Asia’s Demand for Electricity Fuels a Regional Nuclear Boom

While Western governments debate the pros and cons of replacing old nuclear power plants, India, China, and Japan are investing rapidly in new systems.

Nuclear power may have fallen on hard times in some parts of the world, but not in Asia. Demand for electricity is growing steadily across the region, and a number of countries have seized on nuclear fission as a secure energy source that avoids coal’s air-choking carbon and sulfur emissions. And as oil and gas prices rise to record high levels, nuclear energy is starting to look more affordable. The result—on paper at least—is a boom. “Sixteen of the 25 nuclear power plants currently under construction worldwide are in Asia,” says Akira Omoto, director of the Division of Nuclear Power of the International Atomic Energy Agency in Vienna, Austria.

China is embarking on a nuclear power plant building spree. Korea and India are both beefing up their nuclear electric grids. And Japan—despite public opposition that has blocked one project—plans an expanded nuclear power network that includes a controversial fast neutron reactor. Other novel designs are being tried in China and India.

Steep climb
China has the most ambitious nuclear plans of any country in the world, although it is starting from a small base. Nine nuclear power plants are operating in China today, accounting for about 2% of the national power output. Two more reactors are under construction in eastern Jiangsu Province; they will come online by the end of this year, raising total nuclear capacity from 6.7 billion watts, or gigawatts, of electric power (GWe) to 8.7 GWe. For comparison, the 104 nuclear power plants in the United States now produce more than 10 times as much power, about 98 GWe. China’s target is to have nuclear power supply 6%, or about 40 GWe, of the nation’s electrical energy needs by 2020.

Kang Rixin, general manager of China National Nuclear Corp. (CNNC), says meeting this goal will require the construction of about 30 new 1-GWe nuclear power plants over the next 15 years. And many of China’s nuclear power boosters believe that will only be the start. Zhang Zuoyi, head of the Tsinghua Institute of Nuclear and New Energy Technology (INET), envisions a bigger leap after that: “Nuclear power generation should reach 300 GWe by 2040, as it is the only solution to meet demand for energy in China.” CNNC puts the cost of 30 new plants at roughly $50 billion.

Xu Mi, a nuclear power engineer at the China Institute of Atomic Energy, says China has the technology and talent to handle the ramp-up. He notes that France built more than 40 nuclear power plants in the 1970s and ‘80s. “Given China’s pace of development, constructing 30 nuclear power plants is not unrealistic,” Xu says. And China is ready to pay for foreign help. AREVA in France, AtomStroy-Export in Russia, and Westinghouse Electric Co., which is based in the United States but owned by British Nuclear Fuels PLC, have submitted bids on four new 1-GWe power plants to be completed by 2010. A decision is expected this November.

China is sticking mainly to proven designs: All 30 nuclear power plants planned through 2020 are likely to be based on pressurized water reactors, which make up the bulk of commercial plants worldwide.

And China is not the only country in Asia ramping up conventional nuclear power. Japan’s Ministry of Economy, Trade, and Industry, in its 2004 nuclear power development plan, projected conventional nuclear power increasing from 25.5% of the total generated in 2003 to 40.4% in 2013. Two nuclear power plants are being brought online this year, two more are under construction, and another 12 are in various stages of design. India has eight nuclear power plants currently under construction. And Korea is planning eight plants.

Breeders multiply
Although this growth spurt builds mainly on conventional reactor designs, researchers in Asia are also pushing forward with more unusual approaches. INET is planning to build a prototype pebble bed reactor with a capacity of 200 MWe in east China’s Shan-dong province by around 2011, according to the institute’s Zhang (see p. 1172). And a technology that has been all but abandoned in Europe and United States—the fast neutron reactor—will be tested in experimental or prototype reactors in China, Japan, and India.

Fast reactors do away with the moderator—typically water—that’s used in current commercial reactors to slow down highly energetic neutrons in the core. Applying the brakes increases collisions between neutrons and the limited amount of uranium-235. Instead, fast reactors use more highly fissile fuels, such as plutonium or a mixture of plutonium and uranium, and they can be used to produce additional plutonium that can in turn be recycled as reactor fuel.

Western governments once saw the “breeder” as a boon because it promised to reduce the amount of raw ore needed at the front and cut down on waste at the back end. The United States, United Kingdom, Germany, France, Russia, and Japan all built experimental or prototype reactors between the 1970s and ‘90s. France even built a 1200-MWe commercial reactor, the Super-Phenix, in Creys-Malville, in 1985. But the plants were prone to leaks of the molten sodium used as the coolant, and they relied on complex heat-transfer systems.

