An Examination of Future Energy Mix in the Three Northeast Asian Countries and Its Implication

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Abstract:

The increasing threat of climate change draws attention to nuclear power as an emission-free energy source among three Northeast Asian countries, Korea, Japan and China. With the current total operable nuclear capacity of the three countries about 20% of the world total, and with the Fukushima accident, nuclear safety has emerged as a hot issue again with follow-up discussions on replacing nuclear power with coal or LNG to address the safety issues.

Considering energy security and the CO2 emission problems in which China is the biggest CO2 emitter while Japan and Korea are also listed within the world top ten, the potential role of nuclear power in terms of the future CO2 emission reduction and energy security has been examined.

The inevitability of the choice for nuclear power for Chinese long-term energy security is being discussed while nuclear safety problems of her own and neighboring countries are also noted by identifying the earthquake zone with a couple of inland nuclear development plan and regional wind direction.

Further discussions on the institutionalizing the most advanced framework on nuclear energy among the three countries follows in this respect.

I. Introduction

In March 2011 eleven operating nuclear power plants shut down automatically during the major earthquake in Japan. Three of these subsequently caused an INES[1] Level 7 Accident due to loss of power leading to loss of cooling and subsequent radioactive releases. This event magnified the role of the federal government in the national economy about nuclear energy policy. In Germany for instance, her coalition government has announced a reversal of policy that will see all the country's nuclear power plants phased out by 2022. In France, nuclear power plants are designed to withstand an earthquake twice as strong as the 1000-year event calculated for each site. Switzerland suspended approval for three new plants and Bulgaria prepared to freeze a nuclear project. On the other hand, Poland announced to building its first reactor, Romania also decided to build two additional reactors, and Brazil is building its third plant. China has announced a freeze on approvals for new reactors as regulators examine safety procedures and it has finished a half year safety check on both the nuclear facilities already in operation and plants under construction until July 2011. China will continue its long-term nuclear plans including inland nuclear power plant, but they should fully grasp the importance and urgency of nuclear of nuclear safety and development of nuclear power must make safety the top priority.

On 22th September, The Korean President Lee Myung-Bak delivered a keynote speech at the high-level meeting at UN on nuclear safety and security. He said that the accident at the Fukushima Daiichi Nuclear Power Plant, which dealt a huge blow to confidence in nuclear safety, should not be the cause to renounce nuclear energy. He also said the use of nuclear energy is inevitable as it is one of the best alternatives capable of meeting growing global power demand and helping solve the problem of climate change but the regional cooperation should be strengthened as a nuclear accident is

[1] International Nuclear and Radiological Event Scale

transactional. Actually, except Germany, there is no nation giving up for nuclear power because of increasing dependence of energy on overseas.

In addition, nuclear is regarded a kind of CO2 reduction technology. With a research, the paper, "Nuclear power is the only green solution" written by Lovelock, J (2004) explains serious situation of global warming in earth with various examples, and it concludes that nuclear power is the only breakthrough. Sailor (2000) analyzed the safety and economics of nuclear power and he suggested that nuclear power would take a major roll to cope with climate changes under the assumption of securing safety. Zhou (2010) argues that nuclear power is a relatively clean energy source without green-house gas emission, so that nuclear development has a promising future in China. He not only presents some driving factors of nuclear power in China including the brisk electricity demand and oil supply security but also raises some questions regarding its safety. Some suggestions and recommendations are then submitted for development of nuclear in China.

First of all, as was stated above, the nuclear power has a lot to do with dependence of energy on overseas. Recently, growing concerns in energy security has appeared in a number of global challenges – fluctuating energy resource prices, uncertain energy supply and global warming issues. Uncertainty in oil market with high price volatility makes it difficult to have a long term decision on energy projects. The energy price rises are a disaster for countries that rely on imports for their energy needs. International Energy Agency (IEA) warned that there could be another oil market crisis within 5 years due to supply uncertainty. Moreover, no agreement on climate issue has been achieved among countries yet since it is also a political and an economic issue. With such situation, it has been strongly required to ensure a stable and steady energy supply to meet the nation's growing demand.

In this paper, issues related to energy mix in power sector for 3 north-east Asian countries, Korea, Japan and China are reviewed and evaluated. The objectives of this paper are discuss the role of nuclear power in long-term energy mix greenhouse gases mitigation in China, by referring to Korean and Japan experiences of energy security, some suggestions and recommendations have been proposed for nuclear power development. In the final part, implications and conclusion have been proposed.

II. Energy Mix and Nuclear Power in Power Sector for 3 North-East Asian Countries

A. Korea (South)

Currently, monthly dependency on imported energy varies from 95% to 97% in Korea. Therefore, securing energy stability by reducing this dependency on imported energy is one of the most important energy policies for Korean government.

