CHINA

Jong Seon Kim[1]

1. Background

Before the Fukushima nuclear disaster took place, there were 88 operating nuclear power plants in the three Northeast Asian countries: South Korea, China and Japan. These three Northeast Asian countries were building 37 new nuclear power plants and planning to build additional 204 nuclear power plants. In total, there are 329 nuclear power plants in Northeast Asia, which was expected to become a region with the highest density of nuclear power plants in the world.

When analyzed by country, South Korea has 21 operating nuclear power plants, is building 7 new nuclear power plants and plans to build 4 additional nuclear power plants whereas Japan has 54 operating nuclear power plants, is building 3 new nuclear power plants and plans to build 12 additional nuclear power plants. And China has 13 operating nuclear power plants, is building 27 new nuclear power plants and plans to build 188 additional nuclear power plants, contributing most to the rapid increase of nuclear power plants in Northeast Asia.

China's rapid nuclear development policy had been regarded as China's national matter that has little or nothing to do with the safety of South Korea or other neighboring countries before the Fukushima nuclear accident occurred in Japan. However, countries began to realize that nuclear accident is not just a problem of one country but a cross-border issue that requires concerted global attention. Based on such realization, Northeast Asian countries began to regard China' nuclear policy on building the largest number of nuclear power plants in Northeast Asia in the fastest way as one of the important variables determining the prospects of peace and wellbeing of the Northeast Asian region.

Due to the lack of information on China's nuclear power development, it is difficult to build a good understanding of the current status of China's nuclear development and safety, which in turn makes it hard for us to set up the future direction of nuclear development for the safety of the Northeast Asian region. In this paper, therefore, we look into China's nuclear safety policy and R&D policy in order to have a better understanding of Chinese nuclear development and safety. Specifically, we will first examine the necessity of nuclear development in China and then explore the changing trends of China's nuclear policies and R&D directions in the aftermath of the Fukushima nuclear disaster.

2. The Necessity of China's Nuclear Development

As China's economy has been growing very fast in these few years, the country's demand for energy has also been on the rapid rise. The total amount of energy consumed in China (ten thousand ton/standard coal) rose to 3.48 billion ton in 2011, up from 3.036 billion ton in 2009, and is expected to reach 7.9 and 18.6 billion ton in 2020 and 2030 respectively.[1)] In 2009, China emerged as the world's largest energy consumer, surpassing the US.

Approximately 60% of China's increment in energy demand is fulfilled by coal, because the coal reserves account for 73.2% of the country's total primary energy resources that can be utilized whereas hydropower, oil and natural gas stand at 24%, 1.3% and 1.3% respectively. China's coal reserves account for 12.6% of the world's total, placing it in the third place in the world in terms of total coal reserves and making it a coal exporting country. Nonetheless, the existing coal reserves in China were not sufficient to meet the rapidly increasing demand for energy and the country became a coal importing country from 2009. In addition, most coal reserves are located in

[1]Science and Technology Policy Institute(STEPI), 25 F Specialty construction center 15, Boramae-ro 5ga-gil, Dongjak-gu,395-70, Shindaebang-dong, Seoul, 156-714, Republic of Korea
E-mail:jskim@stepi.re.kr

1) News: China's coal energy consumption is expected to reach 18.6 billion ton by 2030, Beijing S&T Electronic News, Nov. 3, 2010. http://www.cnmn.com.cn/ShowNews1.aspx?id=188932

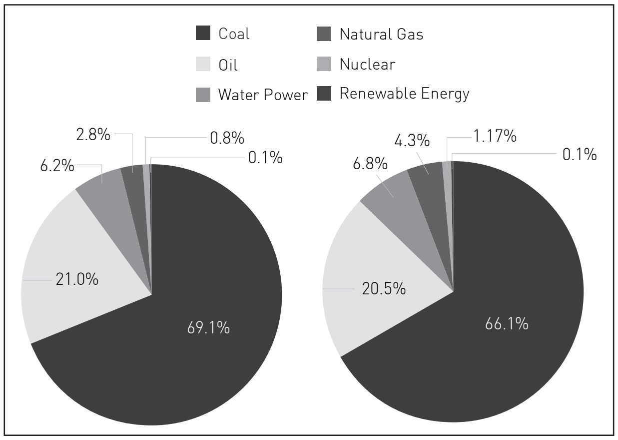
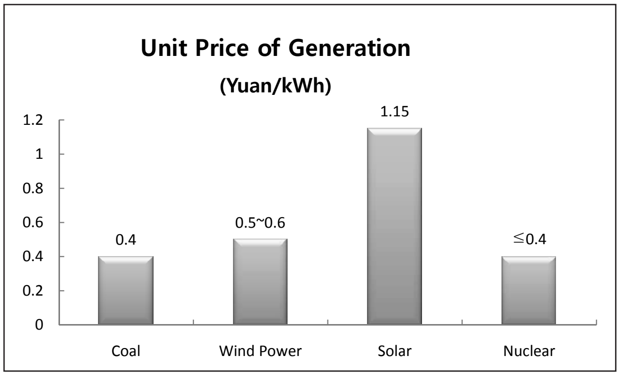


