The Role of Nuclear Power in Addressing Climate Change Issues in Korea

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1. Introduction

Korea is the 6th largest GHG emissions country in the world, recording 591 million ton of CO2 in 2005. Even if Korea has no compulsory obligation on the reduction of GHG emissions under the framework of UNFCCC until 2012, it seems inevitable for Korea to make a commitment to the reduction of GHG emissions in the Post-Kyoto regime. The purpose of this study is to investigate the role of nuclear power for a power supply with the CO2 emissions target, and to estimate the positive externality of nuclear power in terms of a CO2 emissions avoidance by taking into account the contribution made by nuclear to the national economy.

2. Methods and Major Assumptions

In order to analyze the Korean electricity system, we used the MESSAGE(Model for Energy Supply Strategy Alternatives and their General Environmental Impacts) program, developed by IIASA and updated by IAEA[1].

In this study, the economic and technical parameters of these power options were referred to the 3rd Basic Plan of Long Term Electricity Demand & Supply[2], which was published in December of 2006. The study covers the period of 2006-2030. The introduction of new nuclear power is assumed to be available from 2013 with the maximum allowable capacity of 1,400MW per year. In the case of Coal, the available maximum allowance is between 1,500 and 4,600 MW per year.

We obtained from a join study carried out between IAEA and Korea the net riffle effect of the replacement of nuclear with coal power on the national economy[3].

3. Results

3.1 Investigating the role of nuclear power in the power sector considering the emission target of CO2

The role of nuclear in the power sector is investigated under the carbon emission intensity target of 0.11 kg-C/kWh, which was considered in the 3rd Basic Plan of Long Term Electricity Demand & Supply. We assumed 3 cases to investigate the effect of nuclear on the electricity system under the restriction of CO2 emission; In addition to the base case, we considered two other cases. One is the Limitation on the nuclear case, which is based on the base case with a limit on nuclear. The limitation is implied in a way that no new nuclear is allowed from 2013 to 2017 for 5 years. In other words, the maximum nuclear investment allowed in this case is less than in the base case by 7,000 MW, total 5 units of nuclear power plant. The other case is the allowance of additional nuclear case. This case makes extra 7,000MW of new nuclear investment available (from 2013 to 2017) compared with the base case.

Figure 1 is a result from the model on the percentage shares of power options out of total power generation by cases.

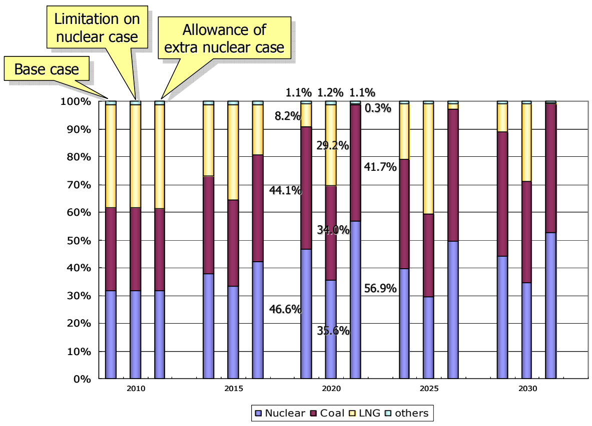

Figure 1. Share of power options out of total generation under intensity target on carbon emission, 0.11 kg-C/kWh

In 2020, in the base case, nuclear accounts for 47%, coal for 44% and LNG for 8%. At the same year, in the nuclear limitation case, the shares of nuclear and coal are reduced to 36% and 34% respectively, while the share of LNG increased to 29%. From this result, we understand LNG is introduced at the expense of Coal to meet the carbon emission limit.

For the same year, in the allowance of extra nuclear case, full 7,000MW of new nuclear is chosen by the model as it is cost effective in the optimization process. As a result, the share of nuclear increased to 57%, with the share of coal power increase to 42%. In this case, Coal is introduced at the expense of LNG. It is because there is no problem to meet the carbon emission limit with a large amount of nuclear available in the electricity system.

3.2 Estimating positive externality of nuclear power in terms of CO2 emission avoidance

In this scenario, no carbon emission is imposed. It is because the purpose of this scenario is to estimate the externality nuclear power potentially brings in terms of CO2 avoidance. We do not need to impose any carbon emission regulation.

Base case in this scenario is the same as in the previous scenario except no imposition on the emission limit. Limitation on the nuclear case is based on the base case with a limit on nuclear as in the previous scenario, where no more introduction of nuclear from 2013 to 2017 is allowed. Compared with the base case, the maximum nuclear introduction allowed in the limitation on the nuclear case is less than by 7,000 MW, total 5 units of nuclear power plant.

