Energy Outlook and Nuclear Energy in China

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1. Introduction

The world seems to be in trouble to make a balance among Economy, Energy and Environment (3Es). These 3Es conflict each other, as we need energy to develop our economy resulting environmental pollution as well. It is so called tri-lemma of 3Es [1].

China receives attention from the whole world as not only have they become a country spending the most energy in the world [2], but also the amount of energy they need is still increasing. Consequently, many problems related to environmental pollution have occurred in China.

Recently, China agreed to reduce carbon emission in order to deal with this issue. Therefore, they need to find energy sources other than fossil fuel; the nuclear energy could be an alternative. In addition, it is considered to be a base load owing to its low fuel cost and continuation of electricity generation. In reality, the Chinese government is planning to build about 400 Nuclear Power Plants (NPPs) up to 2050.

Therefore, it is expected that China will become a giant market in the nuclear industry. It could give us either chances to join the huge market or challenges to meet not merely nuclear fuel price crisis but competitors from China in the world nuclear power plant market. In any case, it is obvious that the energy policy of China would influence us significantly. Accordingly, we need appropriate prediction of the Chinese nuclear industry to cope with the challenges.

In this paper, we developed a simple methodology to predict energy consumption and electricity generation in China up to 2050.

2. Methods and Results

All data of population, GDP, energy use per capita, and electricity generation per capita used are obtained from World-Bank [3].

### 2.1 Basic assumptions and the comparison group selection.

Since 1970, a few researches have been reported to explain the relationship between economic growth and electricity generation [4]. Therefore, reasonable estimation of Chinese GDP growth in the future would give us either concrete prediction or, insight of outlook of energy consumption and electricity generation trend in China.

Avoiding complex procedure taken in the previous researches, we assumed that the development aspects of China would be comparable to the one of Korea and Japan owing to the similar feature of their culture and economic structures. In addition, it is assumed that hosting the Olympics would be a good reference point to compare the three countries. We also added the US as one of comparison group, because it is considered the two of world leading country with China, so called G2.

2.2 GDP prediction
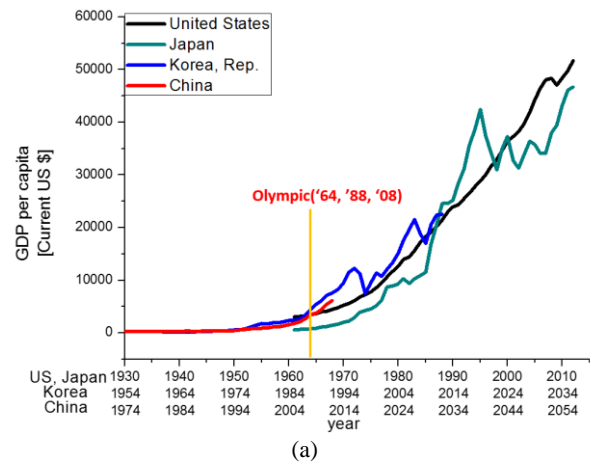
(a)
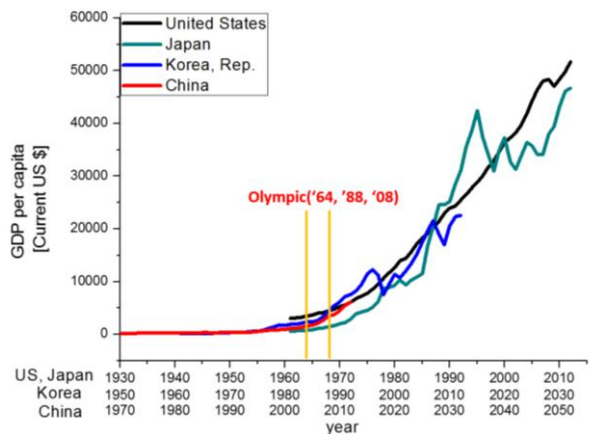
(b)

Fig. 1. GDP per capita in 4 countries plotted with time gaps of their development (a), based on the Olympic hosting year, (b), with time gaps of 20 years.

