PACIFIC ENERGY SUMMIT

2012 Summit Papers

Prospects for Nuclear Energy in Asia

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EXECUTIVE SUMMARY

This paper outlines the reasons for Asia's interest in nuclear power and argues that despite the 2011 disaster at Fukushima, the region will continue to be the main arena for expanding the use of nuclear power.

Main Argument

Asia has established itself as the world's largest energy consumer, accounting for 45.2% of the global energy consumption in 2010. Today, fossil energy accounts for the bulk of regional energy requirements, but many factors have demanded diversification of the region's energy mix to include non-fossil energy—particularly nuclear power, which can provide clean energy on a large scale and in a reliable manner. While concerns about the safety of nuclear reactors are legitimate, they are not a strong argument for dismissing nuclear energy. Consequently, safety concerns have not resulted in serious plans in Asia to reverse or downsize nuclear energy programs in its countries with active programs or serious existing plans.

Policy Implications

- The Asia-Pacific region has been growing at a significant rate, which ensures a high and increasing demand for goods and services. In turn, such economic momentum has unsurprisingly ensured a large and growing demand for energy in the region.
- Against a background of a resurgence of interest in nuclear energy in developing countries, evidence suggests that Asia is opting for nuclear energy on a larger scale than other regions. Reasons for this interest include energy security concerns, geopolitical considerations, financial imperatives, desires to mitigate global warming, and opportunities to benefit from exporting nuclear technology.
- Fukushima has not been a game changer when it comes to Asia's nuclear power sector. Unconvinced by the argument equating nuclear energy with nuclear disasters, and having compelling reasons to continue with nuclear energy, all Asian countries with active and serious nuclear programs will continue at paces determined by their countries' specific needs for and views toward nuclear energy. Japan seems to be an exception to the rule, having shut down many of its reactors for inspection right after the Fukushima crisis and suspended the construction of its two new projects. Yet, having no realistic alternative to nuclear energy, the Japanese government has pointed out this reality as a prelude to a gradual re-opening of the shut-down facilities.

The dropping of nuclear bombs on Hiroshima and Nagasaki in 1945 heralded the beginning of the nuclear weapons era.[1] However, the peaceful use of nuclear power started about a decade after the first nuclear reactors for electricity generation went online in Europe and the United States. In 1956 the world's first commercial nuclear power station, Calder Hall, went online in Sellafield, United Kingdom, with a capacity of 45 MW.[2] The first American commercial nuclear generator (the Shippingport reactor) entered operation in Pennsylvania in the following year.

Small in scale, these nuclear reactors set the stage for the rapid expansion of the nuclear energy industry worldwide in the 1960s, 1970s, and early 1980s. However, various factors stopped this fast-paced growth in the 1980s.[3] One major factor that contributed to this slowdown was that while crude oil costs skyrocketed during the 1973–74 oil crisis, oil prices declined in early 1974. Another factor was the high cost of realization of nuclear reactors compared to oil-, gas-, and coal-fired power generators. The growing anti-nuclear movement, especially in Europe and also in parts of the Asia-Pacific region (e.g., Japan), was yet another major factor. Primarily aimed at promoting nuclear disarmament to prevent nuclear war between the USSR and the United States, this movement helped create a widespread disgust with anything related to nuclear power regardless of its military or peaceful implications. Consequently, many people saw harnessing nuclear energy for generating electricity as an unacceptable step toward nuclear weapon production and/or a dangerous project with the potential to release harmful radioactivity through accidents.

Yet the most important factor in halting the expansion of the nuclear industry was the widespread concern that harmful radioactivity could be accidentally released. In particular, major accidents at Three Mile Island in the United States (February 1979) and Chernobyl in the Soviet Union (May 1986) served as a major disincentive for embarking

[1] Parts of this section were originally published by the author in "In Search of Energy Security in the 21st Century: The Asia-Pacific Region Opts for Nuclear Energy," *Northeast Asia Energy Focus* 7, no. 4 (2010).

[2] "1956: Queen Switches on Nuclear Power," *BBC on This Day*, October 17, 1956, http://news.bbc.co.uk/onthisday/hi/dates/stories/october/17/newsid_3147000/3147145.stm.

[3] European Nuclear Society, "Nuclear Power Plants, World-Wide," 2010, http://www.euronuclear.org/info/encyclopedia/n/nuclear-power-plant-world-wide.htm.

on nuclear energy projects worldwide, a sentiment that lasted for over two decades. In both cases, these accidents released radioactive materials as the reactors' cores melted down—because of errors in reactor design, mechanical failure, and human mistakes (Three Mile Island)[4] or because of mainly human error, the conduct of an unusual and unsafe test, and the absence of an appropriate containment structure (Chernobyl).[5] While Three Mile Island did not result in any reported deaths or detectable health-related cases (e.g., cancer) among the people living in the reactor's vicinity,[6] Chernobyl led to the deaths of 47 workers and firefighters who were severely exposed to radiation during the first days of the accident.[7] Additionally, about 60,000 people were highly exposed to radiation from Chernobyl, of whom at least 4,995 died between 1991 and 1998, according to a World Health Organization report.[8]

In short, these factors, especially the safety concerns that increased drastically because of Chernobyl, led to a major decline of the nuclear energy industry, mainly in Europe and North America. This trend is demonstrated in the cancellation of more than two-thirds of all nuclear plants ordered after January 1970.[9]

[4] General Public Utilities Corporation, "Three Mile Island : One Year Later," 1980, available at ThreeMileIsland.org, a website of Dickinson College, http://www.threemileisland.org/downloads/221.pdf.

[5] Burton Bennett, Michael Repacholi, and Zhanat Carr, eds., "Health Effects of the Chernobyl Accident and Special Health Care Programmes," World Health Organization, July 2006, http://www.who.int/ionizing_radiation/chernobyl/WHO%20Report%20on%20Chernobyl%20Health%20Effects%20July%2006.pdf.

