QUICKEN THE PACE OF DEVELOPING NUCLEAR ENERGY IN CHINA

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ABSTRACT

China is facing the challenging problems in both the potential energy resource shortage and the serious environmental pollutions. The author suggests that nuclear energy could play an important role for ensuring the long term energy security in China. The technical problems to be solved for the sustainable development of nuclear energy in China are also discussed and the R&D work in next 20 years are briefly suggested to meet the requirements of nuclear energy development in China.

INTRODUCTION

The energy security is the foundation for developing the national economy and ensuring the national security. With the drastic increase of China's oil and gas consumptions since mid 1990s, China is becoming more and more dependent on energy imports such as oil and gas, and the major source of oil imports is the Middle East, the most unstable area in the world. The Iraq war has aroused the people to pay attention to the potential energy crisis in China.

2 .CHALLENGES TO CHINA'S ENERGY SECURITY

China's energy security is facing to two big challenges. The first one is the contradiction between the ever increasing demands of the country's energy and the shortage of the reserves of the fossil fuels. Presently, China's per capita energy consumption is only 1 tce/a, which is about half of the world average. According to the goal of our national development, China's GDP would be doubled twice to US$4000 Billion by the year 2020. To achieve this goal, the nation's total energy demand is expected to be 2.45 Btce/a by that time and the power generation capacity needs to be increased to 800~850 GWe from the present 350 GWe.. However, published data shows that China's per capita reserves of fossil fuels are much low than the world average (.See Table 1).

Table 1 China's per capita exploitable reserves of fossil fuels

fuel	Per capita reserves	Compared to the world average	Compared to the USA
coal	90 t	2/3	1/10
oil	2.6 t	1/9	1/5
gas	1074 m^3	1/23	1/16

The second challenge comes from the irrational energy structure of which coal covers 60% of the primary energy and 75% of the power generation. The coal based energy structure causes serious problems of environmental pollution and emission of green house gases. China has become one of the most polluted countries in the world. In 2000, China emitted 20 Mt of SO2 and 3 Gt of CO2 , both ranked the world No.2. Data published by the World Bank in 2001 show that of the 20 world's most polluted cities 16 are in China! The economic loss by environmental pollutions accounts for 3~7% of GDP in China. These problems would hinder the further development of the country if they could not be solved properly..

Owing to the rapidly increasing demand of oil and gas, the situation that China's economy is heavily dependent on oil and gas imports can never be reversed. Data shows that in 2002 China's oil output was 167 Mt/a while the imported oil was 70 Mt. It is estimated that in 2020, China's oil demand will be ca 400 Mt and nearly 300 Mt will depend on import. However, the oil supply from the Middle East is basically controlled by the US, and the long oil transportation line in the sea is quite unsafe. Facing this severe situation, some people suggest to practise the multi-channel imports and to establish the national strategic reserves of oil. These measures may be effective to alleviate some problems in few decades. But, considering the fact that the oil and gas reserves in the earth will be depleted in less than 100 years, we have to adjust from now on the energy structure in China, gradually reducing the sectors of coal, oil and gas and increasing the sectors of new energy resources.

Among the alternative energy resources, hydro power resources, as the renewable and clean energy resources, are abundant in China and will be exploited with top priority. In China, the estimated exploitable hydro power resources are 526 GWe, which is equivalent to 700 Mt standard coal per year. At present, the installed capacity of hydro power is 83 GWe.

The non-hydro renewable resources, such as solar, wind, biomass energies, are under development and could not replace the fossil fuels in a large scale in the foreseeable future owing to their low energy density, intermittent supply and high cost.

Nuclear energy is another clean energy which can replace the fossil fuels other than the hydro power resources. There is a big space for the development of nuclear energy in China.

3. PREDICTION OF NUCLEAR POWER DEVELOPMENT IN CHINA

By June 2003, China's total operating capacity of nuclear power was 6.1 GWe. Another 3 units with the total capacity of 2.6 GWe are under construction and 4 units of 4.0 GWe are planned to be built.

As mentioned above, the total power capacity by 2020 is expected to be increased to 800~850 GWe from the present 350 GWe. It is estimated that even if the fossil energy and hydro power are fully exploited, there will still be a gap of 32~40 GWe, which must be filled with nuclear power. Therefore, China's nuclear power capacity would be at least 32 GWe by 2020, which would covers 4% of the total electric capacity of the country. To achieve this goal, 2~3 units of 1 GWe would be started to construct from now on. The nuclear share would be further increased to 120~240 GWe, about 10~20% of the total capacity, by the mid of the 21 century, making nuclear energy as one of the three major energy resources in China other than the cleaned coal-burning and hydro powers.