Based upon the assumptions postulated in section 2.1, we drew a GDP per capita with matching the reference

point, the Olympics in the three countries, and it shows fairly good agreement (Fig. 1a).

After slight rearranging time scales for the better agreement, which are 20 & 40 years gap for Korea and China to Japan, respectively (Fig. 1b), we could identify that the trends of GDP per capita in the Asia countries are close to the one of US. Consequently, it could be a reasonable approach to use the GDP per capita data of US obtained up to 2010 as a prediction of Chinese GDP per capita data up to 2050 with 40 years of delay. According to the prediction, it is expected that the Chinese GDP per capita will reach about current US $50,000 in 2050.
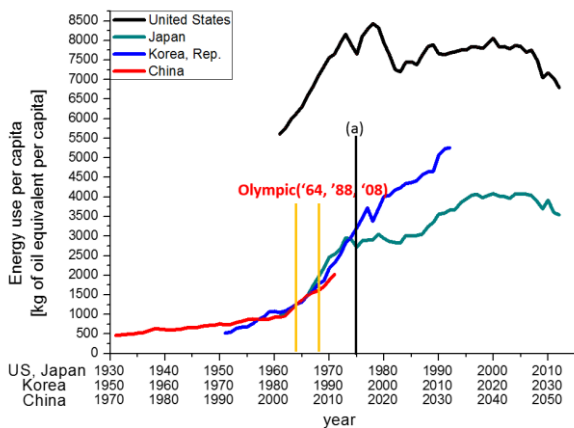
2.3 Energy Outlook

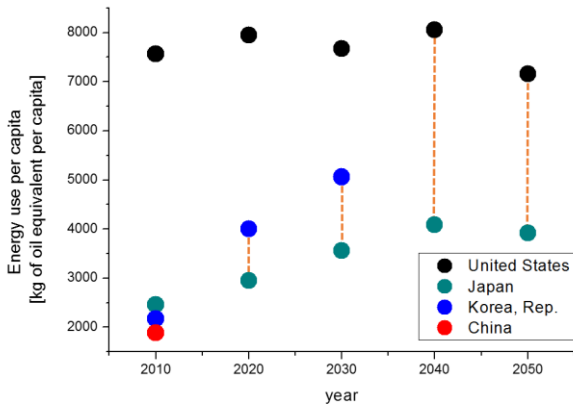Fig. 2. Energy use per capita in 4 countries.

Fig. 3. The prediction of energy use per capita in China.

From the analogous trend of GDP growth in the three Asian countries, we could expect that the energy trend of China would be predicted by using the one of Korea and Japan, if we consider the previous researches about the relationship between the GDP growth and energy usage.

The expected approach could be valid, at least, for a certain period of time, where the energy use per capita data agrees well, which is up to time (a) (Fig. 2). However, there also exists a little discrepancy after the time (a) in between the data of Korea and Japan. This

might be caused by different structure of energy usage, and national characteristics.

We postulate that Chinese energy consumption trend will follow somewhere in between what Korea and Japan have shown, because it is observed that all the Asian countries have followed well up to (a). Therefore, we suggest the lower and upper bounds of the predictions of Chinese energy consumption per capita, with the one of Korea and Japan. Because of the lack of data of Korea after 2040 in Chinese time reference, we adopted the data of the US as its upper bound in 2040 and 2050. From the prediction, the Chinese energy consumption per capita will be in between about 3 and 7 TOE in 2050. If we consider their population at the time [3], total Chinese energy consumption would be 5.4 to 9.7 GTOE.