[6] General Public Utilities Corporation, "Three Mile Island: One Year Later."

[7] Bennett et al., "Health Effects of the Chernobyl Accident and Special Health Care Programmes."

[8] Ibid.

[9] Steve Cohn, *Too Cheap to Meter: An Economic and Philosophical Analysis of the Nuclear Dream* (Albany: State University of New York Press, 1997), 127.

Asia as the Main Arena for Nuclear Expansion to Continue in the Foreseeable Future[10]

Today, Asia has established itself as the world's largest energy consumer, accounting for 45.2% of the global energy consumption in 2010 (12002.4 million tons of oil equivalent, hereafter Mtoe).[11] This is the result of various contributing factors, first and foremost that Asia is now the world's largest economy, and that it also has a large and growing population—close to half of the world's total population—with constantly improving living standards. The Asia-Pacific region also houses regional and global heavyweights, Japan and South Korea, alongside smaller, but still vibrant economies such as Singapore and Taiwan. The gradual and quiet introduction of market-economy reforms to Vietnam since the 1990s has helped the country sustain significant economic growth rates—at an average of 7% since 2003.[12]

In short, the Asia-Pacific economy and population have both been growing at significant rates, which ensures a high and increasing demand for goods and services. In turn, such economic momentum has unsurprisingly ensured a large and growing demand for energy in the region. Given that all indicators suggest the region's continued economic growth in the foreseeable future, there is no doubt that regional energy consumption will continue to increase at a significant rate that maintains its current global rank.

Today, fossil energy accounts for the bulk of regional energy requirements (91.2% or 4163.3 Mtoe), just as is the case everywhere else (evident in **Table 1**). However, many factors have demanded diversification of the region's energy mix to include non-fossil energy. These include the increasing cost of imported fossil energy, excluding a few exceptions (e.g., Malaysia and Brunei); that countries in the region, especially the heavyweights (China, India, Japan, and South Korea), are not energy self-sufficient; and

[10] Parts of this section were drawn from the author's article "In Search of Energy Security in the 21st Century."

[11] *BP Statistical Review of World Energy 2011* (London: BP plc, 2011), 40. The provided figure consists of 43.9% for Asia-Pacific, 5.8% for the Middle East, and 1.3% for Central Asia and the Caucasus, excluding Armenia, Georgia, Kyrgyzstan, Tajikistan, and also Afghanistan, for which such statistics are unavailable.

[12] "Vietnam GDP – Real Growth Rate," Index Mundi, 2010, http://www.indexmundi.com/vietnam/gdp_real_growth_rate.html.

concerns about the political and security implications of heavy dependency on imported supplies. Yet, more important than these factors, halting and hopefully reversing the worsening global warming caused mainly by about two centuries of heavy consumption of fossil fuels requires a substantial decrease in fossil energy consumption and, hopefully, its eventual total replacement with environmentally-clean types of energy. Hence there is a need for changing the regional energy mix in favor of certain non-pollutive renewables (e.g., wind, solar, and tidal energy) and nuclear energy. The latter is especially suitable as a type of energy for electricity generation; electricity production has been the single largest contributor to greenhouse gas emissions owing mainly, but not exclusively, to coal-fired power generators.

Table 1: The energy mix of the Asia-Pacific region (Mtoe)

Consumption	Asia-Pacific	World	Share of Asia-Pacific
Oil	1267.8	4028.1	31.47%
Natural gas	510.8	2858.1	17.87%
Coal	2384.7	3555.8	67.07%
Nuclear	131.6	626.2	21.02%
Hydroelectricity	246.4	775.6	31.77%
Renewables	32.6	158.6	20.55%
TOTAL	**4573.8**	**12002.4**	**38.11%**
Share of fossil fuels	91.02%	87.00%	N/A
Share of non-fossil fuels	8.98%	13.00%	N/A

Source: This table was created by the author based on data from *BP Statistical Review of World Energy 2011* (London: BP plc, 2011), 41.

Of course, nuclear energy is not new to the Asia-Pacific region, thanks to Japan and, on a relatively smaller scale, China, India, South Korea, and Taiwan. However, nuclear energy's share of the regional energy mix and its contribution to power generation have both been limited (2.80%, equal to 131.6 Mtoe). With nuclear energy accounting for a significant percentage of their national energy mix, Japan (13.21%,

equal to 66.2 Mtoe), South Korea (12.94%, equal to 33.4 Mtoe), and Taiwan (8.10%, equal to 9.4 Mtoe) are three major exceptions.[13]

Evidence suggests that the Asia-Pacific region is opting for nuclear energy on a larger scale than other regions. This is manifested in its approximately 100 ongoing nuclear projects, which have been considered, negotiated, and signed, and close to half of them are in the implementation stage. China accounts for the bulk of these projects (22), followed by South Korea (6) and India (4); others include Taiwan (2), Pakistan (1), and Japan (2).[14]

In Southeast Asia, Vietnam has embarked on constructing a power plant consisting of four nuclear reactors with the assistance of Russia and Japan, with preliminary work on a Russian reactor in progress and scheduled for completion in 2020.[15] As a West Asian country, Turkey has also followed the Asian trend. It signed a deal with Russia on May 12, 2010, for Russia's financing, building, and operating of four 1,000-MW reactors in Turkey whose electricity would be sold to the Turks. Their construction is scheduled for 2013. As planned, the first unit will be operational in 2018, while the other three are expected to be launched within an interval of one year. [16] Turkey's deal was preceded by the United Arab Emirates' $40 billion contract of December 27, 2009, with a South Korean consortium led by state-owned utility Korea Electric Power Corporation (KEPCO) with the participation of Hyundai Engineering and Construction Company, Samsung C&T Corporation, and Doosan Heavy Industries & Construction. Having a capacity of 1,400 MW each, all the reactors are scheduled to be completed by 2020.[17]

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[13] The percentages have been calculated by this author based on the data available in the *BP Statistical Review of World Energy 2011*, 41.