Figure 2 shows the percentage shares of power options out of total power generation by cases.

In 2020, in the base case, nuclear accounts for 45%, coal for 53%. For the same year, with the limitation on nuclear, the model chooses coal power as an economical option. Full 7,000 MW was switched to coal power in the model. No more LNG appeared because no emission regulation is imposed. As a result, the share of nuclear decreased to 35%, with the share of coal increased to 64%. There was no room for LNG to play.

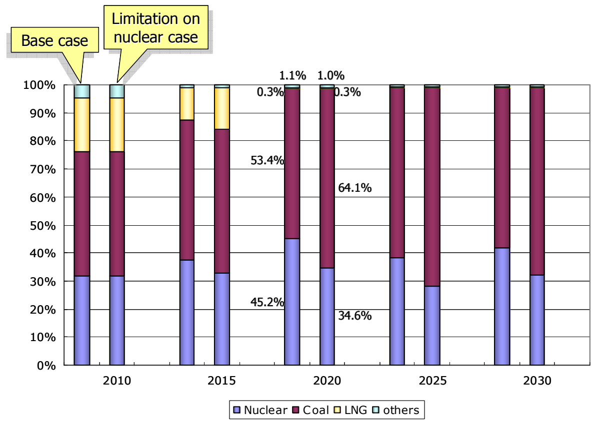

Figure 2. Share of power options out of total generation under no constraint of CO2 emission

Table 1 shows an additional CO2 emission due to the replacement of nuclear with coal. There is no difference before 2014. It is because the replacement was put into the model from 2013. The difference of CO2 emissions between the base and limitation nuclear case is estimated to 76,149 thousand CO2 ton at the amount discounted for the first period, 2006, during the whole period.

Table 1. CO2 emission difference between two cases

(1,000 CO2 ton)

Year	Base Case	Limitation on the Nuclear Case	Difference	Discounted Difference
2014	188,127	190,003	1,877	1,092
2015	193,775	199,902	6,127	3,333
2016	193,364	211,783	18,419	9,363
2017	185,207	213,372	28,165	13,381
2018	183,279	214,218	30,939	13,737
2019	179,982	209,381	29,399	12,199
2020	176,015	202,763	26,748	10,373
2025	153,552	180,300	26,748	7,396
2030	113,467	140,215	26,748	5,273
Total			195,169	76,149

We obtained the amount of net loss of a value added from a joint study carried out between IAEA and Korea. According to the joint study, net loss of a value added was estimated to about 2,570 billion won(2,570 million dollars) in 2005. This number was estimated by using an IO analysis on the assumption that all the nuclear power generation in 2005 was replaced with thermal power. This number was referred to in the estimation of the net value added loss calculated in this study.

Net value added loss shown in table 2 was calculated as follows:

Net VA loss in a year =

(2,570 billion won/Nuclear Generation in 2005) x

(Nuclear Generation Difference in a year between the two cases)

Table 2. Net value added loss between nuclear and coal power

(Billion won)

	Net VA loss	Discounted Net VA loss
2014	193	113
2015	387	210
2016	580	295
2017	773	367
2018	966	429
2019	917	380
2020	917	355
2025	917	253
2030	917	181
Total	6,566	2,584

Positive externality of nuclear power in terms of CO2 avoidance is calculated dividing total sum of discounted value added loss attributable to the replacement of nuclear with coal power by total sum of discounted CO2 emission difference. In this study, we supposed that there is no difference in an electricity generating cost between nuclear and coal power assuming no difference of electricity generating cost between nuclear and coal power. The empirical results show that the externality of nuclear power in terms of a CO2 avoidance is estimated to be 33,933 won/ton of CO2.

4. Conclusions

Positive externality of nuclear power can be regarded as a negative externality of coal power in terms of CO2 emissions, the real cost of CO2 coming from coal power should be at least more than 33,933 won/ton of CO2. This empirical study result is believed to be useful in determining a reasonable future share of nuclear out of a total power generation in addressing the coming Post-Kyoto Regime, to which a very high priority is given in Korea.

REFERENCES

[1] MESSAGE, User Manual, IAEA, 2007.

[2] The 3rd Basic Plan of Long Term Electricity Demand & Supply, MOCIE, 2006.

[3] Nuclear Technology and the Korean Economy, IAEA, 2008 forthcoming.