Figure 1 Primary energy consumption in China

the western part of the country while the demand for energy is rapidly picking up in the eastern part where the economy is booming, making it hard to move coal through the country. In short, China is currently at a critical juncture where it needs to secure new alternative energy sources to replace coal so as to overcome the difficulty of moving coal and to strengthen energy security.

Moreover, China gains energy mostly from fossil fuel such as coal, oil and natural gas and it became the world's largest emitter of CO_2 in 2010. As the international convention on climate change was signed to deal with climate change and countries became obliged to reduce greenhouse gas emissions, China



Source: Third-generation nuclear power technology AP1000 becomes a new engine in China's nuclear energy sector, CPI Jiangxi Nuclear Power Co. Ltd., Aug. 15, 2011, http://www.jxnpc.com.cn/ReadNews.asp?NewsID=2659

*Note: Power generation unit price for nuclear power is estimated based on AP1000 reactor.

Figure 2 Power Generation Unit Price by Energy Source

may face increasing pressure due to its heavy reliance on fossil fuel. It can be stated that China is in an urgent situation to find alternative energy sources such as wind power, hydropower, photovoltaic or nuclear power. Among these potential energy sources, wind power, hydropower and photovoltaic energy are unpredictable in energy production because the production of these energies is very sensitive to changes of climate and environmental conditions. On the contrary, nuclear energy is considered as better alternative than wind power, hydropower and photovoltaic energy in terms of technology, cost and energy production control. Therefore, it is highly likely that China would choose nuclear energy as its energy alternative for the future to meet the rapidly increasing energy demand in the country and to reduce the burden on the environment. That is why, in spite of the Fukushima nuclear disaster, China will continue to feel the necessity to develop nuclear energy.

3. Nuclear Policy in China

3.1 Shifting from Large-Scale Development to HighEfficiency Development

In the mid-2000s, the Chinese government recognized nuclear energy development as a realistic alternative to meet the growing energy demand and to reduce greenhouse gas emissions, and enacted a policy to develop large-scale nuclear power plants, which then lead to the establishment of the 2007 Mid-to-Long-Term Nuclear Energy Development Plan. Under such national nuclear development policy and plan, China is expected to expand the capacity of nuclear energy power plants to 40 million kW by 2020. In Feb. 2009, the Chinese government made an upward adjustment to its target capacity of nuclear energy power plants to 70 million kW by 2020.

Since the Fukushima nuclear accident took place in Japan, the Chinese government's nuclear policy shifted its focus from large scale nuclear power development to stable and high efficiency nuclear power development. Such a change in policy stance became obvious when President Hu Jintao emphasized nuclear safety and a sustainable nuclear development