Following figure shows the past, current energy mix in power sector from 1978 with the changes of oil price and average price of electricity and this energy mix to be extended up to mid 2030. Analyzing the period of international oil price soaring between 1978 and 1980, it is easy to realize how vulnerable the power mix had been to an external impact, such as oil price shock. From the figure below it can also be seen that oil power generation took 72.51% of total electricity generation in 1980. Due to the impact of fluctuating oil price, average electricity price has gone up from 22.33 won/kWh in 1978 to 69.87 Won/kWh in 1985.

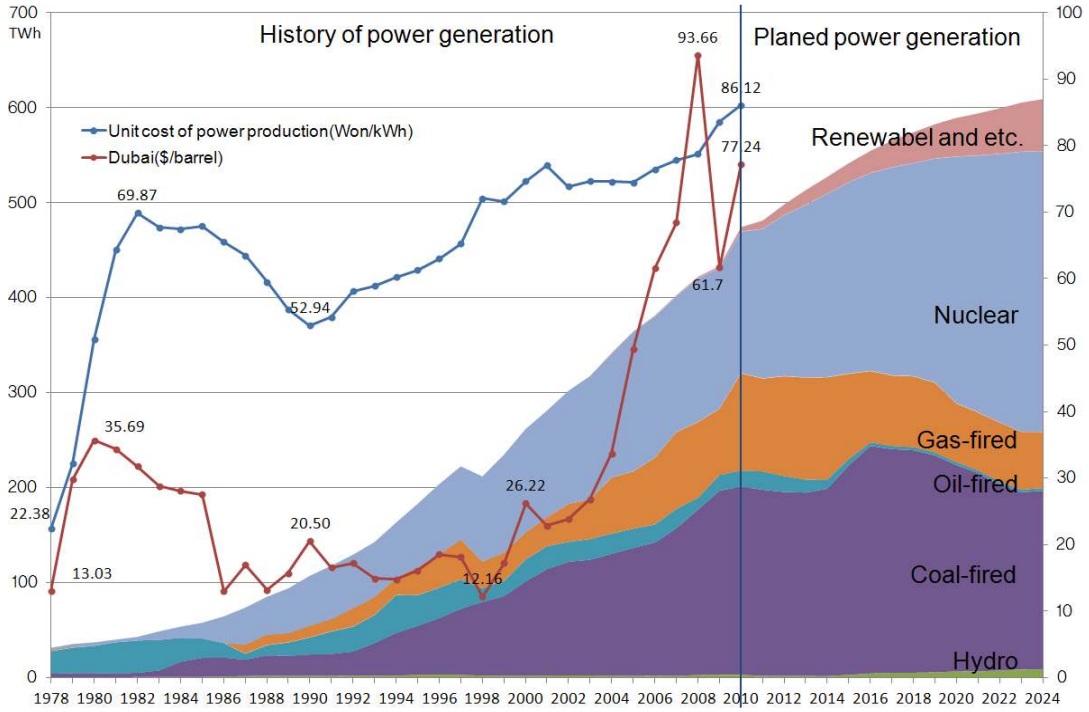

Figure 1 Korean Government's Policy for Power Mix Change in Early 1980's

Source: Korea Ministry of Knowledge Economy, The 5rd Electric Power Demand-Supply plan, 2010

Afterwards, the government drastically changed her policy in power sector energy mix and currently the oil power generation takes only 3.57% of total power generation while nuclear power generation takes 44.05%, LNG 22.18% and coal power generation of 30% (Table 1). Though there were another oil price fluctuations with crude oil price changing from 20$/bbl in year 2000 to 2008 with average oil price over 90$/bbl, the average price of electricity has not been changed much as the figure shows.

Table 1 Energy Mix in Power Sector

	Water	Coal	Oil	LNG	Nuclear	New and Renewable
1978	0.00%	12.76%	75.08%	4.79%	7.38%	0.00%
1980	0.17%	11.69%	77.81%	0.99%	9.34%	0.00%
1990	1.56%	20.90%	16.75%	11.54%	49.25%	0.00%
2000	0.61%	38.00%	8.86%	10.89%	41.64%	0.00%
2010	0.59%	41.85%	3.57%	21.69%	31.36%	0.95%
2020	1.06%	36.93%	0.52%	10.54%	44.05%	6.90%
2024	1.35%	30.96%	0.48%	9.73%	48.54%	8.95%

Source: Korea Ministry of Knowledge Economy, The 5rd Electric Power Demand-Supply plan, 2010

In addition to reducing the heavy reliance on foreign energy source and securing energy stability, and on the other hand, as the 11th largest emitter of CO2, Korean government has set a goal in Copenhagen of 30% reduction compared to the expected emission of 2020 to play a leading role of reducing greenhouse gas in international society, and Korean government is pushing strict energy policies to accomplish this goal. It is clear that the target cannot be achieved without the active promotion and development of nuclear power.

