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Nuclear Energy Thrives in Asia

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SUMMARY Nuclear power may have stopped growing throughout much of the world, but it is alive and thriving in Asia. Many Asian nations see nuclear power as one way to satisfy their growing power demands and reduce their dependence on other nations for imported fuels; nuclear power is also valued for simple prestige. But nuclear energy is expensive to develop, competes with independent power producers, and is very controversial because of concerns over safety and weapons proliferation. Countries such as Japan, South Korea, Taiwan, China, and India plan to expand their already substantial nuclear power programs. Others, such as Pakistan, Indonesia, Bangladesh, and Vietnam, hope to either launch new programs or expand small ones. A few have ruled out the idea completely. Generation of nuclear power will therefore grow in Asia, although not as fast as power from other sources. Some nations underestimate the cost, controversy, and complexity of nuclear power; those unwilling to develop nuclear power safely should not do it at all.

Nuclear Power In Asia

In much of the world, development of nuclear power appears to have stopped or slowed. In the United States, where nuclear power now provides 20 percent of the nation's electricity, utilities plan to build no new reactors and will shut down some of their older ones. Sweden has announced plans to shut down its existing plants, even though they provide more than 40 percent of the nation's electricity. France's program remains strong, but with nuclear already accounting for almost 80% of electricity generated, the program can no longer grow rapidly. But in Asia, nuclear power is thriving; the region is the site of a large share of the new nuclear power plants opened worldwide in the last few years.

Nuclear power has proven to be attractive in Asia for a number of reasons. The demand for electricity by the industrializing countries of Asia is soaring with many nations experiencing 8 percent or more annual growth. Each country feels pressure to provide further power to fuel their economies. In many Asian countries, energy self-sufficiency is a national ambition, making them reluctant to import fuel. The countries most experienced with nuclear power—Japan, South Korea, and Taiwan—have few indigenous sources of power or have resources that are difficult to harness. Additionally, China has a lot of coal but much of it is in remote locations. Concern about pollution also makes nuclear power attractive, although the disposal of nuclear waste is a serious long-term concern.

Countries often pursue nuclear power for reasons of self-sufficiency or prestige

Advantages and Disadvantages of Nuclear Energy

Nuclear power has both economic pluses and minuses, but the reasons countries pursue it often have less to do with economics than with environmental factors, self-sufficiency, and prestige concerns.

Economics. Nuclear power has a number of economic advantages over other forms of power. Fuel costs, for example, can be a small fraction of those for gas, oil, or coal-fired power plants, which is important for nations that import raw materials for electricity. The operating costs of a nuclear plant, much of which are related to safety considerations rather than fuels, are often competitive with the cheapest available alternative sources and in some cases might be less. Nuclear plants, when well run, also tend to be in operation (not under maintenance or repair) more of the time, as much as 80 percent or more, an advantage over fossil-fuel plants which usually need more downtime. In some cases (in South Korea, for example) nuclear plants have been operated continuously for more than a year without a maintenance shutdown. Nuclear power has been less reliable in India, and China's recently opened Daya Bay plant has had much downtime—although it remains to be seen if these are start-up problems or omens for the future.

But even though the operating costs of nuclear power plants are competitive, they are far more costly to build—capital expenses, construction and planning time, and space are all required in greater amounts. Building a nuclear plant to the safety standards of most developed countries is two or three times as costly as a conventional power plant and can take six to 10 years or more to build. By comparison, a coal-fired power plant can be built in a few years and a combined cycle plant (which combines steam with other forms of generation, usually a gas turbine) can be brought to completion in about a year. An investor laying out money for the time it takes to build a nuclear plant needs a very low discount rate for profitability; even then, a nuclear plant runs the risk of being canceled for financial or other reasons. Nuclear plants also need large tracts of land, which can be costly for a crowded or developing country. Bangladesh, for example, has since 1965 reserved one-half square mile of land for a nuclear plant that has never been built. And since nuclear plants tend to provide large amounts of power—new reactors can be over 1,000 megawatts—areas with small electricity requirements will not be able to use nuclear energy's full efficiency.*

*Manufacturers are designing smaller reactors in an effort to reach these markets, but few are being installed. A Chinese 300-megawatt reactor design going to Pakistan and Iran is probably not commercially viable elsewhere.