[14] Japan suspended the construction of these reactors after the Fukushima accident to ensure their consistency with all safety regulations.

[15] Author's calculated percentage is based on the data provided in the *BP Statistical Review of World Energy 2011*, 40.

[16] Richard Weitz, "Nuclear and Gas Pipeline Woes Trouble Russian-Turkish Energy Partnership," *Turkey Analyst* 4, no. 6 (March 21, 2011), http://www.silkroadstudies.org/new/inside/turkey/2011/110321B.html.

[17] Amena Bakr, "UAE to Sell Nuclear Power," Reuters, December 29, 2009, *(*http://www.reuters.com/article/2009/12/29/us-emirates-nuclear-idUSTRE5BS2C120091229.

Why Nuclear Energy is Needed in Asia

The following section will discuss five main reasons that nuclear energy is in demand in Asia: energy security concerns, geopolitical considerations, financial imperatives, mitigating global warming, and export potential.

Energy Security Concerns

Like the rest of the world, Asia's continental energy mix is heavily dominated by fossil energy, particularly oil and gas. This requires and, in fact, justifies diversification to decrease vulnerability to fluctuations in the availability of oil and gas supplies and price hikes. Nuclear energy is a suitable addition to this energy mix to decrease dependency on imported fossil energy by using an indigenous source of energy.

Geopolitical Considerations

Apart from coal being abundant and available on demand thanks to a large number of regional suppliers, fossil energy's availability and pricing are affected by political factors, especially interstate relations, political moods, and security challenges in supplying countries and regions, including the security of sea routes for oil/liquefied natural gas (LNG) tankers. Unavailability of supplies or uncertainty about their availability due to instability, political or military conflicts, or imposition of UN- or country-led sanctions on supply countries have been a major concern for Asia. Major military conflicts in the Persian Gulf and collective and unilateral sanctions on Iran have been only a few examples substantiating this concern. The outbreak of the "Arab Spring," affecting many Arab oil and gas (LNG) exporters to Asia, has reinforced this concern, especially because of the possibility of its spreading to the major Arab exporters of the Persian Gulf (e.g., Saudi Arabia and Kuwait). Although the situation in Kuwait has yet to develop into a situation similar to Egypt, the rise of a mass movement in the country and the storming of the Kuwaiti parliament in November 2011 indicate how realistic this

possibility is.[18] For its help in reducing dependency on oil/gas (LNG) imports from such suppliers, nuclear energy has gained popularity in the Asia-Pacific region.

Financial Imperatives

Heavy dependency on imported fuels is a growing financial burden that creates an imperative to reduce such dependency on fossil energy. Alongside other factors—e.g., the growing tension between Iran and the United States/European Union; the continued civil wars in Iraq, Libya in the post-Gaddafi era, Nigeria, and Yemen; the nationalization of the oil/gas (LNG) industries of Venezuela, Bolivia, and Ecuador; and a steady increase in global demand for oil and gas—the outbreak of the Arab Spring in late 2010 has further increased the cost of imported fuels for the large Asian importers (China, India, Japan, South Korea, and Taiwan) with the effect of reducing or at least complicating their economic recovery and growth. Nuclear energy can certainly reduce dependency on imported fuel for power generation at least.

Mitigating Global Warming

Global warming is a factor, though not yet the most important one, in increasing Asia's interest in nuclear energy. As global warming is a human-made phenomenon, there is no question that its mitigation, let alone eradication, requires a substantial decrease in greenhouse gas emissions, especially CO_2, whose main source is fossil energy. Hence, ending current dependency on such energy by replacing it with non-fossil energy is a must. However, environmentally-clean renewables (wind, solar, tidal, and wave energy)[19] are not suitable for large-scale energy generation due to their current underdevelopment. Currently, nuclear energy is the only type of non-fossil energy capable of generating large-scale energy, making it an indispensable component of Asia's energy mix. Consequently, this reality creates yet another incentive for resorting to nuclear energy in Asia being the world's largest emitter of CO_2.

[18] "Kuwait Security Crackdown after Crowd Storms Parliament," *Guardian*, November 17, 2011, http://www.guardian.co.uk/world/2011/nov/17/kuwait-protesters-storm-parliament.

[19] As opposed to non-environmentally clean renewables such as biofuels (for which production is extremely pollutive) and biomass (for which consumption is pollutive and leads to emissions of greenhouse gases).

Export Potential

Finally, nuclear energy's popularity in Asia is also due to its commercial value. Today, Asia is a major supplier of nuclear technology, as Japan and South Korea have developed into major exporters of the technology, especially large nuclear reactors. China is not in this league yet, but it is focusing on turning itself into a major technology provider for small- and medium-sized nuclear reactors—an objective pursued by India as well. Exporting nuclear technology is also an important trade-diversifying factor for these countries, something that was achieved in the case of Japan and South Korea. South Korea's $40-billion contract with the UAE demonstrates the importance of the nuclear industry in Asia as a contributor to continental trade.

The Status of Nuclear Energy

Historical Background[20]

In Asia, nuclear energy started in Japan in the early 1960s. Having next to nil fossil energy, Japan saw nuclear energy as a means to decrease its heavy dependency on oil, gas, and coal imports for financial and—perhaps more importantly—political, economic, and security considerations. Needless to say, such dependency could enable its major suppliers to squeeze it for concessions of political, economic, or military/security natures or even undermine survival by cutting supplies necessary for the country's normal operation.