Nuclear activities were initiated when South Korea became a member of the International Atomic Energy Agency in 1957. In 1958 the Atomic Energy Law was passed and in 1959 the Office of Atomic Energy was established by the government. The first nuclear reactor to achieve criticality in South Korea was a small research unit in 1962. Ten years later construction began of the first nuclear power plant - Kori-1 with capacity of 573 MWe, a Westinghouse unit built on turnkey contract. It started up in 1977 and achieved commercial operation in 1978(WNA).

In year 2010, 32 years after the first nuclear power plant, Kori-1, has been put into commercial, there are in total 21

operating nuclear power plants. Currently, the total installed capacity of nuclear power plant is 18,715 MW which is an increase of more than 30 times from 1978. For installed capacity, it ranks 6th in the world and is expected to be 8th in the world when the currently planned and proposed capacity are considered all together. Table 2 shows the nuclear plan of Korea.

Table 2 Nuclear Reactors in Korea (Unit: MWe)

	Number of Reactors	Capacity (MWe)	Percentage
Operating	21	18,785	56.95%
Under construction	5	5,700	17.28%
Planned	6	8,500	25.77%
Total	32	32,985	100.00%

Source: Korea Ministry of Knowledge Economy, The 5rd Electric Power Demand-Supply plan, 2010

B. Japan

Japan has few natural resources of its own, so it is considered as a country with poor resources which heavily depends on foreign resource. According to the energy balances of OECD countries (2009 edition) of IEA statistics, the rate of self-sufficiency is 17.7% on its primary energy demand.

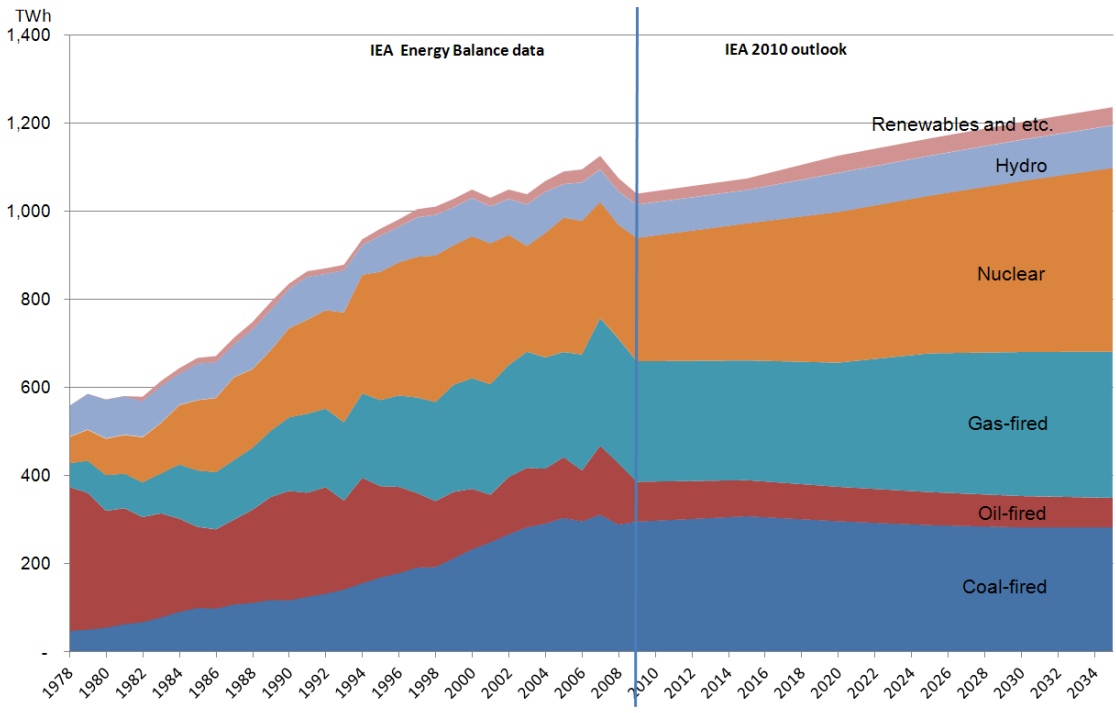

Figure 2 Current and Future Power Mix of Japanese Power Sector

Source: EIA Energy balance data 2010, IEA 2010 outlook

The major source of power generation of Japan during 1980s was oil as is shown in the following figure. After the 1st and 2nd oil shock in the mid of 1970s, however, more of other resources such as LNG and nuclear were utilized for power generation. Similar to Korea, Japan who is highly dependent on overseas energy, has done her efforts to reduce oil portion of overall power generation after oil price fluctuation. As shown in figure above after 1980s, oil-fired power generation has been continuously decreased and planned to have share of only 5% in 2019.