Other disadvantages involve capacity, innovations, and competition. Nuclear power is able to provide a broad continuous energy supply (baseload) but is less well-suited to handling the daily and seasonal (peak load) fluctuations of demand. The more a country depends on nuclear, the more the non-nuclear power supplies must be devoted to covering peak demand, something for which previous facilities might not be suited. Japan and other countries have gotten around this by operating their nuclear plants at night to fill water reservoirs at high elevations and thereby making "pumped storage" hydroelectric power available for peak demands—but this can be expensive. In addition, great breakthroughs in efficiency have not occurred with nuclear technology, which uses mostly steam generation, when compared with the real efficiency innovations continuing in gas turbine plants (the thermal efficiency of which has almost doubled over the past 15 years). Finally, electricity is no longer the exclusive domain of regional or national power utilities; private companies are now generating electricity and selling it to existing grids and utilities. These independent power producers (IPPs) often provide baseload electricity and therefore compete directly with nuclear suppliers to fill this role. Most IPPs have not wanted to use nuclear power due to a combination of high capital cost, complexity, and liability. They prefer fossil fuels and sometimes hydropower or renewable resources such as geothermal and wind power.

Nuclear power is expensive to do correctly

Nuclear power is hard to justify on purely financial grounds (in the absence of high fossil fuel costs) because it is expensive to do correctly; nonetheless, some Asian nations see electricity demand soaring and feel they must use all potential resources. If ambitious schedules are met, nuclear capacity could grow by 3 percent a year; however electricity demand in Asia is slated to grow by at least 6 percent and more likely by 8 percent or more a year. It is also unlikely that all planned nuclear projects will be completed on schedule since nuclear power projects elsewhere have almost never been completed on time. For these reasons, other fuels such as oil, coal, gas, and hydropower will provide an increased share of Asia's electricity supply even with the growth of nuclear power.

Environment. Nuclear energy has low conventional pollution levels compared with options such as coal plants, especially if one measures pollution at each stage from mining to actual fuel use. Nuclear plants produce no nitrogen or sulfur oxides and no carbon dioxide, and thus are not associated with global warming or acid rain. Nuclear advocates like to point out that coal-fired plants often release more radiation than do well-run nuclear plants. On the other hand, there is the problem of disposing of

Nuclear reactors and how they work

Nuclear reactors split atoms in fuel (almost always uranium and plutonium) to release energy in a controlled chain reaction. The heat released turns water into steam, which flows into a turbine and turns a shaft to spin a generator and make electricity. There are several different types of reactors. In a boiling-water reactor, water heated by the core turns directly into steam in the reactor vessel. In a pressurized water reactor, the water is kept under pressure so that it does not turn into steam but remains liquid; it is then used to heat a separate loop of water, which turns into steam and powers the generator. High-temperature, gas-cooled reactors are also double-loop systems, but use gas rather than water to carry heat from the core and evaporate water in a separate loop into steam. Pressurized heavy-water reactors (called Candu after the first "Canadian-deuterium" design, and used in India, Pakistan, and South Korea) use natural rather than enriched uranium and use water with deuterium, a heavier isotope of hydrogen, as a coolant—swapping concerns about costs and international trade of enriched uranium for similar concerns about heavy water. Other facilities include enrichment and reprocessing plants. Enrichment facilities increase the concentration of rare uranium-235 needed for reactors from the 0.7 percent in mined uranium to about 3 percent (the rest being U-238). As some reactors consume the U-235, however, they also turn some of the U-238 in the fuel into plutonium, some of which can also be used as fuel in some reactors (as well as for weapons). Researchers have been working for decades on breeder reactors, which can generate 60 times more energy from natural uranium than conventional plants and also generate more nuclear fuel than they consume, therefore becoming a virtually inexhaustible energy supply. Finally, reprocessing plants reduce the amounts of waste and allow some spent fuel to be reused but have raised fears of weapons use of fuel.

nuclear waste, which is now often stored at the plants, at temporary storage sites, or exported for reprocessing. Retired nuclear plants are themselves hard to decommission and dispose of. Nuclear plants have other environmental impacts. They tend to be far from population centers (mostly for safety), thus long transmission lines are needed to get the power to its users. These transmission lines can be very unpopular and are a major factor in the nuclear power debate in Taiwan and elsewhere.

Security. Another motivation for nuclear power is energy "security"—not being dependent upon other countries for power or raw materials for fuel. This quest for energy security is one reason why almost every Asian country with a nuclear program wants to develop a breeder reactor, which generates nuclear fuel (usually plutonium), even though they will still require some uranium imports. The problem is that these still-experimental plants are very costly to build and operate.