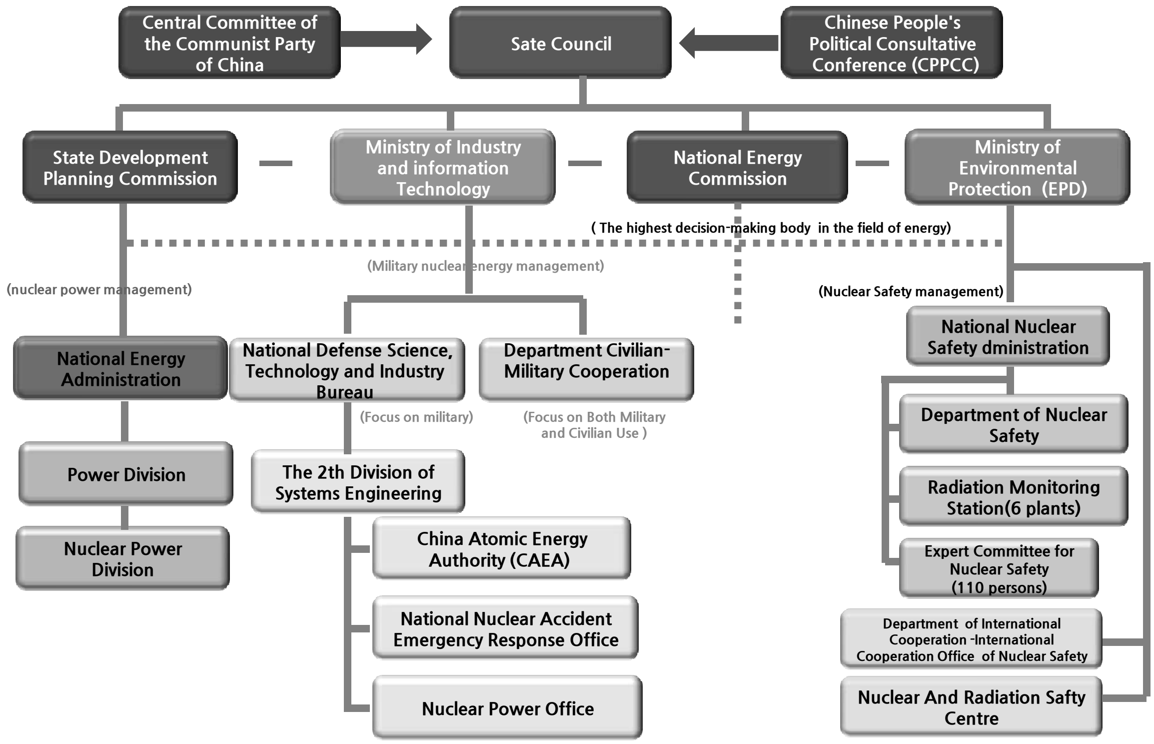


Figure 3 Changes in China's nuclear management system after the Fukushima nuclear disaster

at the Nuclear Security Summit held in South Korea on Mar. 17th, 2012[2)] and when the 2012 Government Report put forth a policy to promote high efficiency nuclear power plant operation. In an endeavor to strengthen nuclear safety, the Chinese government has been implementing policies to strengthen governmental administration related with nuclear energy, to enact relevant laws and standards and to enhance R&D efforts on nuclear safety.

3.2 Strengthening Administration of Nuclear Energy

There are three governmental organizations to manage nuclear energy in China: NEA (National Energy Administration), National Defense Science, Technology and Industry Bureau, NNSA(National Nuclear Safety Administration). NEA governs the activities in the nuclear energy sector; participates in nuclear law and policy making activities; plans the construction of nuclear power plants; establishes and implements technology standards for nuclear power plants; supervise sscience and technology researches at nuclear power plants; and evaluates nuclear power plant management.

National Defense Science, Technology and Industry Bureauis responsible for the use of nuclear fuel circulation outside nuclear power plants and the management of military nuclear facilities; regulations on nuclear fuel; exports and imports of nuclear fuel; international cooperation and communication as an international nuclear energy representative of China; and the establishment and implementation of emergency measures to deal with nuclear accidents.

Lastly, NNSA performs the role of establishing regulations and evaluating technology standards on nuclear materials and nuclear reactor operation; assessing the safety of nuclear installations and managing abilities of operational entities; issuing and canceling nuclear facility safety permit; supervising the safety of nuclear materials and reactor; investigating

2) News: China's coal energy consumption is expected to reach 18.6 billion ton by 2030, Beijing S&T Electronic News, Nov. 3, 2010. http://www.cnmn.com.cn/ShowNews1.aspx?id=188932

Table 1 Expansion of China's nuclear management system after the Fukushima nuclear disaster

NEA (National Energy Administration)	• Elevated the status of Nuclear Power Officeto Nuclear Power Divisionin Feb. 2012.
National Defense Science, Technology and Industry Bureau	• Elevated the status of National Nuclear Accident Emergency Response Office to Nuclear Accident Emergency Response Unit.
NNSA (National Nuclear Safety Administration)	• Expanded the number of a nuclear safety management office to three offices (Sep. 2011). • The first, second and third nuclear and radiation safety supervision and management offices. • Planed to increase the number of nuclear safety supervision officials to 1,000.

negligent accidents and taking the follow-up measures; establishing, implementing and supervising contingency plans to deal with nuclear facility accidents; researching on nuclear installations' safety and management; establishing international cooperation; supervising civilian nuclear materials and the safety of nuclear installations; and mediating in international nuclear safety disputes.