Due to the lack significant domestic source of fossil energy, Japan started its nuclear research program in 1954, and the Atomic Energy Basic Law, which strictly limits the use of nuclear technology peaceful purpose, was introduced in 1955. Since then, Japanese were working to increase the availability of nuclear power, until 2011, the total capacity of operating

nuclear reactors has reached 44.6 GW. On the other hand, Japan has had a long history of earthquakes and seismic activity, and destructive earthquakes, often resulting in tsunamis, occur several times a century. Due to this, concern has been expressed about the particular risks of constructing and operating nuclear power plants in Japan. Following an earthquake, tsunami, and the failure of cooling systems at the Fukushima I Nuclear Power Plant on March 11, 2011, a nuclear emergency was declared.

In the long-term overview, nuclear has already had a growing nuclear industry and nuclear power has been expected to play an even bigger role in future with 41% of all resources for power generation in 2019, it is quiet higher than that of 17% in 1980. Such a change in power generation mix reveals that Japanese government realizes the importance of energy diversification for energy security and of the reduction of greenhouse gas.

As is seen above, nuclear power has been chosen as an alternative for the future power generation mix, although the future energy mix in Japanese power sector is still under discussion due to Fukushima accident.

Following table shows the details of nuclear facilities in Japan. Installed capacity of constructed nuclear power plants is 44.6 GW in March of 2011, and others that are under construction or to be constructed up to 2020 will be 8.2GW. The status is presented below.

Table 3 Nuclear Reactors in Japan (Unit: MWe)

	Number of Reactors	Capacity (MWe)	percentage
Operating	51	44,642	65.7%
Under construction	2	2,756	4.1%
Planned	10	13,772	20.3%
Proposed	5	6,760	9.9%
Total	68	69,730	100.0%

Source: WNA Nuclear Power in Japan

Nuclear power plants can produce a huge power by consuming relatively small amount of nuclear fuel. For example a 1000 MW fossil power plant burns about 2 million tce of coal annually, while a nuclear plant of comparable capacity consumes about 190 tons of natural uranium as fuel. It is argued that nuclear power generation will greatly reduce fossil fuel consumption and alleviate the pressure on the environment caused by coal consumption, because nuclear energy is clean without green-house gas emissions.

The demand for electricity continues to grow in China with surging economic growth. In eastern areas, supply of electricity hardly satisfied demand in some cities. In 2004, China suffered its worst power shortage since the ‘90s, imposing power to be cut or to be limited in 27 out of 31 provinces, municipalities and autonomous regions. Since then, China faces summer power shortage almost every year. In some areas they had to “shut the power down” which hindered economic development and also caused big trouble to local residents.

The objectives of this paper are discuss the role of nuclear power in long-term energy mix greenhouse gases mitigation in China, by referring to Korean and Japan experiences of energy security, some suggestions and recommendations have been proposed for nuclear power development. The second part elaborates the China’s energy mix. The third part identifies global and China’s nuclear power status and the role of the nuclear power in China’s long-term energy mix. T The objectives of this paper are discuss the role of nuclear power in long-term energy mix greenhouse gases mitigation in China, by referring to Korean and Japan experiences of energy security, some suggestions and recommendations have been proposed for nuclear power development. he fourth part analyzes the experience from Japan and Korea comparing with China. In the final part, implications and conclusion have been proposed.

C. China

According to the World Energy Council (2009), China holds an estimated 114.5 billion short tons of recoverable coal reserves, 14 percent of the world’s total reserves, and the third-largest in the world behind the United States and Russia. The northern part of China has the most reserve and thus produces more coal compared to other areas. With all the economic activities centered around south-eastern area—specifically around Beijing, Shanghai and Guangdong, a large amount of coal must be transported to the eastern coastal regions from the west due to this uneven distribution of coal. It not only causes heavy demand for land transportation but also puts pressure on the prices of coal.

Although China holds richer energy resources compared to Korea and Japan, she has become a net oil importer in 1993 and a net coal importer in 2007 with her real economic growth rate of over 9% per year and the rapidly rising energy demand. China now faces a great challenge to meet her increasing demand and energy security. The power supply hardly satisfies the demand of cities in eastern area. In 2004, China suffered her worst power shortage since the '90s, imposing power to be cut or to be limited in 27 out of 31 provinces, municipalities and autonomous regions. Since then, China faces summer power shortage almost every year. In some areas they had to "shut the power down" which hindered economic development and caused big trouble to local residents at the same time.

Nuclear, as a relatively clean energy source, has been paid high attention by Chinese government. Since China put its first nuclear power plant (named Qinshan) into commercial operation in 1992, 14 nuclear reactors are in operation with the capacity of 11,271MWe and the electricity generation has reached 71 billion TWh until August 1st of 2011. In March 2006, China State Council issued the "Medium and Long-term Nuclear Power Development Plan (2005-2020)" which outlined its goal of increasing China's capacity to 40GWe by 2020. In July 2009, the State Council has reported a consideration of raising the target up to 86 GW installed and 18 GW under construction until 2020. According to the "China's energy long-term (2030, 2050) development strategy" the total nuclear power installed capacity will reach 200GW, 400GW accounting for the proportion of 10%, 16% of total electricity capacity, respectively.

