Analysis on the Electric Power Supply - Demand Measures of Japan in 2011 Summer after Earthquake and Tsunami

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1. Introduction

Only 12 of 54 nuclear reactors are in operation as of September 1, 2011 in the wake of the earthquake and tsunami in Japan. The share of nuclear power in the nation's installation capacity fell to about 14% in August from about 30% before March 11, 2011. Government or many of research institutes estimated that the power supply system in Japan would fall to the minus reserve margin, if the nuclear power stations could not be restarted as scheduled. However, the current situation of power supply system in Japan is less severe than expected before, because the power companies and public have engaged in various diligent efforts to boost supply capacity or reduce demand in response to the electric power crisis.

This paper aims to analyze the how much Japan electric power supply system depends on the nuclear power, what kinds of countermeasures of electric power supply-demand are taken by electricity companies in summer time to avoid the blackouts and why the saving electricity in Japan could be possible unlike Korea. Insights from this paper would be taken into account in the long term energy planning, even though the further study in depth should be followed.

2. Strategic Energy Plan of Japan before Accident

According to the Strategic Energy Plan of 2030, electricity demand of Japan is supposed to increasing annually by 0.8% on average up to 2019 with peak demand increasing every August by 0.4%. From 2010 to 2019, electric power companies are supposed to add power generation facilities with a total capacity of 29.74GW, 44% (12.94GW) of which will be accounted for by nuclear power. It will lead to increase the nuclear installation capacity up to 61GW (24% of total) and the generation capacity up to 447TWh (41% of total) by 2019. In case of Korea, according to the first Basic Plan on National Energy (2008-2030), the nuclear power is expected to take up about 41% of the nation's total installed capacity by the year 2030. Total installed capacity of Japan is 3 times larger than that of Korea, however, portion of nuclear power in nation's total installed capacity is slightly higher than that of Japan as shown in Table 1.

Table 1. Comparison of Nuclear Power Role

	Japan (yr)	Korea (yr)
Total Installed Capa. [GW]	241 ('09)	75 ('10)
Nuclear Ratio of Nation's Total Installed Capa. [%]	20% ('09)	24%('10)
Peak Demand [GW]	155('09)	68('09)
Reserve Margin [%]	7 ('07) 25('09)	4~5('09)

In Korea and Japan, nuclear power is the key base-load power source and will continue to play an important role in contributing to stable supply and help to deal with global environmental issues.

3. Electric Power Crisis after Accident

The power generation capacity in Japan that remained suspended, immediately after March 11 due to the great earthquake, totaled 27.1GW, which accounts for about 50% of total nuclear installation.

As of mid-August, 5 months after the Fukushima nuclear accident, only 16 nuclear reactors are in operation in the wake of the natural disasters and the capacity share of nuclear power in the nation's energy supply fell to about 14% in August from about 30% before the earthquake and tsunami in Japan.

Electric power companies in Japan produced the electricity of 278,778GWh (around 30% of total electricity) with the 48GW of nuclear installation in 2009, however, generation record from January to July in 2011 drastically dropped to 12,347GWh with the just 13GW of nuclear power plants in operation. This generation amount is merely 4% of total nuclear power generation in 2009. The March 11 tsunami knocked out more than two thirds of the nuclear power plants.

4. Analysis on Measures of Japan in this Summer

After the natural disaster, the share of nuclear power generation dropped to below 5% of 2009 and generation more than 60% was lost by government request and inspection as shown in Fig.1.

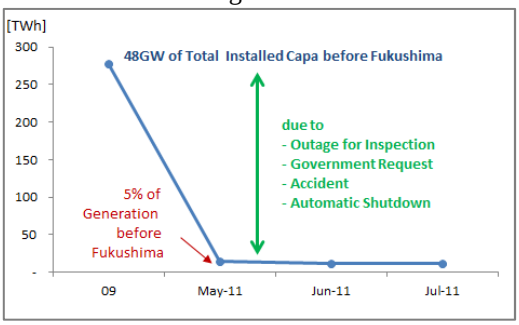

Fig. 1. Decrease of Nuclear Generation after Disaster

All 54 of Japan's reactors could go offline by May 2012 if the public fears over nuclear power due to the Fukushima nuclear accident could make their restart delay. If Japan had to stop any nuclear plant operation, around 7~9 % short was estimated by the government. However, a combination of mandatory power cuts and voluntary savings by companies and consumers allowed

the utilities to match supply and demand without resorting to rolling blackouts.

