The Future of Nuclear Power in South Korea after Fukushima

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South Korea stands before an ocean of opportunity rippled with waves of uncertainty. Since joining the IAEA in 1957, South Korea has made its civilian nuclear program a cornerstone of its energy future. Under President Lee's plan, the prevalence and significance of nuclear power will continue to rise, as the Republic of Korea seeks to build a slew of new reactors by 2030. In addition, South Korea is poised to become a global leader in nuclear technology exports, especially in light of the landmark deal struck in late 2009 with the United Arab Emirates. However, for all the importance of nuclear energy to this country of nearly 50 million, the events of Fukushima Daiichi have called into question the wisdom of continuing the domestic and international expansion of the South Korean nuclear complex. With national elections coming up in 2012, public concerns are not to be taken lightly, nor is the impact that any decision on the fate of nuclear energy will have on the Korean economy. Though there are multiple potential courses of action, analysis shows that the best course of action for South Korea is continued expansion of its domestic and international nuclear programs, with significant improvements to regulation structure, safety measures, and emergency planning.

History & Background

In 1958, shortly after becoming a member of the IAEA, South Korea enacted its Atomic Energy Law, establishing the Office of Atomic Energy. In 1978, ten years after construction began, South Korea's first nuclear reactor, Kori 1 came online. This reactor—along with Wolsong 1, Kori 2, and other early plants—was part of a series ordered on a turn-key basis from foreign suppliers, especially US-based Westinghouse. After these early units, Korean firms began to manage construction on future plants, starting with the Kori 3 in 1985. Even then, some parts continued to be ordered from abroad. In 1987, the Korea Electric Power Corporation (KEPCO) attempted to use the System 80 design created by US-based Combustion Engineering as the basis for a standard Korean design[i]. From then on, Korean engineers worked with CE, as well as numerous subcontracted US companies, to develop what eventually became the OPR-1000 reactor. By 1999, a fully Korean design was completed and designated the APR-1400. Construction of the first two APR-1400 plants was started in 2006.

Today, South Korea operates 21 nuclear power plants. Their combined 18.7 GWe supplies approximately 40% of total energy needs[ii]. Seven more reactors are currently under construction, and many more are scheduled to be built, according to the government's energy plan. President Lee's energy platform has centered on a promise to have 35 reactors running by 2024, which will meet roughly 50% of the country's energy demand. Over the last two decades, electricity demand in South Korea has increased by an average of 9% per year[iii]. Since 1980, the country has seen 8.6% annual growth in GDP, which has in turn caused an enormous surge in electricity consumption, from 33 billion kWh in 1980 to 371 billion kWh in 2006.[iv] South Korea's total generation capacity, which was 72.5 GWe in 2008, is expected to rise to 88 GWe by 2017, of which 30% will be nuclear[v]. As nuclear plants have increased in number and size, nuclear power costs in Korea have remained significantly lower than those of other energy sources. The Korea Hydro & Nuclear Power Co (KHNP), a subsidiary of KEPCO, announced that in 2008, nuclear power cost 39 won per kWh, compared to 54 won for coal, and 147 won for LNG. At present, plans call for 18 plants to be built by 2030, at a total cost of $32-40 billion. Estimates report this will provide roughly 59% of South Korea's energy.

Policy Options

Given the large percentage of South Korea's electricity that is provided by nuclear power, and the fact that there are no viable short- or mid-term alternatives, we can rule out categorically the idea of phasing out existing nuclear energy capacity. Two options remain: to continue on the pre-Fukushima path of domestic expansion and global export, or to leave nuclear power where it is and devote energy and resources instead to filling the future energy gap with renewables and other sources of power. To be sure, a slowdown has its merits. There is significant public concern about the safety of existing nuclear facilities[vi]. Locals near sites slated to become nuclear plants have begun to voice their opposition to any new construction. This public reaction could be a significant issue in the 2012 Presidential election. As such, it may be politically untenable for President Lee to campaign on a platform of continued expansion with his usual ardor. The safest thing to do may be to abandon much of the scheduled build-up in nuclear capability. Political issues aside, perhaps the greatest disadvantage of continuing the nuclear expansion is the increased risk of a nuclear disaster like Fukushima. Should South Korea continue on its current course, it will have, by 2024, the highest density of nuclear plants in the world. According to an analysis of data from the World Nuclear Association and Korea Hydro & Nuclear Power (KHNP), Korea's per-kilometer system capacity will rise to 365 kilowatts, more than three times that of France and twice that of Japan.[vii] Correspondingly, the number of residents that would face "direct damage" in the event of a radioactive leak would rise to an estimated 3.7 million. While South Korea's unplanned capability loss factor of 0.5% attests to its impressive safety record, risk remains.[viii] The threat of widespread catastrophe is exacerbated by the lack of a national plan for evacuation, emergency transportation, and radiation protection.