Safety. The safety of nuclear energy remains controversial. Nuclear engineers point to the industry's generally good safety record—accidents are much rarer than at conventional plants. Most major accidents have occurred at either obsolete reactors or those not operated in the context of an active and serious "safety culture"—an attitude in the nation, its nuclear industry, and at each plant that time and money will be spent to assure that each step is done safely. Those who criticize the safety of nuclear energy however, point out cases of serious accidents that, even if they are infrequent, can cause greater damage than accidents at conventional plants. Some countries have lacked the necessary commitment to safety, and even the best safety culture is hard to maintain at all times. Even if a plant is operated well, there is the danger of damage from some natural disaster. Economic development around nuclear sites is often restricted to avoid attracting large population levels, and some forms of tourism may be inappropriate near a plant.

Most major accidents have occurred at obsolete reactors or at those without a 'safety culture'

Weapons. Some nations seeking nuclear-based electricity are without question also trying to build nuclear weapons, another source of pride as well as, in their view, security. This is clearly what South Africa did (although it has since renounced its nuclear weapons program) and what Pakistan appears to be doing. Nuclear power has not been a major source of fuel for weapons programs. Instead, weapons fuel has mostly come from "research" reactors, which most countries that have nuclear power programs also possess or want. The grade and variety of fuel involved in nuclear power plants differ from those needed for nuclear weaponry, although it is possible to enrich the spent fuel and use it as one of several sources for nuclear weapons material. Many countries suspected of trying to produce nuclear weapons allow international inspection of their nuclear power plants but not their research reactors. Nations concerned about proliferation usually seek inspection of both before they aid nuclear power programs.

Status. Many countries view nuclear power the way they view steel mills or petrochemical plants: as something a modern nation does. This seems to be a major motivation in Asia especially.

Asia's Established Nuclear Power Producers

Within the Asia-Pacific region, countries such as Japan, South Korea, Taiwan, and India plan to expand their nuclear electricity programs.

Japan. Nuclear power now supplies about 30 percent of Japan's electricity needs, a share that would remain roughly constant under government plans to nearly double capacity from around 38.5 gigawatts (billion watts) in 1994 to 70 gigawatts in 2010. Few expect that target to be met; the unpopularity of nuclear energy on safety and environmental grounds makes it difficult to find acceptable sites. Nonetheless, Japan, which values nuclear for its low operating costs and energy independence, expects to build a large share of Asia's future nuclear plants, using many existing sites more intensively. A prototype fast-breeder reactor (named Monju), which recently became operational, cost $5.7 billion or $20 million per megawatt—about ten times the cost of building a conventional reactor and around 20 times the cost of conventional fossil-based power.

Japan's nuclear program is criticized as a factor in the nation's high electricity costs

The nuclear program also includes increased domestic reprocessing of spent fuels at a $10 billion facility at Rokkasho-mura. These projects contribute to Japan's high cost of electricity, which authorities are committed to reducing from the current 25 cents per kilowatt hour (three to five times the cost in other nations). Opposition from public utilities recently helped cancel plans for a prototype Advanced Thermal Reactor, fueled with a mixture of plutonium and uranium, which was to have been built at Ohma on the northern tip of Honshu in 2004 at a cost of $4.5 billion. The utilities can be expected to become even less enthusiastic about expensive nuclear power if the soon-to-be-permitted independent power producers become competitive.

South Korea. South Korea produced 36 percent of its electricity requirements from nine nuclear reactors at four sites in 1994. Only a few other nations, all in Europe, are so dependent upon nuclear energy. Several future plant sites have already been acquired, and the existing sites have the capacity for many more reactors. This early acquisition of sites and the role of South Korea's political system in minimizing dissent has reduced the controversy over sites that its neighbors, Japan and Taiwan, have experienced. Despite this, it is unlikely that South Korea will see a large increase in the share of nuclear power in its generation mix (the target for 2006 is 44 percent). If the growth in nuclear capacity were to match the 9 percent predicted annual growth in electric consumption, nuclear capacity would have to grow from the current 8.6 gigawatts to nearly 25 gigawatts in 2010. South Korea, like most of Asia, is developing a private power generation program. At present, potential generators are not permitted much leeway in selecting fuel or location, thus competition is only in construction and operating costs; liberalizing this policy could allow producers to compete economically with nuclear power. A growth area for South Korea's nuclear power might be outside the country; the state-owned utility Korea Electric Power Corporation (Kepco) is increasingly interested in exporting its nuclear technology to other Asian nations.