Ministry of Economy, Trade and Industry (METI) of Japan published "Electricity Supply-Demand Measures in Summer Time" as decided by the Electricity Supply-Demand Emergency Response Headquarters on May 13. In response to the decrease of supply capacity caused by the earthquake disaster, additional measures have been taken to increase the supply capacity as well as making efforts to restrain demand by setting a target of a 15% reduction. As for five electric utilities in western Japan, if the nuclear power stations restart operation after completing their regular inspections as scheduled, the reserve rate is estimated to be around 10%. However, if it is not the case, the total reserve rate of the five utilities in western Japan is forecasted as minus 2.3%.

This measure is based on the idea that peak hour supply capacity (kW) of electric power companies should be decreased, therefore, restriction could be focused to reduce the peak demand at peak hours in terms of kW (height) as shown in Fig. 2.

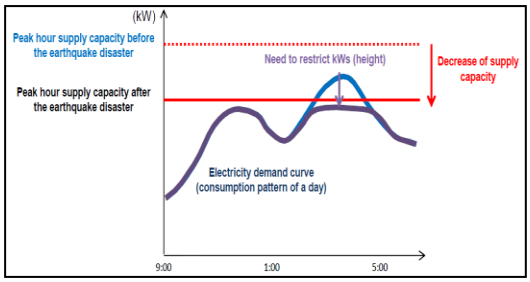

Fig. 2. Approach of Japan to Restrict the Peak Demand

To find the reason why Japan choose the reduction of peak demand among various demand side management methods, demand patterns in 2007 between Japan and Korea were compared using the Load Duration Curve (LDC), which explains the how long time the same loads are lasted.

According to the Fig. 3, the peak load of Japan is located in summer time in contrast with the flat load over the broad time period in Korea. It means that Japan could avoid the shortage of electricity by cutting the summer peak, while Korea has to make the overall load down or keep the reserve margin enough during the winter as well as summer. Therefore, power restriction of Japan could be focused on the reduction of the peak demand in summer time. Assuming conservatively that Japan has just 7% of reserve margin as 2007 summer, 10% of supply capacity is decreased due to the earthquake and tsunami, and no measures of power supply-demand are taken by government, Energy Not Served (ENS) period would be occurred and public would suffer the unplanned outage of electricity in this summer. In case of Korea, it is unlikely to have shortage of electricity, even though about 10% of total installed capacity is lost. However, Korea has the burden to keep the reserve margin enough or keep the demand low for saving electricity over long period and additional capacity for high reserve margin could make the power system cost less economic. It could be considered that low electricity price of Korea contributes the overuse of electricity according to the fact that electricity consumption per capita of Japan is much lower than that of Korea, while Japan's electricity price of industry sector is over twice as high as Korea in Fig. 4. The relationship of Korea's flat load pattern and high reserve margin and the electricity price remains as the further study.

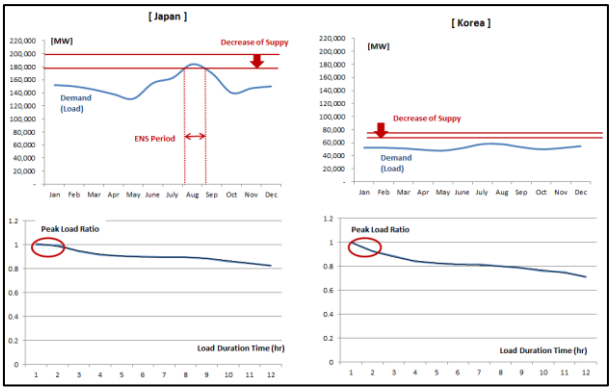

Fig. 3. Comparison of Load Pattern and Saving

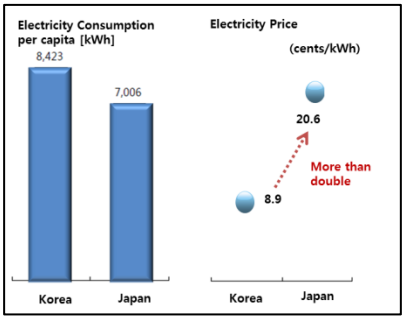

Fig. 4. Comparison of Electric Consumption and price

5. Conclusions

The differences and similarities of nuclear role in long term energy plan, Japan's measures of electric power crisis in this summer and comparison of saving electricity and price between Korean and Japan were analyzed in this paper. To diversify the energy portfolio and to avoid blackouts caused by a tighter supply-demand balance, various measures and lesson learned from Japan such as energy saving, changes of replace schedule of thermal power, and supply capacity increase with zero-emission sources should be taken into account in the power supply program.

REFERENCES

[1] Ministry of Science and Technology, Electricity supply-demand measures taken by the five electric utilities in western Japan this summer, 2011.
[2] The Federation of Electric Power Companies of Japan, Electric Review Japan, 2011.