After the Fukushima nuclear disaster occurred in Japan, these three major nuclear agencies in China were expanded in size; NEA (National Energy Administration) elevated the status of Nuclear Power Office to Nuclear Power Divisionin Feb. 2012 while National Defense Science, Technology and Industry Bureau elevated the status of National Nuclear Accident Emergency Response Office to Nuclear Accident Emergency Response Unit. Meanwhile, NNSA, a national agency responsible for nuclear safety, increased the number of nuclear safety management office to one to three offices (the first, second and third nuclear and radiation safety supervision and management offices) in Sep. 2011 and planed to increase the number of nuclear safety supervision officials to 1,000 down the road.

3.3 Complementing the Existing Nuclear Safety Policy

In addition to expanding the size of organizations, the above mentioned three nuclear institutions in China have been exerting their best effort to enact polices to strengthen nuclear safety. First, NNS Aestablished the Nuclear Safety Plan[3)] and submitted it to the State Council of China in Feb, 2012. NEA (National Energy Administration) also made the Nuclear Power Plant Safety Plan and the Revised Mid-to-Long-Term Nuclear Power Plant Development Plan and is expected to submit them to the State Council of China. So far there are no confirmed plans submitted from those agencies.

Table 2 Enactment of nuclear safety policy in China

Nuclear Safety Plan	• Proposed by NNSA (National Nuclear Safety Administration) • Status: NNSA submitted it to the State Council of China in Feb 2012.
Nuclear Power Plant Safety Plan	• Proposed byNEA (National Energy Administration) • Status: The draft version is made and it is expected to be submitted to the State Council of China sooner or later.
Revised Mid-to-Long-Term Nuclear Power Plant Development Plan	• The draft proposed by NEA (National Energy Administration) • Status: The draft version is made and it is expected to be submitted to the State Council of China sooner or later.

*Note: Nuclear Safety Plan was submitted to the State Council of China in Feb. but is not approved yet because a lot of details need to be examined.

3) Nuclear Safety Planrefers to the Five-Year Plan on Nuclear Safety and Radioactive Pollution Prevention and the 2020 Vision. This plan is aimed at promoting a sustainable use of nuclear installations and technologies in a safe and sound manner through supervision and management and reducing the danger of radioactive pollution, thus ensuring nuclear safety, environmental safety as well as the safety of citizens. This plan also clear stipulates concrete obligations and measures related to nuclear development, reactor, and fuel circulation, use of nuclear technologies, nuclear safety facilities, uranium treatment and early processing of nuclear facilities (http://money.163.com/11/1214/01/7L6SIEEM00253B0H.html).

3.4 Strengthening Nuclear Safety Laws

In China, the Atomic Energy Act was first drafted in 1984 but failed to be made into the official law because of conflicting opinions among relevant institutions and limited influences of nuclear safety organizations. The coordination of conflicting opinions is still underway and that is why there is no national basic atomic energy law encompassing all nuclear related issues such as nuclear energy production, utilization and safety management. The only national level law on nuclear issues is the Radioactive Pollution Prevention Act enacted in 2003 while there are 8 administrative regulations, 27 industrial regulations and 6 local laws.

The Chinese government realized the importance of establishing the nuclear safety system after the Fukushima nuclear disaster and has been making efforts to strengthen and revise the laws and regulations related to nuclear energy development. For instance, the Chinese government is striving to enact the Atomic Energy Act to govern all issues related to nuclear power development with the particular emphasis placed on nuclear safety, security and safety guard. However, the prospect of enacting the Atomic Energy Act doesn't seem rosy as there are still prolonged conflicts of opinions between different government institutions.