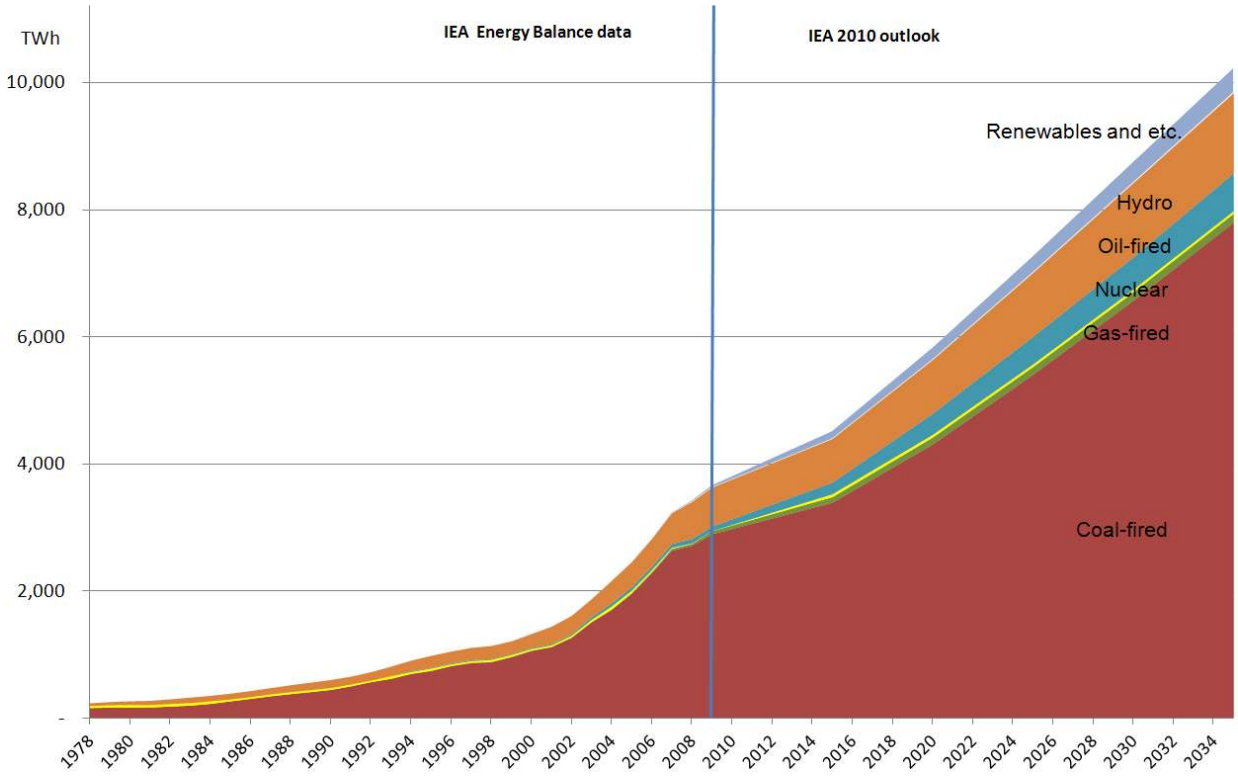

Figure 3 Current and Future Energy Mix in Chinese Power Sector

Source: EIA Energy balance data 2010, IEA 2010 outlook

Figure 3 shows the current and future energy mix in China's power sector. It is clear that the demand for power in China is expected to grow continuously during the period of our examination. Even with such a massive expansion plan of nuclear power as is discussed above, most of the power generation is expected to be filled with coal power generation. With the increasing share of nuclear power, its share in total power generation in China by year 2035 will be around 6%.

Total final energy consumption trend together with these two figures are showing the importance of power sector even more clearly. In the Figure 3, it can be seen that the total installed capacity is forecasted to be increasing almost threefold, from far less than 4000 TWh in 2008 up to more than 10000 TWh in 2035.

Table 4 China Energy Mix in Power Sector

Year	Coal	Gas	Oil	Nuclear	Hydro	Wind
1978	65.322%	0.000%	16.315%	0.000%	18.363%	0.000%

1980	59.422%	0.251%	19.073%	0.000%	21.234%	0.000%
1990	72.480%	0.453%	6.268%	0.000%	20.798%	0.000%
2000	79.192%	0.432%	2.387%	1.256%	16.687%	0.046%
2009	78.946%	1.387%	0.206%	1.915%	16.808%	0.734%
2020	73.910%	1.888%	0.824%	5.750%	14.521%	3.107%
2030	75.112%	1.521%	0.549%	5.856%	13.348%	3.614%
2035	76.287%	1.399%	0.450%	5.852%	12.351%	3.660%

Following table summarizes current nuclear plan of China including those under construction, planned and proposed altogether.

