A NEW LOW CARBON ENERGY VISION OF JAPAN

Fengjun Duan, The Canon Institute for Global Studies, +81362130550, fengjun.duan@canon-igs.org

Overview

The Japanese government submitted the Intended Nationally Determined Contribution (INDC) to UNFCCC on July 17 2015. The new post-2020 climate action target of reducing its GHG emissions of 26.0% by 2030 compared to 2013 was built upon an attached strategic energy mix. At the meanwhile, the document stated that the submitted INDC is consistent with the long-term emission pathway up to 2050 to achieve the goal of achieving at least a 50% reduction of global GHG emissions and a 80% or more reduction of developed countries in aggregate by 2050. However, there was not additional information of the long-term vision to illustrate how the country can get there from 2030 target.

Several long-term scenario projections have been examined recently [1), 2), 3)]. According to the results, a more ambitious target of 2030 than the submitted INDC is necessary for achieving a deep reduction vision in 2050 based on the current and developing technologies. On the other hand, bottom up approach analysis started with a similar energy mix in 2030 indicated that the emission reduction in 2050 would be approximately 50% compared to 2005. The barrier of rapid reduction beyond 2030 in all of these projections is the difficulty of reducing emissions from industrial process in which a large amount of fossil fuel is necessary to provide heat demand. Hydrogen has been considered to be a low carbon alternative fuel. However, being secondary energy, the production of hydrogen will dominated the total effect of this kind of replacement.

The High Temperature Gas Cooled Reactor (HTGR), a nuclear technology different with the current dominate one, draws increasing attention recently even though is has as long development history as the light water reactor (LWR). It is a near proven technology with the dvantages of inherent safty and high temperature provision capability. This paper investigates a new low carbon energy vision by introducing HTGR in order to examine a possible consistent pathway from the submitted INDC in 2030 to deep reduction goal in 2050.

Methods

The national energy flow chart in 2050 was first established based on the macro economic perspectives, the national energy conditions and the expected technology improvements throgh bottom up approach started from 2030 strategic energy mix, while HTGR was not taken into account. Then the possibility of introducing HTGR was investigated sector by sector to fill in the gap between the resulted CO2 emissions and the deep reduction target. Finally, the simple economic analysis was carried out for the modified energy vision.

Results

The estimated national energy balance sheet in 2050 indicates the total primary energy supply will be approximately 330 MTOE. The number is about a quarter lower than the government target of 2030. This is mainly due to the decrease of necessary energy service in line with the population decrease and the energy efficiency improvement. The nuclear energy is estimated to occupies 15% of the TEPS with the same capacity of 2030, while the renewable energy increasing to about 20% of the TEPS. The fossil fuel will keep a large share in TPES of about 65% in 2050. As to the power generation, the ratio of fossil, nuclear and renewable energy will be approximately 50:20:30. The resulted energy related CO2 emissions will be about 600 million tones, which is about half of 2005 level. The CO2 emissions come from power generation, industry, residential and transportation sectors will be 260, 220, 60 and 60 million tones respectively.

The HTGR is assumed to be introduced for industrial process heat provision and hydrogen generation. The ability of one module of a 600 MWt HTGR can be estimated to generate 0.408MTOE of heat with a temperature of 750 to 900 degreeC or 5.355 Mt of hydrogen annually. Heat is assumed to be use to replace the gas and oil consumption in industry sector. Hydrogen is assumued to be use to replace coal consumption in steel industry and petrol fuel in

transportation sector. The replaced gas in industry sector is assumed to be used in power generation to replace the coal consumption. As a result, the introduction of 226 modules of HTGR can reduce coal and oil supply of 55 MTOE and 47 MTOE respectively. This replacement can reduce the energy related CO2 emissions to about 250 million tones, which is approximately 21% of the 2005 level.

The capital investment for HTGR is about 1440USD per KWt. If the expense rate was set to be 17%, the annual cost of a 600MWt module could be estimated to be approximately 147 million USD. Therefore, the calculated replacement would cost 33 billion USD in 2050. On the other hand, the fule saving would be 19 and 40 billion USD with the oil price of 40USD/b and 100 USD/b. The estimation indicate that the new low carbon energy mix will be beneficial in the case of high oil price, which is the more likely in the target year.

Several other scenarios were also examined with the options of scaling up replacement of nuclear power generation and introducing carbon capture and storage (CCS) in power sector. The results are summarized in Table 1 together with the HTGR only case described above and the default case.

Table 1 Low carbon energy mixes of Japan in 2050 towards deep reduction (unit: MTOE)

	Coal	Oil	Gas	RE	Nulcear power	Nuclear HTGR	Total	CO2 (Gt)
Default	66	57	84	62	60	0	329	0.59
HTGR only	11	10	84	62	60	93	320	0.25
HTGR + LWR up	22	10	60	62	100	67	321	0.24
HTGR + LWR up + CCS1	22	8	89	62	100	39	320	0.24
HTGR + LWR up + CCS2	22	25	94	62	100	22	325	0.24

Note: LWR up indicates to replace the current nuclear power plants with higher capacity plants and improve the total capacity to be 50 GW. CCS1 and CCS2 mean to introduce CCS in power generatin sector with a capacity of 50 Mt CO2 and 100Mt C\O2 per year respectively.

Conclusions

In order to be consistent with the submitted INDC and the long-term climate goal of Japan, HTGR, a new nuclear technology was examined to establish a new low carbon energy vision. Investigation result indicated that the introduction of HTGR can replace most of the fossil fuel in industry and transportation sector, thereby benefit the CO2 emission reduction in 2050. A simple economic assessment suggests that the new low carbon energy mix can be beneficial in the case of high oil price.

Several other technologies such as the safer nuclear power generation and CCS could also contribute to the deep reduction target in 2050. Careful examination of economics and energy security is necessary to establish the long term energy vision together with the technology development and deployment policy framework.

References

Yuji Matsuo, et al.,The perspective of the introduction and position of hydrogen in a 2050 low carbon society, IEEJ, 2013, http://eneken.ieej.or.jp/data/4854.pdf.

Mikiko Kainuma, et. al, Japan Chapter, Pathways to Deep Decarbonization, 2014 report, SDSN and IDDRI, 2014, http://unsdsn.org/wp-content/uploads/2014/09/DDPP_2014_report_Japan_chapter.pdf.

Fengjun Duan and Tetsuo Yuhara, Toward a New Climate Regime Establishment (5) Contributions of Japan, 4th IAEE Asian Conference, September 19-21, 2014, Beijing, China, 2014.