Status of Chinese NPP Industry and Nuclear Fuel Cycle Policy

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1. Introduction

With all attention about the media focusing on North Korea's nuclear tests and Iran's alleged intention to pursue a nuclear weapons program, a great interest in nuclear energy has been renewed around the world and China is no exception. China has been developing Nuclear R&D since 1950s that is gradually covered the expertise in both importation and exportation of Nuclear Power Plants(NPPs). China still extended their experiences to both domestic and overseas so far. Chinese State Council approved its "Medium and Long-term Nuclear Power Development Plan" in November 2007, indicating further definition for nuclear energy as indispensable energy option and future self-reliance development of nuclear industry [1].

China intends to become self-sufficient not only in NPPs capacity, but also in the fuel production for all those plants. There are currently 17 NPPs in operation, and 28 NPPs under construction. However, domestic uranium mining supplying is currently less than a quarter of nuclear fuel demands [2].

This paper investigated and summarized the updated status of NPP industry in China and Nuclear Fuel Cycle(NFC) policy. There still remain a number of technical innovation and comprehensive challenges for this nuclear developing country in the long-term, but its large ambitions and dramatic improvements toward future should not be ignored.

2. Why NPP industry attracts China extremely?

2.1 Electric energy consumption

The total electric power consuming of China in 2011 is about 4.69×106GW/hr, which is 11.7% increased compared to the last year. Additionally, the increasing electric power consuming of western China is much higher than eastern coastal areas, and the demand for energy is increasing rapidly up to more than 10% annually. The total energy consumption of China is expected to be closed to US in 2020 as shown in Fig. 1.

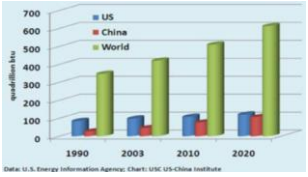

Fig. 1. World total energy consumption

Fig. 2 shows the trends of electricity generation in China.

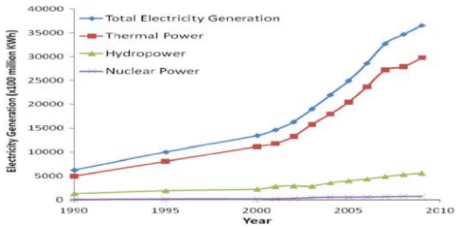

Fig. 2. The total electricity generation situation in China

More than 50% raw coal is consumed by thermal power plants, and more than 45% sulfur dioxide and 30% national emissions of carbon dioxide are also emitted by the thermal power plants [1]. The coal-dominated energy consumption structure is one of the obvious features in Chinese energy supply, and also appears to be the biggest obstacle to the development of low-carbon economy. Nowadays, China becomes the world's second largest emitter of energy-related CO_2 gas. Therefore, making updated policy of energy and environment utilizing renewable energy becomes the top priority in this breakneck economic growth-country. Nuclear energy will be realistic selection for China in terms of its reasonable clean energy.

2.2 The prosperity and development of NPP construction in China

Though China now claims to be a "uranium-rich country" on the basis of some two million tonnes of uranium, uranium resources were inadequate for the country's needs [2]. Uranium is increasingly being imported from Kazakhstan, Namibia, Niger and Australia. Table 1 shows the current uranium mines in China.

Table. 1. Current Operating uranium mines in China

Mine	Province	Type	Nominal capacity (tU/year)	Started
Fuzhou	Jiangxi	Underground, mill	500	1966
Chongyi	Jiangxi	Underground, heap leach	300	1979
Yining	Xinjiang	In-situ leach(ISL)	500	1993
Lantian	Shaanxi	Underground, heap leach	100	1993
Benxi (&Ginglo)	Liaoning	Underground, heap leach	220	1996 &2007
Shaoguan	Guangdong	Underground, heap leach	200	2008
Total*			1820	

*including new capacity at first three, and China National Nuclear Corporation (CNNC) is the only current supplier of domestic uranium

The nuclear total electricity power capacity of China by the end of 2011 is about 1056GWe, meanwhile the nuclear power capacity is around 12.57WGe as shown in Fig. 3 and electric power output

is about 87,400GWh with 1.85% proportion. 41 NPP units with 41.77GWe will be up to 2015.