Table 5 Nuclear Reactors in China (Unit: MWe)

	Number of Reactors	Capacity (MWe)	Percentage
Operating	14	11,271	4.0%
Under construction	26	28,710	10.1%
Planned	50	58,320	20.5%
Proposed	116	186,160	65.4%
Total	206	284,461	100.0%

It is noted here that the total figure of 284GW summarized above does not include nuclear reactors of Jiyang, Yingtan, Lanzhou, Yibin, Hebaodao, Xianning, Qiaofushan, Shizu etc., whose planned and proposed capacity not yet clearly identified in their official website and is still much higher figure than what is reported in WNA 2011.

China has announced a freeze on approvals for new reactors as regulators examine safety procedures and she has started a half year safety check on both the nuclear facilities already in operation and under construction on March 16.

D. Summary of Nuclear Power Plan of Three Northeast Asian Countries

Summarized in the following table are the future reactors in the world envisaged in specific plans and proposals and expected to be operating by 2030. It can be seen that USA ranks first for operable capacity, but in a long term, China will hold the biggest total capacity(including under construction, planned and proposed reactors), which is much larger capacity that that of USA which ranks the second in the world.

Table 6 Ranking of World Nuclear Power Capacity (Aug 1st 2011, Unit : MWe net)

	OPERABLE		OPERABLE +UNDER CONSTRUCTION		OPERABLE +UNDER CONSTRUCTION + PLANNED		OPERABLE + UNDER CONSTRUCTION + PLANNED + PROPOSED	
1	USA	101,421	USA	102,639	USA	109,839	China	222,971
2	France	63,130	France	64,850	China	99,971	USA	148,439
3	Japan	44,642	Japan	47,398	France	66,570	Russia	76,044
4	Russia	23,084	China	39,981	Japan	61,170	India	72,985
5	Germany	20,339	Russia	32,044	Russia	48,044	Japan	67,930
6	Korea	18,785	Korea	24,585	Korea	32,985	France	67,670
7	Ukraine	13,168	Germany	20,339	India	23,985	Ukraine	37,868

8	Canada	12,679	Canada	14,179	Germany	20,339	Korea	32,985
9	China	11,271	Ukraine	13,168	Canada	17,479	U.K.	29,425
10	U.K.	10,745	U.K.	10,745	U.K.	17,425	Canada	21,279
total	world	371,584	World	432,918	World	605,013	world	993,318

Source: WNA, Nuclear Power in China, Aug 1st 2011.

Table above shows the nuclear power capacity of China is expected to grow continuously when reactors under construction, planned and proposed are considered in addition to those currently in operation. Japan and Korea(South), currently 3rd and 6th in their nuclear power capacity in the world, respectively, are expected to be 5th and 8th after all the future plans are considered due to those of Russia and India who are expected to be ranked 3rd and 4th followed by USA. It is worth noting that the current total operable nuclear capacity of the three northeastern Asian countries accounts for 20.1% of the world total, while the figure will be 32.6% when the additional reactors under construction, planned and proposed are considered in addition.

Considering this large combined share of nuclear power capacity of three northeastern Asian countries, a more strengthened cooperation among the three countries seems and urgent and important matter, especially in the aspect of nuclear safety. Once a nuclear accident happens in any of the three countries, it will surely affect other Asian countries.

III. Challenges in the Development of Chinese Nuclear Power Plan

A. Nuclear Development of China and Its Potential Impact

Since China put its first nuclear power plant (named Qinshan) into commercial operation in 1992, there has 14 nuclear reactors in operation with the capacity of 11,271MWe and the electricity generation has reached 71 billion TWh until August 1st of 2011. Most of the nuclear reactors are located in coastal areas and generally use seawater for cooling a direct once-through cycle and they have been playing an important role for coastal economic development.