Taiwan. Despite a government commitment to nuclear power, Taiwan has not installed any new nuclear capacity since 1984 due to the increased politicization of the issue. Critics question the safety of nuclear power and object to proposed sites for plants and transmission lines; anti-nuclear demonstrations occur regularly and opposition parties often take anti-nuclear positions. Taiwan currently has three nuclear power sites, each with two reactors, which have a combined capacity just short of 5 gigawatts. These provide about 30 percent of electricity used. A fourth nuclear power site has been identified in a national park and two reactors are planned, but construction has been delayed, in part over anticipated high costs. Long-term plans call for as many as 20 more reactors at the four sites, but further new sites on the small island nation are unlikely. As in other areas, a new independent power program might delay more ambitious nuclear plans as long as fossil fuel costs remain relatively low.

India. India's large nuclear program has been plagued by inefficiency, maintenance problems, and accidents. If one measures the program by the amounts of electricity generated, it has been a failure. Each of

Installed and Projected Nuclear Capacities (megawatts)

	1992	1994	1996	1998	2000	2002	2004
Japan	32,444	38,961	41,708	44,244	45,544	49.069	52,344
Korea	7,616	7,616	9,616	12,178	14,040	16,740	20,440
Taiwan	5,152	5,152	5,152	5,152	6,152	7,152	7,152
China	0	2,260	2,260	2,260	3,460	5,260	5,260
India	1,700	2,140	2,375	3,315	4,020	4,020	4,020
Pakistan	139	139	139	139	439	439	439
North Korea	0	0	240	250	250	250	250
Total	47,051	56,268	61,500	67,538	73,905	82,930	89,905

India's 10 completed reactors has been derated (determined to have a smaller capacity than initially planned); those at Tarapur in Maharashtra and at Kota in Rajasthan are now rated significantly below their design capacity. Total generation declined from 7.0 terawatt (trillion watt) hours in fiscal year 1989 to 6.6 terawatt hours in 1992 and 5.4 terawatt hours in 1993, despite the opening of new reactors. Plants have been criticized for being operated at less than peak condition; the secondary steam generation unit at Tarapur has not functioned for over a decade, while repairs at Madras have been criticized as improvised.

The most publicized accident occurred at the Narora Atomic Power Station in Uttar Pradesh on March 31, 1993, when two turbine blades of one reactor failed under stress, sparking a fire that damaged all four redundant but poorly designed safety systems. The plant was barely shut down before the accident became serious. Although there were no fatalities or radiation release, the incident heightened safety concerns. The plant at Kaiga in Karnataka state also suffered an accident while under construction when a large portion of a concrete containment building collapsed. India's 1974 detonation of a nuclear device led to cancellation of most international cooperation after only the two Tarapur reactors and one of the two at Kota had been completed. Later reactors were built primarily using indigenous technicians, construction, and management. India has declined to cooperate fully with international inspection programs—especially those involving "research" reactors—since 1974. Both China and Russia have recently offered aid in providing fuel and new plants. The potential of private power initiatives makes it less likely that financially strapped state electricity boards will invest much further in nuclear power.

A 1993 accident at an Indian nuclear plant damaged all four safety systems

Asia's New Producers

Several countries have nuclear programs that are relatively new but extensive.

China. Although China's long history of nuclear weapons production—its first atomic bomb was exploded in 1964—leads many to imagine that it has long produced nuclear power, China's "commercial" nuclear power production only began in 1993. This was the 300-megawatt Qinshan reactor, built mostly with domestically adapted technology, which China now hopes to export to other nations, including Iran and Pakistan. Two larger reactors are planned at the same site in China. China's only other operating nuclear power reactors are two units at Daya Bay built with French technical assistance and primarily intended to supply power to Hong Kong. The reactors opened commercially in 1994, and early technical problems appear to have been overcome; a second plant is planned nearby. Many more reactors are planned, but high costs will probably prevent development of all. Most planned sites are in coastal areas near industrial centers, far from China's domestic coal and hydroelectric resources. China's rumored shortage of enriched uranium may be why proposed plants include gas-cooled reactors and pressurized heavy water reactors that use natural uranium fuels. China is also buying enrichment equipment from Russia and is among those East Asian nations seeking to develop fast breeder reactors. China has been extensively criticized for the low priority it gives to restricting the sale of nuclear power technology to nations that intend to develop nuclear weaponry.

Pakistan. Pakistan became one of the first nations in Asia to generate nuclear power when it opened the small (138 megawatt) Kanupp nuclear plant near Karachi in 1972. Kanupp remains Pakistan's only nuclear power plant and is reputed to have an unreliable history of operations. Nonetheless, a second nuclear plant (300 megawatts), built with Chinese aid, is to open as early as 1998 (though possibly later) at Chasma south of Islamabad. International aid to Pakistan's nuclear program has been scarce because of a general belief (backed up by stray comments from some politicians) that Pakistan intends to develop nuclear weapons. Of particular concern is a 40 megawatt reactor at Kahuta in the Punjab being built under tight security (also with Chinese assistance) that some observers believe will produce nuclear materials ideal for weapons production.