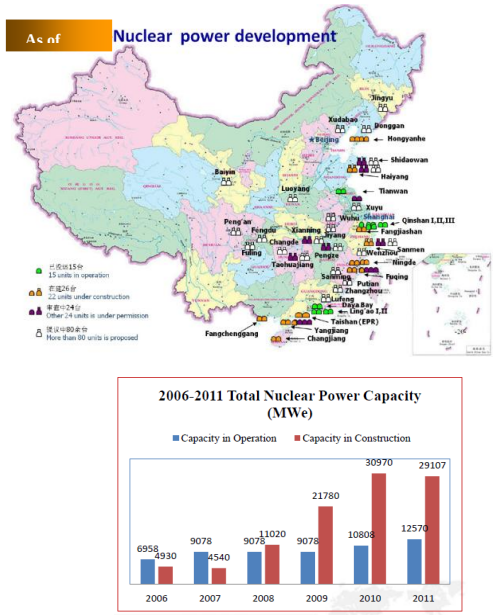

Fig. 3. Current Chinese NPP statistics [2][4]

Nowadays, NPP construction scale of China ranks the first (26/63) in the world, is about 41%. NPP capacity of operation is expected to reach above 40 GWe by the end of 2015 and about 6 large commissioning units will increase per year from now then. All those will be almost comparable to US nuclear power development in last 70 's. Up to now, all operating NPPs have good performance without abnormal nuclear events happened. In addition, the China Experimental Fast Reactor (CEFR) is grid-connected and produces 20 MWe per year[6].

3. Chinese Nuclear Fuel Cycle Policy

3.1 Current spent fuel storage in China

The amount of accumulated spent fuel generated from Chinese reactors from 1991 to 2005 is approximated to 1100 tonnes[4]. Until 2020, the estimated amount of spent fuel will reach to 6579 tonnes by calculating the mass of fuel loaded in one PWR reactor annually. Table 2 shows the current status of storage facilities in China.

Table 2. The current and planed storage capacities in China

The current status of spent fuel storage at nuclear power plants in China.

NPP name	Unit no.	Date of first connection to the grid	Spent fuel storage method	On-site spent fuel storage capacity (years)	Year when storage capacity is expected to fill up
Qianshan		12/15/1991	Dense-pack wet Pool size expansion	35	2025
Daya Bay	Unit 1	08/31/1993	Wet storage	10	2003
	Unit 2	02/07/1994			2004
Qinshan Phase II	Unit 1	02/06/2002	Dense-pack Wet storage	20	2022
	Unit 2	03/11/2004			2024
LingAo	Unit 1	02/26/2002	Dense-pack	20	2022
	Unit 2	09/14/2002	Wet storage		2022
Qinshan Phase III	Unit 1	11/19/2002	On-site wet/ dry storage	40	2042
	Unit 2	06/12/2003			2043
Tianwan	Unit 1	05/12/2006	Wet storage	20[a]	2026
	Unit 2	05/14/2007			2027

[a] Newly planned reactor designs include a 20 year on-site spent fuel storage capacity.

3.2 Reprocessing plants plan

After Fukushima nuclear accident, China slowed down and postponed the operation of new NPP approvals including the construction of two reprocessing plants as shown in Table 3.

Table. 3. Reprocessing plants plan in China

Site	Plant	Operation time	Capacity(tHM/y)		Constuction time
			Present	Future	
Hongtasi	RPP LWR	2025	0	550	2011
Lanzhou	CRP LWR (With Areva)	2020	100	800	50 tHM/y pilot-scale plant's hot test in 2010

A pilot-scale MOX fuel fabrication plant using the Purex process facility with an annual capability of 0.5 tonnes is under construction. China plans to construct a commercial MOX fuel fabrication site by 2020, which couples with the proposed commercial reprocessing plant. CIAE has showed two 40 tonnes/year MOX plants in operation by about 2018.

4. Conclusions

As shown in this paper, the most suitable approach for China to achieve both environmentally-friendly power supplying and increasing energy demands meeting simultaneously must be considered. Nuclear energy now was recognized as the most potential and optimal way of energy supply system. In addition, to accommodate such a high-speed NPP construction in China, it should also focus on when and how spent nuclear fuel should be reprocessed. Finally, the nuclear back-end fuel cycle policy should be established, taking into accounts of all costs, uranium resource security, spent fuel management, proliferation resistance and environmental impact.

REFERENCES

[1] Country Analysis Briefs: China, Energy Information Administration, U.S. Department of Energy, available at: <http://www.eia.doe.gov/emeu/cabs/index.html>

[2] World Nuclear Association, 2013. Nuclear Power in China. Available at: <http://www.world-nuclear.org/info/Country-Profiles/Countries-A-F/China--Nuclear-Power/>

[3] World Nuclear Association, 2013. China's Nuclear Fuel Cycle. Available at: <http://www.world-nuclear.org/info/Country-Profiles/Countries-A-F/China--Nuclear-Fuel-Cycle/>

[4] Yun Z., China's spent nuclear fuel management: Current practices and future strategies, Energy Policy 39 (2011) 4360-4369.

[5] Uranium 2011: Resources, Production and Demand, "Red Book", OECD Nuclear Energy Agency and International Atomic Energy Agency (2012).