As a result, Japan embarked on a major program for nuclear power generation, which has continued to this date. As of 2011 Japan had 51 commercial nuclear power reactors, the third largest in the world.[21] The Japanese nuclear sector's total realized capacity is 44,642 MW.[22] However, as of January 2012, only three reactors were in operation. as others were offline for periodic inspections, unplanned inspections,

[20] Parts of this section are drawn from the author's article "Nuclear Energy in Asia: A Post-Fukushima Perspective," *Journal of Energy Security* (May 2011).

[21] World Nuclear Association, "Nuclear Power in Japan," updated February 2012, http://www.world-nuclear.org/info/default.aspx?id=344&terms=Nuclear%20Power%20in%20Japan.

[22] Ibid.

equipment replacements, measures to increase their resistance to tsunamis, and precautionary measures following the Fukushima accident.[23] Other Asian countries with realized nuclear power plants are China with 15 units (11,881 MW),[24] South Korea with 21 units (18,785 MW),[25] India with 20 units (4,385 MW),[26] and Pakistan with 3 units (725 MW).[27] Iran is the only other Asian country, which joined the club just recently, with only one operational unit (1,000 MW).

As reflected in part in the number of operating units concentrated in the Pacific region, by and large, factors sharply decreasing interest in nuclear power during the 1980s and 1990s did not have the same effects in Asia as they did globally. Of course, a range of factors practically removed nuclear power as a realistic option for many Asian countries. These included an inability to finance nuclear projects through domestic or foreign sources; the lack of an indigenous technology supplier or inability to secure a foreign supplier for various reasons (e.g., political); the lack of the required degree of infrastructural, industrial, and scientific advancement and the necessary technical expertise; and the absence of social and/or political stability.

As a result, an economically strong Asian country like Japan with its advanced industrial and scientific sectors embarked on a major nuclear power project on its own, an option unavailable to many other Asia nuclear aspirants. Achieving a high degree of capability in the nuclear sector and mastery in quality control, Japan was confident enough about its safety and security measures to increase the number of its nuclear reactors although the country was, and still is, prone to frequent earthquakes. Hence,

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[23] "Japan—Earthquake, Tsunami and Nuclear Crisis (2011),'' *New York Times*, January 31, 2012, http://topics.nytimes.com/top/news/international/countriesandterritories/japan/index.html.

[24] World Nuclear Association, "Nuclear Power in China," updated January 2012, http://www.world-nuclear.org/info/default.aspx?id=320&terms=China%20Nuclear%20Power.

[25] World Nuclear Association, "Nuclear Power in South Korea," updated February 22, 2012, http://www.world-nuclear.org/info/default.aspx?id=348&terms=Nuclear%20Power%20in%20South%20Korea.

[26] World Nuclear Association, "Nuclear Power in India," updated February 2012, http://www.world-nuclear.org/info/default.aspx?id=338&terms=Nuclear%20Power%20in%20India.

[27] World Nuclear Association, "Nuclear Power in Pakistan," updated August 2011, http://www.world-nuclear.org/info/inf108.html.

neither Three Mile Island nor Chernobyl made Japan scale down or halt its nuclear program. With increasing energy needs and growing dependency on imported fuels, China, India, and South Korea were not deterred by these accidents for more or less the same reasons. They therefore aimed at developing a large nuclear power sector.

As their energy requirements continue to increase due to their fast-growing, robust, and vibrant economies, these countries in the Asia-Pacific region have planned to expand their nuclear power sectors to generate a larger portion of their increasing electricity requirements by nuclear energy. Through nuclear power, Japan generated 30% of its electricity need in March 2011 (now down drastically due to shutting down all but three reactors as of January 2012), and South Korea now generates 31% of its electricity needs.[28] These percentages will increase in both cases, owing to the capacity now under construction, provided Japan authorizes the resumption of operations for its shutdown reactors. Such authorization is now very realistic as Yoshihiko Noda, Japan's prime minster, has departed from the policy of his predecessor (Naoto Kan) on the future of his country's nuclear energy. Whereas then prime minister Kan called for ending Japan's dependency on nuclear power, Prime Minister Noda has stressed Japan's need for this energy to prevent electrical shortages, which could worsen its economy.[29]

Although this percentage is much smaller in the cases of India (4%)[30] and China (2%), both nations are aiming at increasing production.

The Current Situation: Asia as the Main Arena for Nuclear Energy Expansion

When it comes to the expansion of nuclear energy in the Asia-Pacific region, much of the growth will take place in the region's large economies with growing electricity demand. Currently, there are 106 operating nuclear power generators in the region, which will increase significantly in the near future given that 37 units are now under construction, 84 units have firm construction plans, and 180 units are under serious

[28] "Nuclear Power in South Korea."

[29] "Japan — Earthquake, Tsunami and Nuclear Crisis (2011).''

[30] "Asia's Nuclear Energy Growth."

consideration.[31] The majority of these projects are concentrated in the major regional economic powerhouses, namely: Japan with 2 under construction and 12 planned for a total of 19.0 gigawatts (GW); China with 22 under construction for a total of 24.6 GW, plus 35 planned and 120 proposed; South Korea with 6 under construction and 6 planned for a total of 15.0 GW; and India with 4 under construction, 20 planned, and 24 proposed.[32] However, a significant number of other countries in the region have stated or at least seriously considered establishing a nuclear power sector, including Vietnam and Pakistan.

Large reactors as the norm. Since the 1990s, Asia has been the main arena for nuclear energy expansion, a reality for the foreseeable future given numerous reactor projects in place as ongoing, planned, and envisaged. The majority of Asia's reactors are large, given that factors such as large/large-enough territories, the lack of adequate funds, and the need for large-scale electricity generation have limited or shaped their choices.