For all the risk involved in continuing South Korea's growth, the benefits are compelling. On the domestic front, as energy needs continue to rise, nuclear power is essential to maintaining national economic growth. Increases in nuclear energy generation and availability correlate with the impressive growth in Korea's GDP in recent decades. Low-cost nuclear electricity has been a boon for industry and Korea's critical manufacturing sector. At present, there are no alternatives that can replace nuclear power in the foreseeable future, or compensate for the supply-demand gap that would appear in the case of a reduction in nuclear power generation. Indeed, many Korean government officials have testified to this fact.[ix] However, what is at stake is not just the goal of running much of the growing South Korean economy on nuclear power but the dream of exporting nuclear reactor technology to countries around the world. The centerpiece of this effort so far is the deal signed between a South Korean consortium led by KEPCO and the United Arab Emirates in December 2009 for four APR-1400 reactors, worth $20 billion.[x] This agreement represents the prospect of future growth in the export market. The government's aim is to capture a 20% share of the global market by 2020, which, according to the Ministry of Knowledge Economy, amounts to 80 nuclear reactors worth an estimated $400 billion.[xi] A market share of this size would place Korea at a level similar to Russia. In addition to reactor exports, South Korea hopes to win a share of the lucrative market for the maintenance and repair of reactors worldwide. Especially in light of Fukushima Daiichi, demand for overhauls and life extensions for heavy water reactors has grown, and the market is worth an estimated $78 billion today.[xii]

The success of South Korea in the international market will also increase its ability to maintain a strong foreign policy posture. The US-Korean bilateral agreement, signed in 1974, extended US industrial and governmental support for the building of 14 of South Korea's reactors[xiii]. This agreement gave US companies permission to supply technology and fuel for Korean plants, many of which were constructed under license from US firms such as Westinghouse. The current pact expires in 2014, and South Korea has made impressive strides in nuclear plant design and construction since the original document was signed. It can thus use its burgeoning position in the world nuclear supply chain as leverage in renegotiating the deal with the US. Above all, South Korea would like to be able to extract and reuse plutonium and uranium from spent fuel to harvest more energy. The current agreement prohibits this closed fuel cycle on non-proliferation grounds, but it is in South Korea's interest to achieve this concession in any new deal.[xiv] Given all of the above political and economic considerations, South Korea should continue its planned nuclear expansion. However, important steps can be taken to mitigate the risks inherent in pursuing this plan. The necessary improvements fall primarily in the areas of regulation infrastructure and safety practices.

Regulatory Reorganization

South Korea needs to conduct a thorough review of its nuclear regulatory system in order to ensure that its most critical bodies maintain independence. The dense network of professionals engaged in the nuclear complex, whether in the governmental, industrial or political sphere, creates a potentially dangerous lack of autonomy in the regulatory framework that oversees the South Korean program. The country's nuclear safety infrastructure has undergone tremendous changes since its inception.[xv] In the initial phase, lasting from 1958 to around 1980, a basic regulatory system was set up to manage the reactors purchased on a turnkey basis. This consisted of a 1-step licensing process by the government, with terms based on those of the vendor country involved. In the decade that followed this initial phase, a transition ensued that saw the development of a legal hierarchy, as well as domestic regulatory requirements and a subsidiary safety expert organization, the Nuclear Safety Center. Finally, starting in 1990, steps were taken to meet increasing regulatory demand sparked by a surge in construction of new plants.[xvi] The Korea Institute of Nuclear Safety (KINS) was established as a regulatory expert organization, taking the place of the early NSC, and in 1997, the Nuclear Safety Commission (NSC) was organized as a decision-making body for national nuclear safety policies. While KINS operates today under relative autonomy, the NSC works under the umbrella of the Ministry of Education, Science and Technology (MEST). This presents a problem of independence similar to the issue of regulatory capture faced by the US Nuclear Regulatory Commission. The NSC should maintain its current internal structure of 9 members and 5 sub-committees, but must become fully independent of MEST to ensure maximum efficacy in implementing nuclear safety policy. It should report directly to the President.

Additionally, the entire regulatory structure should work to strengthen institutional cooperation and knowledge sharing. Important steps have already been taken on this front, including the establishment in 2008 of the International Nuclear Safety School, the Nuclear Safety Master Degree Program in 2009, and a number of other training programs co-hosted with the IAEA.[xvii] Further cooperation should be established with regional entities such as the Arab Network of Nuclear Regulators (ANNuR), the Forum of Nuclear Regulatory Bodies in Africa (FNRBA), and the Ibero-American Network (FORO).

Safety Improvements

Spent fuel storage: The Fukushima disaster called attention to the vulnerability of spent fuel pools. Korea should work to expand facilities for dry cask storage. Although this does not solve the underlying problem of spent fuel, it would make storage safer in the meantime and address the nuclear program's urgent needs for expanded storage. As a side note, South Korea may want to consider including pyroprocessing rights in the renegotiated US-Korea bilateral agreement in 2014. This would begin to address the principal problem of spent fuel.

Facility safety evaluation: KINS should continue to perform stress tests at all 21 nuclear facilities, with an emphasis on system redundancy. The Kori reactor, especially, should be examined, as it has now outlived its initially intended 30-year lifetime[xviii]. Special attention should be paid at all facilities to earthquake and natural disaster readiness.

Emergency planning: Given the projected density of power plants in South Korea, a national contingency plan should be drafted to prepare for emergencies beyond a design basis accident. The plan should include emergency communication and evacuation schemes. KINS should be principally in charge of maintaining the plan, although KEPCO and MEST will need to be heavily involved as well.

Equipment upgrades: Mobile power generators should be installed at all facilities and should be adapted to withstand the forces that disabled power at Fukushima Daiichi[xix]. In addition, passive autocatalytic recombiners should be added to reduce hydrogen explosion risk in the case of an accident.[xx]

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