Navy and that the company's boilers and pollution-control equipment for coal plants are competitive strengths.

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“If small reactors become a big market, that’s icing on the cake,” Landy says.

With 14.4 million shares, T. Rowe Price is Babcock’s biggest investor. Babcock shares rose 52 percent from Aug. 2, when the company was spun off from McDermott International Inc. (MDR), to \$35.09 on March 10, the day before the earthquake. The stock has dropped 9.8 percent since then, to \$31.65 on March 22.

Landy says negative publicity over Fukushima may impede large U.S. reactors already fighting to raise money. Buyers may view Babcock’s small models as safer, partly because they’re buried in the ground, he says.

NRC Gears Up

The NRC has been marshalling resources for when applications for mini-reactors start rolling in, NRC Chairman Gregory Jaczko says. The commission has 50 people who will determine whether the models need the same personnel, security and insurance as big designs and whether operators should pay similar licensing, disposal and decommissioning fees.

The NRC is familiar with NuScale’s basic design and is likely to certify it, BNEF’s Gadomski predicts. Hyperion’s 8-foot-tall models present a tougher security challenge because they’re intended for remote locations. Common thieves probably couldn’t steal them, but a rogue government could -- and then may convert the uranium into weapons, he says.

Even as Republicans in Congress attacked Obama’s energy plan, they left most nuclear programs intact. After Japan’s woes, Democrats may be less likely to support the administration’s nuclear agenda.

The day after the earthquake, Representative Ed Markey, a Democrat from Massachusetts, called for a moratorium on new plants in seismically active areas until additional safety reviews could be completed. Senator Joseph Lieberman of Connecticut, an independent who heads the Senate’s Homeland Security Committee, sought a pause until the Japan accident could be analyzed.

Evaluating Risk

The U.S. nuclear industry is already growing more slowly than those of China, Russia and India. Nuclear generating capacity may jump by 77 percent in the Far East, including China, by 2020 compared with 12 percent in North America, the IAEA says. Capacity in Western Europe may drop 24 percent in that period, the agency says.

Most U.S. utilities still see too much risk. Constellation Energy Group Inc. (CEG) abandoned a five-year quest in October for a third big reactor in Lusby, Maryland. Chicago-based Exelon Corp. (EXC), the largest U.S. nuclear operator, with 17 reactors, is reassessing a \$3.65 billion plan to raise output at its nuclear plants because the company expects safety reviews by the NRC, CEO John Rowe said on March 16. Marilyn Kray, vice president of nuclear development, says if utilities need power, and can be convinced that small reactors are cost-effective, they may build them at existing nuclear or coal sites, which already have transmission lines and permits.

1,000 Alarms

That thinking meshes with Reyes’s plans for NuScale.

Seated in his office near Oregon State University, where two paintings by Austrian artist Friedensreich Hundertwasser lean, unhung, against the wall, Reyes recalls how living through the worst U.S. nuclear accident taught him about scale.

He was working as a safety analyst at the NRC during the partial core meltdown at General Public Utilities Corp.’s Three Mile Island plant in 1979. He studied how operators of the Babcock reactor were baffled by 1,000 alarms going off simultaneously. Today, a plant’s key diagnostics fit on one computer screen, he says.

“Simplicity matters,” Reyes says.

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Reyes began forming his idea for NuScale after he got a DOE grant to develop reactors for emerging markets. He built a mock power plant that resembles a 12-foot-tall chimney to troubleshoot his designs in a four-story garage at Oregon

State, where he's on leave from his job as a tenured professor. He decided to commercialize the technology and filed 18 patent applications.

'Right Way to Go'

Reyes, who holds a Ph.D. in nuclear engineering from the University of Maryland, used similar equipment to convince the NRC in 2005 that a \$6 billion, 1,117-megawatt behemoth designed by Toshiba's Westinghouse unit was safe partly because, like NuScale's, it relies on passive safety systems. China later adopted Toshiba's design for its future reactors.

"After reviewing all these events in Japan, people may decide that these passive plants might be the right way to go," Reyes says.

Reyes had been struggling to raise money even before the Japanese crisis. His woes worsened in January, when the U.S. Securities and Exchange Commission filed a lawsuit against his biggest backer, Francisco Illarramendi, claiming that Illarramendi transferred money among investment accounts without telling clients.

Worth Billions

Illarramendi, principal owner of Michael Kenwood Group LLC in Stamford, Connecticut, pleaded guilty in March to what the SEC described as a multiyear Ponzi scheme. He could face up to 70 years in prison, prosecutors say. John Gleason, his attorney, declined to comment.

In January, when the lawsuit temporarily froze NuScale's bank account, CEO Paul Lorenzini fired 30 of 100 employees and hundreds of contractors and cut pay by as much as 50 percent.

One potential investor, Ray Rothrock, who works in Palo Alto, California, for venture firm Venrock Associates, says he passed on NuScale because no one can predict whether or when the NRC will approve its design. The Fukushima accident magnifies the uncertainty, he says.

"This will slow things down, cost money and require the regulatory people to opine on it," Rothrock says. If NuScale passes its regulatory hurdles, he says, the company will be worth billions of dollars.

Nuclear Batteries

About 1,450 miles (2,333 kilometers) from Reyes's Oregon lab, in Santa Fe, Hyperion CEO John Deal has been working on what he calls "nuclear batteries" that hospitals, remote communities and oil companies can use for power and heat. Each reactor is designed to run for eight years before Deal retrieves it and drops off a new one.

Deal, 47, worked at Los Alamos National Laboratory, where he says he got the idea to commercialize small nuclear technology, as "resident entrepreneur." By 2020, Hyperion aims to have a prototype that can operate at 1,000 degrees Fahrenheit (538 degrees Celsius), 400 degrees hotter than water-cooled designs. Hyperion's lead-bismuth model and sodium-cooled versions from other companies could generate electricity as well as heat for refining bitumen into crude oil or for warming the maternity ward of a hospital.

Deal says his "batteries" offer advantages over the reactors in Japan. They'd spread out power generation rather than concentrating it; they'd be a fraction the size of traditional models; and they'd be buried inside reinforced bunkers designed to withstand earthquakes. Cooling would work by gravity, without pumps.

'Get Out of Berkeley'

"If there is a worst, worst, worst case, all contamination, if any, should be very local and remain in the ground inside the vault," Deal says.

People are likely to accept such security, especially if lack of power means they don't have basic necessities such as clean water, Deal says.

"You have to get out of Berkeley to realize how badly people need electricity," he says, referring to the California college town that has long been a protest hotbed. If the NRC moves too slowly to license his reactor, Deal says, he'll build it overseas.

The planet has 40 years to slice carbon emissions in half or suffer a deadly rise in temperatures, according to the International Energy Agency, which advises the governments of 28 countries, including the U.S.

Nuclear proponents say meeting this challenge requires a cascade of inventions, including reactors that are smaller, safer and cheaper -- even after the crisis in Japan.

"There is still a need for clean energy and for getting away from fossil fuels," Reyes says. "That part of the equation doesn't change."