The potential for SMRs. Although the Asia-Pacific region has focused on large reactors, small- and medium-sized reactors (SMR) are suitable for this region and thus their construction will likely be a regional trend. SMRs, especially underground ones, are appropriate for countries suffering from land scarcity (e.g., Singapore and Timor Leste). They are also the right type for countries whose populations are scattered across territories and concentrated in many urban and rural communities (e.g., Indonesia, Malaysia, and the Philippines). Many of these communities are too small in terms of electricity requirements to justify large reactors (e.g., 1,000 MW), while supplying them with fossil-fueled power generators is equally unjustified because of the required expensive infrastructure (e.g., pipeline and storage construction and maintenance), apart from the environmental concerns.

Moreover, SMRs are a better option than large reactors for countries with limited financial resources for expanding their electricity-generation sector (e.g., Cambodia and Myanmar). In some cases, available indigenous technology can also reduce the cost of building the nuclear sector. Finally, the desire to develop local technology and cope with

[31] "Asia's Nuclear Energy Growth."

[32] Ibid.

the real or perceived vulnerability to political pressure of foreign suppliers are other supporting reasons.

The Impact of the Fukushima Incident on Asian Countries: No Major Change[33]

The earthquake and tsunami of March 11, 2011, devastated a significant part of Japan, catching the Japanese government and people off-guard. The deaths of over 25,000 people and major damages to the residential, commercial, and industrial parts of the affected areas have been overshadowed and, in fact, forgotten outside Japan, due to the extensive coverage of the accident at the Fukushima Nuclear Power Plant (FNPP).

The exaggerated reporting of the accident has prompted a debate about the wisdom of nuclear power generation in Europe and North America—discouraging further expansion and even suggesting the decommissioning of existing nuclear power plants. Yet this debate has not had a significant impact on the expansion of the nuclear power sector in Asia, the main scene of global nuclear reactor projects, and particularly in the Asia-Pacific region, which accounts for the bulk of such projects. By and large, the continent is determined to continue expanding its nuclear sector despite the Fukushima accident. This cohort includes Japan, which, despite its current understandably cautious approach to this sector, has no realistic alternative to nuclear energy to decrease its heavy dependency on imported fossil fuels and achieve its CO_2-reduction goal. Factors demanding the expansion of this sector in the pre-Fukushima period are still valid to justify the implementation of the planned nuclear projects in Asia. They will likely continue to do so in the foreseeable future to ensure Asia's global rank as the main arena for nuclear power projects.

Fukushima from Myth to Reality: No Strong Case against Nuclear Energy

Numerous reports on the Fukushima accident have portrayed it as another Chernobyl. This unrealistic picture has been the result of various factors, ranging from

[33] Parts of this section are drawn from the author's article "Nuclear Energy in Asia: A Post-Fukushima Perspective."

journalistic exaggeration to the pursuit of political and economic objectives to create fear among many people throughout the world regarding the accident's negative effects on their health. Hence, it is necessary to make the distinction between the myth and the reality of the Fukushima accident to understand why Asia will remain committed to its nuclear projects despite the incident.

Briefly, the FNPP consisted of six reactors, three of which were inactive at the time of the accident. The other three were successfully shut off when the earthquake shook the facility. The plant survived the unprecedented 9.1-magnitude earthquake only to be damaged by the tsunami. The tsunami damaged the cooling system and its backups, causing overheating of the reactors and subsequently the explosion of the built-up hydrogen within the facility, but not the explosion of the reactors' cores containing fuel rods. The existence of containment structures around their cores prevented a massive leakage of radioactive material into the environment. The situation was unlike Chernobyl, where explosions released a large amount of radioactive smoke over a period of days as a result of inappropriate containment structures. The FNPP's containment structures prevented a similar release of radioactive material, although a leak in the cooling system led a release estimated to be about 10% of that of Chernobyl, and in a much smaller area within the FNPP's vicinity.

To date, neither the Japanese nuclear authorities nor the International Atomic Energy Agency (IAEA) has reported any deaths, injuries, or medical complications caused by exposure to radiation in Japan. While clean-up will take a long time, possibly decades in the immediately affected regions, the accident now seems to be under control. Continued measurements of radiation in Japan and elsewhere have not detected high radiation that is dangerous to public health. As a result, the Fukushima accident is not a disaster on a par with Chernobyl, although it is significant enough to create concern in the immediate affected areas.

Two Types of Reactions in Asia to Fukushima

Fukushima has created a sense of panic in many parts of the world, with the effect of many people questioning the wisdom of having nuclear energy. This is especially true in North America and Europe, which have not been the major nuclear enthusiasts for

decades, minus a few exceptions such as France. Yet in the Asia-Pacific region, there is no indication of a serious plan to reverse the regional nuclear power program or downsize them—even in Japan, despite talks along that line.

In reality, countries in the region that have active nuclear sectors or serious plans for building them have largely confined themselves to taking precautionary measures to increase the safety of their nuclear programs, mainly to appease their respective peoples' concerns.

The reaction by countries with nuclear power sectors or serious plans toward them. Having the largest number of nuclear plants under development, China has not stopped their construction. Nor has it made any statement to the effect of its plan to impose a construction moratorium on its roughly 100 projects being considered, studied, envisaged, and planned for the next two decades. However, as a precautionary measure, on March 16, 2011, the Chinese government suspended approval for new nuclear power stations so as to revise safety standards in the wake of the Fukushima accident.[34] To remove any ambiguity about its long-term objectives, the Chinese government on March 26, 2011, clearly stated its commitment to continue its nuclear program. It reaffirmed its goal of developing nuclear power as a clean energy source while stressing the safety of the country's nuclear power facilities. Accordingly, Tian Shujia, director of two nuclear safety centers under China's Ministry of Environmental Protection, stated: "There is a guarantee for the safety of China's nuclear power facilities and [China] will not abandon [its nuclear power plant] for fear of slight risks."[35] This statement is in line with the one made by the Chinese government a day after the deadly earthquake and tsunami in Japan, when Vice Minister of Environmental Protection Zhang Lijun stated that China would not change its plans for developing nuclear power.