In addition to making systematic efforts to improve the country's laws governing nuclear energy development, the Chinese government strengthened its safety system on radioactive waste in Mar. 2012. Specifically, it implemented the Radioactive Waste Safety Management Ordinance to strengthen the safety

Table 3 China's Laws on nuclear energy

National Law (1)	• 2003: 「the Radioactive Pollution Prevention Act」
Administrative Regulations(8)	• 1986: 「Civilian Nuclear Facility Supervision & Management Regulations」 • 1987: 「Nuclear Material Regulations」 • 1993: 「Nuclear Power Plant Emergency Management Ordinance」 • 1997: 「Nuclear Export Regulations」(Revised in 2006) • 1998: 「Nuclear Dual-Use Items and Related Technologies Export Control Ordinance」 (Revised in 2007) • 2005: 「Radioisotopes and Radiation Safety and Protection Regulations」 • 2007: 「Civil Nuclear Safety Equipment Supervision and Regulation」 • 2009: 「Radioactive Materials Transportation Safety Regulations」
Sector Regulations(27)	• 1991: 「Nuclear Power Plant Site Selection of Safety Regulations」 • 2004: 「Nuclear Power Plant Design and Safety Requirements」 • 2004: 「The provisions on the Safety of Nuclear Power Plant Operation」 • 2005: 「Radioisotopes and Radiation Safety License Management Approach」
Other Laws & Regulations	• 2004: 「The Interim Measures on Registration and Management of Nuclear Safety Engineer」 • 2005: 「The Interim Measures on Continuous Tranningfor Nuclear Safety Engineers」 • 2005: 「The Classification of Radioactive Sources」
Local Laws(6)	• 1994: 「Security and Environmental Regulations of the Restricted Zones ofDaya Bay Nuclear Power Plant」 • 1996: 「Guangdong Province Environmental Regulations on Nuclear Power Plants」 • 1997: 「Guangdong Province Nuclear Accident Prevention and Emergency Management Regulations for Civilian Nuclear Facilities」 • 2002: 「Zhejiang Province Radiation Environmental Protection Ordinance for Nuclear Power Plants」 • 2003: 「Shandong Province Radiation Environment Management Approach」 • 2007: 「Jiangsu Province Radiation Pollution Prevention and Control regulations」
International Convention(8)	• 「Convention on Nuclear Safety」 • 「The Joint Convention Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management」 • 「The Convention on Early Notification of a Nuclear Accident」 • 「The Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency」 • 「The Convention on the Physical Protection of Nuclear Material」

Source : CNEIC (China Nuclear Energy Industry Corporation)(2012), "the Absence of the Legal System in China", China's Nuclear Industry, 2012, 1.

supervision on radioactive waste treatment, storage and disposal, which successfully resulted in boosted safety in nuclear waste treatment, storage and disposal. The Radioactive Waste Safety Management Ordinance also strengthen safety of nuclear waste management by specifying measures to complement approval, storage and disposal system on solid nuclear waste treatment, approval standards and procedures, selection and construction procedures for nuclear waste repository as well as safety measures to be implemented after closing nuclear facilities.

3.5 Complementing Nuclear Energy Standards

In China, nuclear energy technologies and reactors were first introduced from foreign countries. Then, the country studied and researched foreign nuclear energy technologies to build its own nuclear technologies. That is why China's nuclear technology standards are somewhat inconsistent with each other. Domestic reactors at Taishan 1 and Taishan 2 nuclear power plants and Canadian reactor in Taishan 3 nuclear power plant were built based on the US ASTM (American Society for Testing Materials) standards while 3 Russian reactors at Daya Bay nuclear power plants were built based on the Russian standards. Other nuclear reactors in China were built in accordance with the French nuclear development standards. Therefore, it would be difficult for the Chinese government to make swift and systematic measures to deal with nuclear accidents because different standards were applied to many different reactors. Hence, the Chinese government is striving to enact the uniform national nuclear energy development standards to prepare for possible nuclear accidents and is in the process of revising the existing standards with the particular emphasis on the second generation advanced reactor and third generation Passive Pressurized Water Reactor (PWR) reactor based on potential problems raised in the aftermath of the Fukushima nuclear accident.

4. Nuclear R&D Trends in China

China is reported to have high levelbasic nuclear technologies while its nuclear energy commercialization technologies are regarded relatively low level. This paper looks into the R&D trends on nuclear energy commercialization technologies in relation with nuclear safety.

4.1 The Future Direction of China's Nuclear R&D Efforts for the Next Ten Years

Most nuclear reactors that are in operation or under construction are the second generation advanced reactor while all the third generation reactors are under construction. A total of 6 third generation reactors including – 4 reactors in Sanmen and Haiyang built based on the third generation AP1000 technology, 2 reactors in Taishan built based on EPR technology - are currently under construction. Under such circumstances, China has been stepping up its effort to strengthen the existing nuclear technologies required for the second generation reactors while introducing and localizing the third generation reactor technologies.