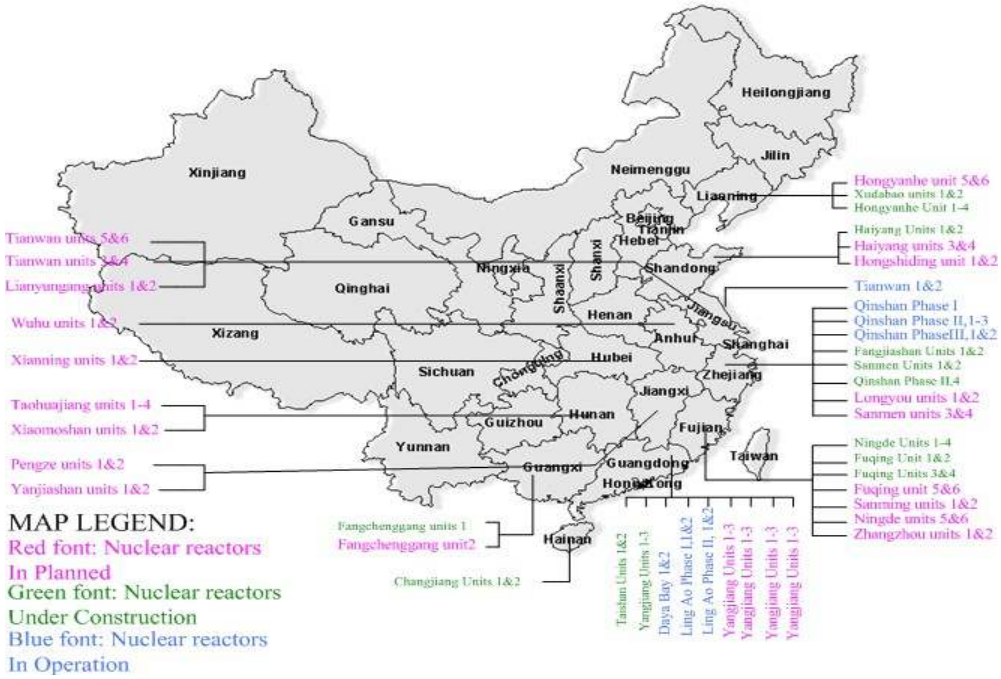

Figure 4 Distribution of Nuclear in China

Source: WNA Nuclear Power in China

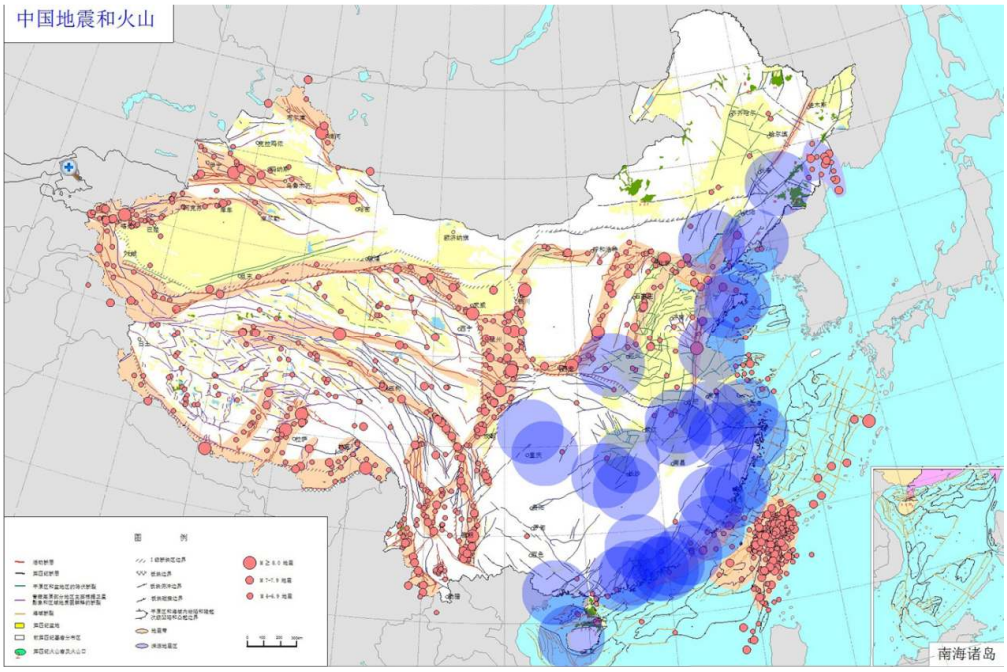

Figure 5 Earthquake zone of China

Source: Institute of Geology, China Earthquake Administration (2011.3)

China has started its strong expansion plan of inland nuclear power plant with half of the planned nuclear power plants will be located in inland. For example, Nanyang nuclear power plant in Henan province is proposed. But he worried issue is that some of the nuclear power plants are around the earthquake-zone, which will be a greater danger for the nuclear security. In the figure 5, red dots are earthquake-prone areas, the blue circles are the seismic zone, and their radiuses are 200km. When a nuclear accident happens, there will be a direct impact in this range.

B. Scenario Analysis of Nuclear Energy Policy for Three Northeast Asian Countries

After Fukushima accident, nuclear safety has emerged as a hot issue again with discussion of replacing nuclear power with coal or LNG to address the safety issues. But, considering the energy security and the CO2 emission problems, nuclear power is still expected to be an inevitable choice. Referring to a long-term energy forecast, following case for the three countries are evaluated to see the potential role of nuclear power in terms of the future CO2 emission reduction and energy security.