As reconfirmed by Tian Shujia, China plans to have 66 nuclear power plants by 2020 with a total generating capacity of 66 million kilowatts (kW), which will account

[34] "China Suspends Approvals for New Nuclear Plants," Xinhua, March 16, 2011, http://news.xinhuanet.com/english2010/china/2011-03/16/c_13782113.htm.

[35] "China Can Guarantee Nuclear Power Plants Safety: Official," *China Daily*, March 27, 2011, http://usa.chinadaily.com.cn/china/2011-03/27/content_12232552.htm.

for 6% of China's total power capacity.[36] Under China's 12th Five-Year Plan, approved just days after Fukushima, the country will launch new nuclear energy projects with a combined generative capacity of 40 million kW. In December 2011 China's National Energy Administration (NEA) also stated that China would make nuclear energy the foundation of its power-generation system in the next ten to twenty years, adding as much as 300 GW of nuclear capacity over that period.[37]

Taiwan has also reiterated its commitment to continuing its nuclear program despite the Fukushima accident. On March 15, 2011, Taiwan's president Ma Ying-jeou said that there was no need to shut down operations at Taiwan's three nuclear power plants despite public concerns over their safety caused by the Japanese accident.[38] Nor was there any need to suspend the construction of Taiwan's new nuclear reactors. Like the Chinese premier, the Taiwanese president acknowledged the necessity of reviewing safety and response measures in place while assuring the public about the safe operation of the existing three nuclear reactors. Hence, President Ma stated the government's awareness of the potential threat and that the consensus was to "enhance safety measures" as his government's policy was moving along that direction.[39] He therefore stipulated the continued construction of Taiwan's fourth nuclear reactor as he held that his mentioned review of safety and response measures included "enhanc[ing] the capacity of Taiwan's fourth nuclear power plant....to withstand multiple disasters, such as the combination of an earthquake and a tsunami as seen in Japan."[40]

As a country with a highly developed nuclear sector that meets 31% of its electricity demand, South Korea has not hinted at scaling down its nuclear sector either. As announced in late 2010, South Korea will build 35 nuclear power plants by 2024.[41] If

[36] "China Can Guarantee Nuclear Power Plants Safety: Official."

[37] "Nuclear Power in China."

[38] "No Need to Close Taiwan's Nuclear Power Plants: President Ma," *China Times*, March 16, 2011, http://www.wantchinatimes.com/news-subclass-cnt.aspx?id=20110316000180&cid=1105.

[39] Ibid.

[40] Ibid.

[41] "South Korea Sticks with Its Nuclear Plans," Korea Realtime blog, *Wall Street Journal*, March 22, 2011, http://blogs.wsj.com/korearealtime/2011/03/22/seoul-sticks-with-its-nuclear-plans.

everything goes as planned, nuclear electricity will satisfy about 50% of the nation's electricity consumption.[42]

With 6 reactors currently under construction and 21 nuclear plants in operation, South Korea is determined to continue expanding its nuclear sector as clearly stated in the post-Fukushima period. According to Yun Choul-Ho, president of the Korea Institute of Nuclear Safety, there is no change in the government's plan for expansion of nuclear power plants. [43] He reasoned the latter on the following grounds: "There is no alternative to nuclear energy at this stage."[44] Instead of eliminating nuclear energy because of potential risks caused by natural disasters, ensuring the ability of South Korean nuclear reactors to withstand natural disasters like earthquakes and tsunamis has become the major focus of attention for the South Korean government.

The reference to nuclear-technology exports reflects the importance of the continuity of the South Korean nuclear program due to its relationship with the country's emergence as a technology supplier to reckon with. Added to the other reasons justifying a large and growing nuclear sector, South Korea has major commercial interests in promoting nuclear power. No wonder that, on March 28, 2011, South Korean minister of knowledge economy Choi Joong-Kyung reconfirmed South Korea's commitment to expanding its nuclear sector, stating: "Our answer to the nuclear industry is that we need to keep going."[45] He also stressed that part of the competitiveness of South Korea's manufacturing industry is due to cheap energy generated by its nuclear sector, a reason why nuclear power cannot be given up.[46] South Korea will therefore go ahead with supplying the UAE with four 1,000-MW reactors per its December 2009 contract.

Unlike those countries mentioned above, Vietnam does not have any operating nuclear plants, but, as mentioned earlier, it has an active program aimed at achieving that

[42] "South Korea Sticks with Its Nuclear Plans."

[43] Ibid.

[44] Ibid.

[45] "No Halt to S. Korea Nuclear Plans; Running Safety Checks," Reuters, March 28, 2011, http://in.reuters.com/article/2011/03/28/idINIndia-55919720110328.

[46] Ibid.

end. Vietnam's heavy reliance on fossil energy has contributed to severe air pollution in its major cities, while at the same time presenting a major financial challenge because the country's expanding economy demands a growing amount of energy. As such, the Vietnamese government has clearly stated its commitment to pursue a nuclear program in spite of the Fukushima accident. Like others in the region, Vietnam has reacted to the accident by stressing the necessity of ensuring the highest possible level of nuclear safety measures. The Vietnamese Ministry of Foreign Affairs echoed this policy in March 2011 as follows: "Vietnam puts nuclear safety–related issues as a top priority. This is particularly important in the context of climate change and natural disasters, particularly the earthquake and tsunami that just happened in Japan."[1] With this in mind, Vietnam is projected to have 8 operational nuclear reactors in the next twenty years, with Japanese and Russian assistance.