The 12.5 Plan for National Energy Technology Development released in Dec. 2011 highlights the R&D programs in the energy technologies' area. According to the plan, China is planning to focus its R&D investment and effort on developing the third generation pressurized water reactor, promoting verification of experimental fast reactor, studying fast nuclear reactor technologies, developing 200MW high-speed gas-cooled reactor technology, researching versatile modular small reactors and fusion reactors, nuclear fuel cladding tube, nuclear spent fuel management as well as developing high-level waste treatment and disposal technologies.

4.2 R&D Efforts to Inspect and Complement Safety of the Existing Nuclear Power Plants

China put a hold on its effort to expand the size of nuclear power plants after the Fukushima accident and began to conduct a large-scale safety inspection program on nuclear power plants and installations. To that end, NNSA under the Ministry of Environment Protection of China established the National Nuclear Power Plant Inspection Team in collaboration with NEA and China Seismological Bureau.

The National Nuclear Power Plant Inspection Team investigated whether the operating nuclear power plants were built in accordance with the initial plans and standards[4], the difference between the standards applied to the existing operating nuclear power plants and the current nuclear power plant construction standards and the problems that need to be resolved in relation with the issues raised in the Fukushima nuclear accident. As a result of safety inspection, 14 issues were pointed out as the problems that need to be improved or addressed. The issues related to a mobile power machine and pump expansion were already addressed while other issues related to developing the flooding prevention system and writing and complementing emergency response guidelines are expected to be solved within the next two to three years.

Major nuclear safety issues were pointed out by nuclear experts and the national R&D efforts are currently being made to solve those issues. The six major nuclear safety issues raised by experts are as follows:

1) Enact nuclear power plant design standards to prevent complex disasters (e.g. tsunami, earthquake, flooding)
2) Prevent flooding
3) Strengthen availability and diversity of power supply system in case of disasters
4) Install the hydrogen explosion prevention equipment
5) Install radioactive filter in nuclear containment and develop spent fuel cooling technology
6) Establish emergency response system

4.3 Expanding R&D Programs on Nuclear Safety

Starting from Feb. 2012, NEA has begun to implement technology development plans to enhance safety and disaster/emergency response abilities of China's nuclear power plants with the particular emphasis on issues raised in the aftermath of the Fukushima nuclear accident in Japan.[5] The China National Nuclear Corporation (CNNC), China Guangdong Nuclear Power Group, Tsinghua University and other nuclear power and new renewable energy R&D institutes were involved in this plan. Thirteen major tasks were selected through the first round of the project.

1) R&D on Passive Emergency Power Supply and Cooling Water System
2) R&D and Experimental Verification on the Prevention and Mitigation of Severe Nuclear Power Plant Accidents
3) Analysis of the Earthquake-Resistant Design Beyond Design Standards and Strengthening of Earthquake-Resistance Capacity of China's Second-Generation Advanced Reactors
4) R&D on External Flooding of Nuclear Power Plant Beyond Design Standards and Prevention and Mitigation Measures for Spent Fuel Meltdown
5) Analysis on Risks of Complex Disasters and Response Measures (Qinshan and Daya Bay Power Plants)
6) Development of Disaster Mitigation Equipment and System to Prepare for Disasters
7) R&D on Extreme Accident Simulation Platform and Hydrogen Control Device
8) R&D on Rescue Robot to Prepare for Serious Accidents
9) R&D on Passive Containment Heat Export System and the Secondary heat Export System
10) R&D on Low-Altitude Fast Measurement Technology for Radioactive Contamination in Large-Scale Nuclear Power Plant Accident
11) R&D on Monitoring and Radiation Protection of Radioactive Materials in Nuclear Accidents
12) R&D on Emergency Treatment Technology and Processing Methodology for Radioactive Wastewater in Nuclear Accidents

4) China's standards on nuclear power plant have undergone constant change.
5) News: Assurance on the nuclear safety by Chinese nuclear energy experts. Ifeng, Mar. 5, 2012, http://news.ifeng.com/gundong/detail_2012_03/05/12975001_0.shtml?_from_ralated

13) R&D on Emergency Repair Technology for the Radiation-Contaminated Environment in Nuclear Accident