North Korea. Long-standing international concern over North Korea's nuclear power program increased in 1994 when it was learned that the nation's sole nuclear plant was in the process of being refueled. There were fears that without international inspection North Korea could use the spent fuel to produce several nuclear devices. North Korea ultimately agreed to halt its original nuclear power program in exchange for enough fuel oil to operate conventional power plants and for the construction of safer and more easily monitored light-water nuclear reactors built with U.S. and South Korean assistance. The agreement appears to be holding despite questions about the sincerity of North Korea, which apparently believes it can use its nuclear power program to win economic and political concessions from the United States and others. It remains to be seen how long the current, quite strange, agreement between adversaries might last.

Asia's Future Producers

Some countries are just embarking on nuclear energy programs; many see nuclear energy as integral to their future power arrangements.

Indonesia. Indonesia sees nuclear power as providing a large portion of its future power needs. Ambitious plans call for developments at 12 sites over the next 25 years on the islands of Java and Bali where most of the electricity demand is now located. Authorities argue that Indonesia's limited gas and oil should be exported or used as industrial raw materials. The one potential nuclear plant site that has been widely publicized (90 hectares at Ujungwatu on Mount Muria in Central Java) has been criticized because it is near an active volcano (an objection that might rule out large portions of Java and Bali). Operation is not planned until 2003, and the estimated cost of the 800-megawatt unit ($1.2 billion) appears low; feasibility studies are ongoing. The government has discouraged internal criticism, but the program's future is uncertain given the country's many other power sources.

The first site of Indonesia's ambitious nuclear program is near an active volcano

Vietnam. Vietnam, where rapid economic growth could fuel a need for power, has been quietly shopping around for assistance to establish a nuclear power program and has announced ambitions to start construction by the year 2000. The most publicized preliminary inquiries have been with Korea Electric Power Corporation. Funding nuclear projects might be difficult, however, because Vietnam appears to have significant natural gas reserves that might provide an attractive alternative fuel source.

Philippines. In 1986 the Philippines canceled plans to open its first nuclear plant, a virtually completed 620-megawatt facility in Batangas province. Cancellation of the facility, upon which $2.5 billion had already been spent, was attributed to both safety concerns and to corruption related to the Marcos regime. Failure to open the plant, which would have increased Philippine generating capacity by 10 percent, was a major reason for the power shortages that later held up economic growth and which have only recently been alleviated. One might expect the Philippines to have completely abandoned nuclear power, but the Ramos government is committed to revitalizing the program. It remains to be seen if the many political hurdles can be overcome.

Bangladesh. Bangladesh's hopes to develop nuclear power predate the nation's creation. Land acquisition for a proposed plant at a now-293-acre site at Roopur in Pabna district began more than 30 years ago. A 300-megawatt plant is now planned (such plans are very preliminary) but the project would require international assistance that is unlikely to be granted, especially while Bangladesh is well-endowed with underutilized natural gas.

Dropouts

Some countries have halted or scaled back their programs or have rejected the idea of nuclear power altogether.

Thailand. Thailand has had an on-again, off-again relationship with nuclear power for some time—more often off than on. Electricity demand has increased over 10 percent annually in recent years, making any scheme promising power without much foreign exchange outflow

tempting. Nuclear power, however, is seen as too expensive and too slow to meet short-term requirements. Independent power production also promises a low-cost alternative. A recent call for power plant proposals to generate 2,000 megawatts of electricity resulted in proposals for more than 8,000 megawatts of non-nuclear power.

Nations not prepared to develop nuclear power safely should not do it at all

Australia, New Zealand. Nuclear power is controversial in both Australia and New Zealand, which have decided against developing it for the foreseeable future. Australia, though well endowed with uranium, has abundant and inexpensive coal and considerable natural gas. New Zealand probably lacks enough demand to justify nuclear power in any case, even though its future hydroelectric developments are likely to be limited.

Conclusion

Asia is a growth center for nuclear power, but nuclear energy is growing less rapidly than other electricity sources. Nuclear power is expensive and hard to do right technically, and it is getting increasing competition from independent power producers. Nuclear power remains controversial, and public opposition is growing within countries where nuclear is already established. Nations not prepared to develop safe and efficient nuclear programs should certainly not pursue their nuclear options. Nuclear power must be undertaken with the correct attitude or the price in money or safety will be too great.

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