Even Japan has not made any statement indicating a policy of scaling down its nuclear sector, notwithstanding a mounting concern among the Japanese about the safety of their nuclear power reactors. As cautionary measures, the Japanese government has temporarily shut down the majority of Japan's reactors for the abovementioned reasons (e.g., inspections and improving their resistance to tsunamis). Of course, the government has avoided firm statements on the future of the nuclear sector, given that the issue has become highly emotional in the post-Fukushima era. Prior to the accident, Japan had 51 commercial nuclear power reactors in operation, ranking it third in the world after the United States and France. The sector produced 30% of the country's electricity in 2010, with a plan to increase the share of nuclear energy of its electricity generation to 40% by 2017.[47] Japan is currently building 2 nuclear reactors, and there is no report that Tokyo has imposed a freeze on already approved projects.[48] There are currently plans and proposals for building 10 nuclear reactors by 2022. [49]

Understandably, the Japanese power-generating companies have decided to slow down in implementing the new nuclear projects, given the current prevailing negative

[47] "Nuclear Power in Japan."

[48] Ibid.

[49] Ibid.

view about nuclear reactors among the Japanese. For example, on March 15, 2011, Chugoku Electric Power Company announced its decision to temporarily suspend land reclamation to build a nuclear power plant in Yamaguchi Prefecture, saying that it would like to "prioritize providing full briefings to nearby residents."[50] However, it is highly unlikely that Japan will opt for a long-term or permanent freeze on its nuclear power sector and/or scale down its reliance on nuclear energy in absence of any comparable alternative capable of providing energy free of greenhouse gas emissions. Nuclear energy is currently the main indigenous source of energy for fossil energy–poor Japan, helping the country decrease its reliance on imported fossil energy.

Hence, despite a prevailing view shared globally and the Japanese government's cautious statements regarding the future of the country's nuclear energy sector, Japan has remained committed to nuclear energy for energy security, financial, economic, military/security, and environmental reasons. For example, this stance became evident on August 17, 2011, when the Japanese government approved the restart of Reactor 3 of the Tomari Nuclear Power Plant (TNPP) in Hokkaido.[51] This is a new unit of the TNPP, whose adjustment operation (i.e., non-commercial test operation) started in March 2011 before the Fukushima incident, but its full commercial operation was delayed for various reasons, including the Fukushima incident.[52] Reactor 3 of the TNPP was the first one that received permission to be placed into service again after the events in Fukushima on March 11, 2011. The new Japanese prime minister's statement is another example of the government's continued commitment to the necessity of nuclear energy. In August 2011, incoming prime minister Noda said that his country would continue to use nuclear power for the next 40 years before phasing it out, a radical shift from outgoing prime minister Kan's promise of a non-nuclear Japan in 20 years.[53]

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[50] "Japan's Nuclear Power Push under Review after Fukushima Plant Crisis," *Mainichi Daily Ne*ws, March 27, 2011, http://mdn.mainichi.jp/features/archive/news/2011/03/20110327p2g00m0fe019000c.html.

[51] "Tomari Reactor Commercial Output OK'd; First since 3/11," *Japan Times,* August 17, 2011, http://search.japantimes.co.jp/cgi-bin/nn20110817x3.html.

[52] Ibid.

[53] Charles Digges, "Japan Announces 40-Year Nuclear Phase Out as Germany Grapples with Upcoming Atomic Power Losses," Bellona, August 31, 2011, http://bellona.org/articles/articles_2011/japan_fourty_year.

The reaction by countries without nuclear power sectors or no serious plans toward them. In the pre-Fukushima era, several countries in the Asia-Pacific region expressed interest in adding nuclear energy to their energy mix without setting any specific deadline, although they did announce plans and made proposals for certain reactors. These include Thailand (2 reactors planned and 2 proposed), Malaysia (2 reactors planned), Indonesia (2 reactors planned and 4 proposed), and the Philippines (1 to be reactivated). After Fukushima, negative or cautionary reactions have been confined to three of them, namely Thailand, Malaysia, and the Philippines. Still, none of these regional countries had an active nuclear program or even a serious and realistic plan toward that end. As a result, even their total abandonment of their nuclear energy programs will not have a tangible impact on the regional nuclear industry.

However, interestingly enough, none of these countries have totally removed nuclear energy as an option in the post-Fukushima era. For instance, in December 2010, Malaysia announced plans to build two 1,000-MW nuclear reactors without specifying any date for their construction while referring to tentative dates of their realization (2021 and 2022).[54] In the new era, it has only announced a delay on making an official decision on their actual realization; on March 17, 2011, Malaysia's energy, green technology, and water minister Peter Chin Fah Kui stated that the proposal to construct nuclear power plants in Malaysia for electricity had not been decided yet by the cabinet. [55] He therefore suggested a pause on reaching any final decision until receiving a full report on Fukushima. However, Kui refused to make any comment on whether his government would eventually build the two nuclear plants.

Unlike Malaysia, Thailand has announced a freeze on constructing the country's first nuclear power plants. In practice, however, this decision has not had any practical implication as the Thai government has never taken any tangible step toward construction. Among other factors, Thailand's government has lacked internal cohesion

[54] Badaruddin Mahayudin, Senior Undersecretary of Energy, Ministry of Energy, Green Technology, and Water ,"Planning for a Nuclear Power Program in Malaysia" (paper presented at inaugural Nuclear Power Conference, Singapore, August 2–5, 2010).