Commercial interest faded as it became clear that fast reactors would cost several times more than a conventional light-water plant. The critical factor, however, was public opposi-
tion to creating and guarding stockpiles of plutonium, which could potentially be diverted for use in nuclear weapons. With the exception of France’s small experimental Phenix, all the fast reactors in the United States and Western Europe have been shut down, although studies of the technology continue.

Although an international planning effort known as Generation IV envisions the future use of fast reactors, it is not clear who will be the first to build a commercial version, or when. Japan, China, India, South Korea, and Russia are all building or planning new reactors using this concept.

In Asia, Japan’s fast reactor program is the oldest and furthest along. The Japan Nuclear Cycle (JNC) Development Institute is now hoping to restart a prototype that’s been on prolonged standby. Monju, a 280-MWe unit in Fukui Prefecture on the Japan Sea Coast, has a troubled history. It achieved initial criticality in 1994 but in December 1995 suffered a massive leak of sodium coolant because of a design flaw in the piping. Plant managers tried to hide the magnitude of the accident, making it worse. After nearly 10 years of investigations, redesign, negotiations with different levels of government, and a court case, the local prefecture gave the green light earlier this year to begin modifications. If all goes smoothly, Monju could be operating again in 2008.

“The basic design of this plant is very old,” admits Yutaka Sagayama, director of JNC’s studies for commercializing fast reactors. But JNC is intent on running Monju to verify its reliability and gain technical expertise. The big challenge will be to lower the price. Sagayama says a Monju-type reactor would cost in the neighborhood of $8000 per KW of capacity, making fast reactors prohibitively expensive.

JNC engineers have been studying more economical fast reactors that would use lead-bismuth and helium gas as potential coolants. They concluded that sodium is still the most promising option. Simplifying the cooling system and using more compact heat exchangers could improve efficiency. But these modifications depend on perfecting a high-chrome-content steel alloy that at present is too brittle. JNC is working with Japan’s steel companies to improve it. If the materials research and other modifications pan out, JNC’s studies show they could build a new advanced sodium-cooled fast reactor plant about one-sixth the size of Monju but five times as productive, at 1500 MWe. This would cut the cost per kilowatt of capacity to $1600. Sagayama says they hope to start building a demonstration commercial fast reactor in about 2015.

The China Institute of Atomic Energy is a few steps behind with an experimental fast reactor with a power capacity of 20 MWe, due to be commissioned in 2008. China plans to follow up with a 600-MWe prototype by 2020 and commercial-scale fast reactors around 2030. India is hoping to complete a 500-MWe Prototype Fast Breeder Reactor by 2010, and Korean researchers are designing a 600-MWe fast reactor.

All these countries foresee an important role for fast reactors. Japan’s long-term plan, Sagayama says, calls for fast reactors to replace conventional reactors completely, although there is no target date. And Huang Guojun, a CNNC deputy general manager, told a conference earlier this year that fast reactors will be the “main type of nuclear reactor to be used in China” by the middle of this century. Researchers in both countries say they will be needed to recycle scarce nuclear fuels. Xu notes that if nuclear power accounts for 20% of China’s power needs in 2050, the country would have to acquire 75% of all known easily accessible uranium deposits.

Japan might still have a problem with public acceptance. Hideyuki Ban, co-director of the Citizens’ Nuclear Information Center (CNIC), a Japanese antinuclear group, says the delays and accidents at Monju and other facilities make it clear that “Japan’s fast breeder program is in trouble.” He says the government’s main nuclear advisory commission has been unwilling to “change a policy established 50 years ago,” and the program seems to be running on inertia.

Also targeted by critics is Japan’s large-scale reprocessing plant at Rokkasho, at the northern tip of Honshu Island, capable of producing 8 tons of plutonium a year. In May 2007, the plant is scheduled to start converting plutonium into so-called mixed-oxide fuel that can be used in conventional reactors, a stopgap until commercial fast reactors come online. Ban’s bottom-line worry is that “if more and more countries acquire [reprocessing] technologies, there will be no controlling the proliferation of nuclear weapons.” CNIC is calling for a moratorium on all plutonium production.

In China, the public seems less aware of such controversies, says Xue Ye, executive director of Friends of Nature, the country’s largest environmental organization. With just nine plants scattered throughout the country, “people have not felt their existence.” He thinks that could change, however, as more plants are constructed. “The Chernobyl explosion is still vivid in the memory of most Chinese,” he says. Beijing residents have protested the construction of laboratories handling dangerous pathogens near their homes; he thinks similar protests could interrupt China’s plans for nuclear electricity. The big question facing Asia’s booming nuclear industry is can it stay ahead of this nascent public opposition?

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Watching the tides. Japan’s troubled prototype fast reactor—Monju—has remained idle on the scenic coast of the Japan Sea for more than 10 years.