This method is to replace nuclear power including operating, under construction, planned and proposed with coal or LNG based on total power generation and its share.

$$CO_2(Q) = fuel(i) \times ecf(i) \times ccf(i),\ i = \text{Coal } or\ LNG$$

$CO_2(Q)$: CO_2 emission quantity

$ecf(i)$: *energy conversion fact*

$ccf(i)$: *carbon emission conversion fact*

Case 1) Assuming that a 1000MW fossil power plant burns about 2 million tce of coal annually. We can calculate the amount of CO2 emission when a ton of coal is burned as follow.

$$CO_2(Q) = 1\ Ton(\text{Coal}) \times 0.000595\ ToE / Ton \times 1.059 TonC / ToE$$
$$= 0.630\ TonC$$

$ecf(C)$: $0.000595 ToE / kg$

$ccf(C)$: $1.059 TonC / ToE$

Table 7 CO2 emission Due to Replacing Nuclear with Coal

	Total Capacity of Nuclear Power (Operating, Under Construction, Planned and Proposed)	Amount of Coal	CO2 emission (Mil. Ton CO2)
Korea(South)	32,985MW	65.97 million tce	41.56
China	222,971MW	445.942 million tce	280.94
Japan	67930MW	139.46 million tce	87.86

Case2) Assuming that a 1000MW LNG power plant burns about 827,632 tons of LNG a year, we can calculate the amount of CO2 emission of burning one ton of LNG.

$$CO_2(Q) = 1\ Ton(\text{LNG}) \times 0.001175\ ToE/\ Ton \times 0.637 TonC/ToE$$
$$= 0.748\ TonC$$

$ecf(L)$:$0.0011755 ToE/kg$ $(IPCC)$

$ccf(L)$:$0.637 TonC/ToE$

Table 8 CO2 emission Due to Replacing Nuclear with LNG

	Total Capacity of Nuclear Power (Operating, Under Construction, Planned and Proposed)	Amount of LNG	CO2 emission (Mil. Ton CO2)
Korea(South)	32,985MW	27.29944 million ton	20.42
China	222,971MW	184.5379 million ton	138.03
Japan	67930MW	56.22104 million ton	42.05

China is the biggest CO_2 emitter while Japan and Korea are also listed within the world top ten, nuclear power seems to be inevitable choice.

Table 9 Top 11 Countries CO2 Emission 2008(Unit: Mil. TCO2)

Rank	Region/Country/Economy	Total CO_2 emissions from fuel combustion	Percentage (%)	Cumulative Percentage (%)
1	People's Rep. of China	6 508.2	22.15	22.15
2	United States	5 595.9	19.05	41.20
3	*European Union - 27*	*3 849.5*	13.10	54.30
4	Russian Federation	1 593.8	5.42	59.72
5	India	1 427.6	4.86	64.58
6	Japan	1 151.1	3.92	68.50
7	Germany	803.9	2.74	71.24
8	Canada	550.9	1.88	73.11
9	United Kingdom	510.6	1.74	74.85
10	Islamic Rep. of Iran	505.0	1.72	76.57
11	Korea(South)	501.3	1.71	78.27

Source: IEA 2010

IV. Concluding Remarks

In this paper, potential opportunities together with the challenges in the development of nuclear have been discussed in view of long term energy mix in three northeast Asian countries including Korea, China and Japan. Issues identified in this process includes the lessons from Korea and Japan in early 1980's to reduce the energy dependency on overseas energy by diversifying the energy mix in power sector including nuclear power, increasing uranium demand and the sustainable uranium supply for nuclear power generation, the potential needs for nuclear waste disposal and the acceleration of the development of nuclear waste treatment technology, proliferation risk and the measures to prevent that, and nuclear safety and the related enhancement measures. With special consideration on the strong expansion plan of inland nuclear power plants by China, the issuance of "Atomic Energy Law", and the need for strengthened cooperation among three Asian countries have been discussed for future suggestions and recommendation.

There are a variety of international conventions in the nuclear field, to which most OECD countries are party, dealing with such matters as non-protection of nuclear weapons, physical protection of nuclear materials, co-operation and mutual assistance in the event of nuclear accident, nuclear safety and radioactive waste management. It would be necessary to set a 'Northeast Asian Nuclear Council' which may be similar to that of 'EURATOM' in Europe to enhance the cooperation for the safety of nuclear power development.

Currently, the total operable capacity of China, Korea and Japan accounts for 20% of the total of the world, additional reactors under construction and planned will account for almost 32%.Considering the striking ratio, the strengthened cooperation among the three countries is very important, especially in the aspect of nuclear safety, Once a nuclear accident happens in any of the three countries, it will surely affect other Asian countries. The three countries should set an institutional framework to enhance the cooperation for the safety of nuclear power development.

Acknowledgement

This work was supported by the New and Renewable Energy Program of the Korea Institute of Energy Technology Evaluation and Planning (KETEP) grant funded by the Korea government Ministry of Knowledge Economy (No. 20093021020020)

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