In addition, the Chinese government has strengthened its support for researchers in the nuclear safety sector. Recently, the National Nuclear Power Plant Safety and Reliability Process Technology Research was launched as China's central process technology R&D institute[6] related to nuclear safety under the Suzhou Thermal Engineering Institute of the China Nuclear Power Technology Research Institute[7]. Considering the fact that there had been only two China's central process technology R&D institutes, National Isotope Process Technology Research Center (China Institute of Atomic Energy)[8] and China Academy of Engineering Physics, in nuclear area in China, we can easily conclude that the country needs to expand its R&D efforts on boosting nuclear safety. The newly-launched National Nuclear Power Plant Safety and Reliability Process Technology Research Centeris focused on conducting R&D programs which deal with analysis on nuclear safety, evaluation technologies, analysis on the effects of nuclear power plants, emergency measures, development of technologies to boost reliability of core facilities, development of maintenance & repair optimization technologies and reliability tests as well as the evaluation and management of life-cycle of nuclear power plants.

4.4 Fostering Nuclear Safety Experts

China lacks nuclear experts and there are about 51,000 experts on nuclear power plant construction, design, operation, maintenance and repair according to the survey conducted by the China National Nuclear Corporation (CNNC) in 2010. Specifically, the China National Nuclear Corporation (CNNC) has 18,000 nuclear experts while the China Nuclear Engineering and Construction Group (CNEC) and China Guangdong Nuclear (CGN) have 15,000 and 12,000 nuclear experts respectively. The above figures indicate that the country significantly lacks adequate human resource in nuclear sector. In particular, there are no sufficient numbers of experts in the fields of fast reactor, post-treatment process, radioactive waste disposal, uranium ore mining and smelting, nuclear safety, and radiation protection. Furthermore, compared with other countries with nuclear power plants where about 35 nuclear safety inspection officials are dispatched to one nuclear facility, the Chinese nuclear facility only has about 24 nuclear safety inspection officials, highlighting a severe lack of nuclear safety inspection and management experts in the country.

China has been engaged in various efforts to nurture sufficient number of nuclear energy experts in the fields. Notably, China's Ministry of Science and Technology, the Ministry of Education, Chinese Academy of Sciences, and China Nuclear Power Group jointly announced a plan to foster 2,000 nuclear fusion experts in the next 10 years in the science and engineering of magnetically confined nuclear fusion related to the international nuclear fusion experiment projects. So far, no specific measures for talent development have been revealed yet.

5. Conclusions

We have examined China's nuclear policy and R&D trends in the aftermath of the Fukushima nuclear accident. We found out that China shifted its policy direction from building large-scale nuclear power plants to promoting nuclear safety and has been engaged in various policy efforts to ensure nuclear safety. China's such efforts are expected to contribute to boosting nuclear safety in Northeast Asia.

However, China's major nuclear institutions have

6) China's central process technology R&D institute plays a significant role in China's national science development plan as it provides comprehensive science R&D services based on its advanced science technology base, facilities and human resources and works closely with relevant companies to create a virtuous cycle of science development efforts.
7) National Energy Administration, 2011, http://www.nea.gov.cn/2011-04/27/c_131072475.htm)
8) It is focused on R&D programs and production of radioactive isotopes. It is the largest isotope R&D and production center in China, produces various products and is capable of producing both reactors and accelerators.

so far failed to reach consensus on the direction of nuclear energy development in the country. The China National Nuclear Corporation (CNNC) argues that China should develop its own third generation pressurized water reactor technologies whereas China Guangdong Nuclear (CGN) insists that the country should introduce French nuclear technologies first and learn from them, and the State Nuclear Power Technology Corporation (SNPTC) argues that the country should introduce American Western House's technologies first. Such conflicting opinions on the future direction of nuclear energy technology development make it hard for China to establish the uniform directions for the country's technology development, nuclear standards and basic act on nuclear energy development. What is worse, they are likely to act as a drag hindering the country's efforts to strengthen nuclear safety. Therefore, China should first coordinate such different opinions of the country's major nuclear institutions to set the systematic future direction of nuclear development.

Lastly, China suffer from lack of nuclear experts in nuclear fields and therefore it is essential for the country to nurture more nuclear experts in order to ensure nuclear safety in the coming years.

Since it takes a long time to foster new experts, China should consider the possibility of promoting international cooperation programs to help nurturing nuclear experts in a broad endeavor to promote nuclear safety in the Northeast Asian region.