China will develop thermal reactor power plants and the associated fuel cycles within 30 years. Fast reactors and the fuel cycles will begin to be deployed 30 years later. Based on the present commercial PWR, the thermal reactor power plants will realize localization and standardization. The planned 12~18 units to be built before 2010 are considered to use Gen-II+ reactors.

The accumulation of the spent fuel will be approaching 10000 t. So, a commercial reprocessing plant with the capacity of 800~1200 t/a and a MOX fuel fabrication plant will need to be built around 2020.

In order to start to deploy the fast reactor system by 2030, we must have the capability of designing the commercial fuel cycle systems for the fast reactors around 2030.

It is estimated that by 2020, the accumulated minor actinides (MAs) and long-lived fission products (LLFPs) in spent fuel will be 7 t and 11.2 t respectively. For the sustainable development of nuclear energy, partitioning-transmutation (P-T) are needed to completely burn the MAs and LLFPs and minimize the volume of high level waste..

In the future, the production of hydrogen by nuclear energy will greatly expand the applications of the nuclear energy.

4. EXPECTED R&D WORK ON NUCLEAR ENERGY SYSTEM IN 20 YEARS

In the past few decades, less attention was paid to the technology development of nuclear energy system in China. As a result, the technology basis of nuclear energy system is rather weak compared to the world advance level. In the thermal reactor energy system, our fuel cycle (especially in the back-end) is far from closed. In the fast reactor energy system, we just focused on the reactor itself. Our P-T studies are at the very early stage. In order to meet the requirements of the rapid development of nuclear energy in China, the following R&D work should be done:

4.1 THERMAL REACTOR ENERGY SYSTEM

Based on the present PWR, great efforts must be made to realize the localization and standardization of the commercial nuclear power system.

Development of Gen-III reactors, which would be deployed after 2010~2015.

R&D work on spent fuel reprocessing to provide technical support to the pilot plant for its safe, reliable and stable operations;

Technology preparations in processes, equipment and control systems for the commercial reprocessing plant;

Technical preparations for the MOX fabrication plant with the complete design parameters;

Basic studies on the pre-selected sites and the key nuclides' behaviors for the final geological disposal of high level radioactive waste.

4.2 FAST REACTOR ENERGY SYSTEM

The development of China's fast reactor energy system will follow the three phase strategy. The first phase is to build the China Experimental Fast Reactor (CEFR) with the capacity of 65/20 MWt/MWe, which is expected to be critical by 2005. The second phase is to design and build the China Prototype Fast Reactor (CPFR), which would be built by 2020. The third phase work is the construction of China Demonstration Fast Reactor (CDFR), which would be put into operation by 2025.

With the goal to start commercialization of fast reactor energy system from 2030, R&D on the fast breeder reactor fuel cycle, including the spent fuel reprocessing and fuels (MOX or metal alloy), must be carried out simultaneously to achieve the on-site fuel cycles.

4.3 PARTITIONING-TRANSMUTATION

There will be a long way to go before the commercialization of P-T of MAs and LLFPs. We will trace the international trends in this area and continue to do the basic researches with ADS or fast reactor.

5. SUMMARY

China's energy security is facing to two big challenges. The first one is the contradiction between the ever increasing demands of the country's energy and the shortage of the reserves of the fossil fuels. The second challenge comes from the irrational energy structure. The coal based energy structure causes serious problems of environmental pollution and emission of green house gases.

Nuclear energy is the clean energy which can replace the fossil fuels in a large scale other than the hydro power resources. There is a big space for the development of nuclear energy in China.

China's nuclear power capacity would be at least 32 GWe by 2020, which would covers 4% of the total electric capacity of the country. The nuclear share would be further increased to 120~240 GWe, about 10~20% of the total capacity, by the mid of the 21 century, making nuclear energy as one of the three major energy resources in China.

R&D work on thermal reactor energy system will be the development of Gen-III reactors and the associated close fuel cycles including the spent fuel reprocessing and the MOX fuel fabrication.

R&D work on fast reactor energy system will follow the three phase strategy, CEFR, CPFR and CDFR and the on-site fuel cycles.