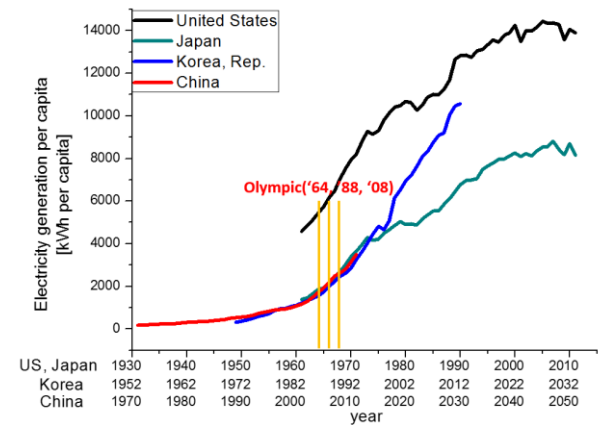*2.4 Prediction of electricity generation*

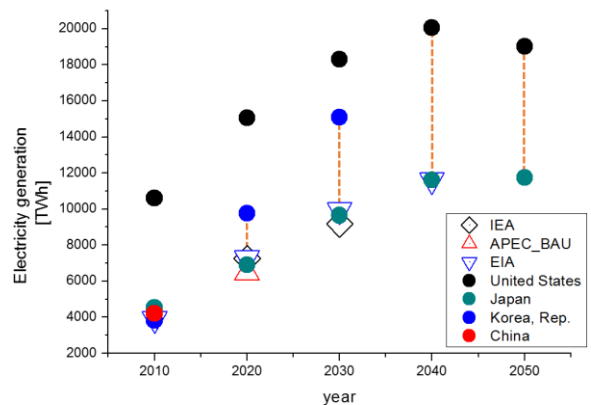Fig. 4. Electricity generation per capita in 4 countries.

Fig. 5. The prediction of electricity generation in China.

The similar procedure has been conducted to predict electricity generation per capita in China, but the better fitting time difference is 22 and 40 years gap for Korea and China to Japan rather than 20 & 40 years, respectively (Fig. 4). It is considered that the characteristics of electricity, which need a time to build infrastructures, would cause this different time gaps to the one used in energy prediction. We also set the upper and lower bound of the prediction of the Chinese

electricity generation per capita with the one of Korea and Japan, respectively.

Recently, other research institutes, such as IEA, APEC BAU, and EIA [5,6,7], have reported their estimations of electricity generation of China up to 2040 and they lie on the Japanese data in our prediction [Fig. 5]. This result could give our prediction validity even after the split occurrence between the one of Korea and Japan. Even though the organizations predicted nearly as same amount of electricity generation as Japan have shown, we could not assure that the China will never position near the upper bound. Therefore, we decided to leave the upper bound rather than exclude its possibility. From the prediction, China will generate about 11 to 19 PWh (Peta Watt-hour) in 2050.

2.5 Nuclear Energy in China

Table I: Predicted number of NPP in China.

	2020	2030	2040	2050
Maximum*	130	200	270	260
Minimum*	90	130	160	160
Chinese Government Plan[8]	60	150	-	400

*: It is assumed that nuclear covers 10% of total electricity generation

From the predictions of electricity generation in China up to 2050, we could calculate the number of necessary nuclear power plants in China. We assumed the capacity factor of NPP as 0.85, the portion of NPP to the whole electricity generation as 10%, and the power capacity of all NPPs as 1GWe (Table I). By 2020, China would need about 90 to 130 NPPs. In addition, it would increase to about 160 to 260 in 2050. According to the Chinese government plan [8], the proportion of electricity generation from NPPs will be less than 10% in 2020, about 10% in 2030, about 15%-25% in 2050.

3. Conclusions

The predictions of Chinese energy outlook and nuclear energy were performed based upon assumptions that the Asian countries would have analogue feature of development with the reference time as the Olympics.

From this research, we can conclude as

1. The Chinese GDP per capita will follow the one of US and it will reach over current US $50,000 in 2050.
2. It is predicted Chinese will spend about 3 to 7 TOE per person in 2050. It would be 5.4 to 9.7 GTOE if we consider their population at the time.
3. They will generate about 11 to 19 PWh in 2050.

4. At 2030, the necessary 1GWe NPPs in China are about 130 to 200, which predicts quite well as Chinese government plan is 150.
5. NPPs will cover about 15-25% of whole electricity generation in China in 2050.

ACKNOWLEDGEMENTS

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