[55] "M'sian Cabinet Has Not Decided on Nuclear Power Plants Yet," Asia News Network, March 17, 2011, available at http://ph.news.yahoo.com/msian-cabinet-not-decided-nuclear-power-plants-yet-20110316-223001-689.html.

and faced social and political instability since the September 2006 military coup led to the overthrow of its prime minister. Thailand has since suffered from political uncertainty thanks to the large and active pro-Thaksin movement. While the central government is in control of the country, the absence of a safe and secure environment to realize a nuclear sector situation will likely discourage nuclear-technology suppliers from supplying Thailand if and when it decides to pursue its nuclear program.

By the same token, the decision of the Philippines to discard plans to activate the shelved Bataan Reactor has not had any practical implication for the region's nuclear energy sector.[56] The reactor was built in the late 1970s, but was not commissioned because of litigation concerning bribery and safety deficiencies.[57] Given the availability of a completed nuclear reactor, the Philippine government commissioned an IAEA team to determine the feasibility of this project in 2008. The team confirmed its feasibility and the safe operation of the nuclear plant for 30 years subject to refurbishment. As such, the March 2011 decision to give up the activation plan had no practical impact on the region's nuclear sector, while denying the Philippines a means to decrease its dependency on imported fuel for power generation.

Interestingly enough, Indonesia has not yet decided to give up its envisaged nuclear program. In fact, the Indonesian government has dismissed the Fukushima accident as a strong reason for shelving its nuclear program. On March 18, 2011, Adiwardojo, the head of nuclear energy development at Indonesia's National Nuclear Energy Agency, said that concerns about a disaster similar to Fukushima were misplaced because Indonesia's future plants would use technology that was far more advanced.[58] Stating that his country would carry out its assessment of potential nuclear sites using standards and guidance from the IAEA, Adiwardojo added: "The important thing isn't that Indonesia is on the Ring of Fire or there are tsunamis, so we can't build. No, the important thing is that we

[56] "To Go or Not to Go Nuclear," *President Post*, November 26, 2011, http://www.thepresidentpost.com/?p=11838.

[57] "Asia's Nuclear Energy Growth."

[58] Aubrey Belford, "Indonesia to Continue Plans for Nuclear Power," *New York Times*, March 17, 2011, http://www.nytimes.com/2011/03/18/business/global/18atomic.html.

fulfill the requirements.''[59] On March 30, 2011, Luluk Sumiarso, director-general of renewable energy at Indonesia's Energy Ministry, echoed the same policy as he stated that the plan to build nuclear power plants would go ahead, while stressing his country's objective of maximizing the use of renewables especially geothermal, hydro-energy, and bio fuels.[60] Of course, there is still opposition within the Indonesian government as there has been since the 1960s. Consequently, the envisaged nuclear reactors may not become a reality in the near future. Yet what is important is that Indonesia cannot discard its nuclear power option given its rapidly depleting fossil energy resources. The fact that it is no longer an OPEC member and has become an oil importer to meet its domestic needs could well make Indonesia more interested in a nuclear option.

The Road Ahead[61]

Reflecting a global reality, Asia's energy mix, including that of the Asia-Pacific region, is not environmentally sustainable due to its heavy reliance on fossil energy, the major contributor to global warming. Hence, it is necessary to diversify the Asian energy mix by adding non-fossil energy, of which nuclear energy is a necessary component. It is especially an indispensable component today and in the foreseeable future because the current underdevelopment of clean renewables (e.g., solar and wind) has created a barrier to those sources of energy becoming viable alternatives to fossil energy. Nuclear energy in its current status can provide energy at a large scale and in a reliable manner to replace fossil energy in many fields, especially in power generation.

Concerns about the safety of nuclear reactors are legitimate, as the release of radioactive materials in the cases of malfunctions, mistakes, accidents, or natural disasters affecting nuclear reactors could be devastating for the immediate surroundings

[59] Belford, "Indonesia to Continue Plans for Nuclear Power."

[60] "Indonesia Puts Renewable Energy Ahead of Nuclear Option," Xinhua**,** March 30, 2011, http://news.xinhuanet.com/english2010/world/2011-03/30/c_13805270.htm.

[61] Parts of this section are drawn from the author's article "Nuclear Energy in Asia: A Post-Fukushima Perspective."

and potentially for areas farther away. However, while legitimate, such concerns are not a strong argument for dismissing nuclear energy.

Other than Three Mile Island, Chernobyl, and Fukushima, there has not been a reported case of an accident of any significance since the 1950s, when the commercial use of nuclear energy started. Among them, Chernobyl has been the only case causing deaths and radioactive-related diseases and significantly damaging the surrounding environment. This is a good record, given that hundreds of nuclear power facilities (441 as of 2010) have since been operating, including in geologically challenging environments such as Japan, which is prone to frequent earthquakes. Operating over 50 nuclear reactors, Japan has had only one major accident, Fukushima, caused not by the exceptionally potent earthquake, but by the devastating tsunami destroying the plant's cooling systems located underground. Placing cooling systems of the similar nuclear reactors at a higher altitude can eliminate the possibility of another Fukushima.

Japan's experience and also that of other Asian countries with a major nuclear power sector (China, South Korea, Taiwan, and India) indicate that there are workable and tested safety measures, which could be put in place to ensure the safe operation of nuclear power generators. For example, modern containment structures, like those developed in Russia and France that were absent in the Fukushima nuclear plant built in the 1970s, practically remove the possibility of nuclear disasters in cases of accidents or natural disasters. Thus, nuclear energy will not necessarily lead to disasters.

In conclusion, the Fukushima accident has not been a game changer when it comes to Asia's nuclear power sector. Unconvinced by the argument equating nuclear energy with nuclear disasters, and with compelling reasons for power generation with nuclear energy, all Asian countries with active and serious nuclear programs will continue them at different paces as determined by their countries' specific needs and their populations' views toward nuclear energy. Asia will therefore retain its global rank as the main scene for nuclear power expansion.

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