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Analysis on the Competitiveness of Electric Resources According to the Fuel Price and Carbon Price Changes

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1. Introduction

There are many challenges and risk of climate changes to the electric industry, i.e. because low carbon fuels are preferred it is easy to guess that the coal power plants could be phased out or fuel switch into the low carbon fuel like gas, nuclear, or renewable is inevitable. And also reduction of carbon emission can be carried out through the economic regulation like a tax or trading as well as accelerating the technology development. However, suspension of the coal power generation or fuel switch is not simple problem in terms of the economics or energy security, because its fuel cost is very volatile and unstable fuel price makes it difficult to select the sustainable resources. Therefore, this paper simulates the effects of the carbon price on the economics of different electric resources and expands their economics in terms of the market price as well as generating cost. In addition, the competitiveness of each fuel in the fuel mix is assessed according to the volatility of fuel price. It has to be kept in reader's mind that because this study is just the preliminary study and still being studied, more detail results can be finalized after current project.

2. Methods and Results

2.1 Alternatives of Carbon Emission Reduction

IAEA published the CO2 emission rates for electricity generating alternatives such as fossil fuelled technologies (coal, oil and natural gas). They have the highest CO2 emission rates per kWh and create the majority of energy related GHG emission. It shows emission rates for the complete fuel cycle, including facility construction, equipment manufacturing, resource extraction, transport, processing and conversion. The complete fuel chain of nuclear power emits only 1-6 g C_{eq}/kWh. This is about the same as wind and hydropower, including construction and component manufacturing. All three, together with solar power and biomass, are well below coal, oil, and natural gas (60-460 g C_{eq}/kWh) even taking account of carbon capture and storage. This statement indicates that stabilizing CO2 concentrations in the atmosphere will require significant reductions in emissions from fossil power, either by technological approach or by renewable energy development [1]. Usually CCS can reduce the 25% of carbon emission and this figure explains the CCS with coal can reduce the 250~350 g C_{eq}/kWh into 75 g C_{eq}/kWh (almost one fifth) and CCS with gas do the 100~200 g C_{eq}/kWh into 75 g C_{eq}/kWh as much as one third.

According to author's previous study results using WASP-IV on the amount of CO2 emission accumulated, the case that the new nuclear power plants replace the other power generation resources is most effective carbon saving point of view comparing to the business as usual (BAU) case of least cost optimized with nuclear and coal and comparing to fuel switch of new coal into LNG. This means the government coal of CO2 emission like a 0.11kg-c/kWh is not easy to be accomplished without the nuclear power and nuclear power plants will take an important role of carbon stabilizer.

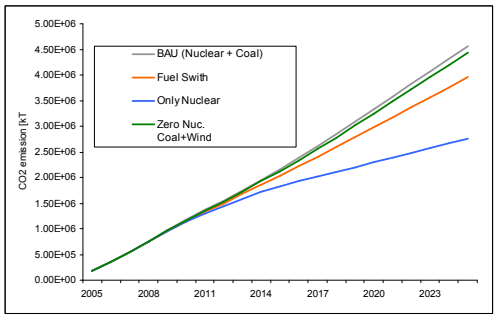

Figure 1. Carbon Emission Accumulation

2.2 Volatilities of Fuel Price and Carbon Price

To validate the role and competitiveness of nuclear, it should be shown that the merit order from nuclear to fossil fuel like a gas and oil is not changed at any condition of fuel cost and carbon price. Even though the fuel cost and carbon price do not impact the economics of nuclear, the change of role of fossil fuel can give some effect on how much generation of nuclear can be expanded in the future power system. Adding the carbon price to the coal power can introduce the Gen.Co's fuel switch into low carbon fuel, however, gas favored strategy is very dependent on the gas price and it is not easy to say that gas plant may be always preferred under the carbon constrained world due to the possibility of gas price hike. Due to these reason this paper analyzes the relationship between the carbon price and gas fuel price.

First, as the carbon price goes up at a current LNG price, the merit order in terms of the production cost is seldom changed until 60$/ton-c which is very unreasonable value of carbon. Therefore this result explains the relative competitiveness between gas and coal may not be changed under the reasonable carbon price range unless the LNG price significantly drops. As

low as 50% of current LNG price, LNG becomes more economic than coal at the 26.5$/ton-c of carbon price

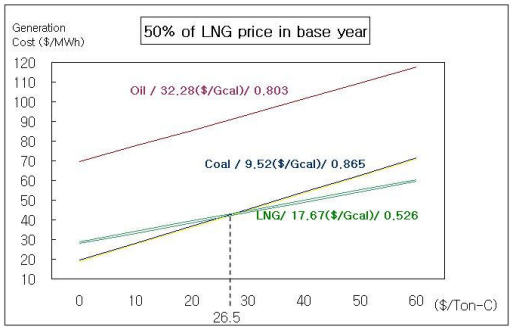

Figure 2. Merit Order of Fossil Power according to the change of Fuel Cost and Carbon Price

The reason why the nuclear does not appear this graph is that its production cost, i.e., variable cost including the fuel cost and O&M cost much lower than these of coal and LNG.

In summary, to be a LNG preferred, it is not possible at the current LNG price level due to the unrealistic carbon price over than 80$/ton-c. Below 25$/ton-c coal becomes competitive only provided the LNG price keeps over than 50% of current price.

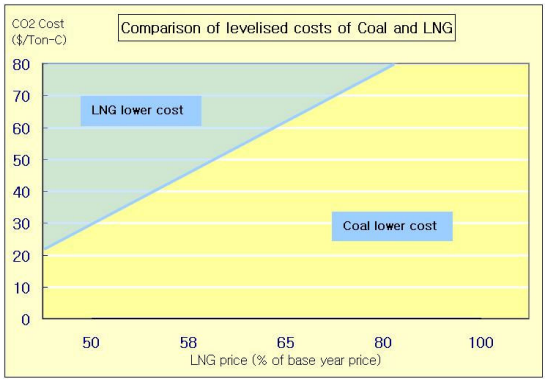

Figure 3. Comparison of Competitiveness between LNG and Coal

2.3 Effect of Low Carbon Fuel Mix on Market Price

Provided that nuclear and hydro are the "must-run" generator as like as the 3rd government plan of demand and supply, increase of nuclear and hydro make the market price gradually down. According to the renewable such as wind, small hydro and biomass coming into the on-line by the "fee and tariff," generation amount from base load is increased and marginal generator can shift toward more economical generator. It is the main reason that makes the market price lower.

In other case of that carbon price is added to the generation cost, increased production cost of coal power generation makes their revenue low. However, more than 70$ ton-c of carbon price, revenue from the high market price can be more than the burden of production cost due to the carbon price. It means that ultimately high carbon price can offset the increase of generation cost through the increased revenue.

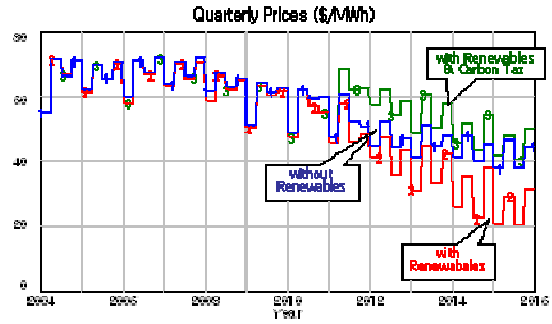

Figure 4. Comparison of Market Price between Renewable and Carbon Price

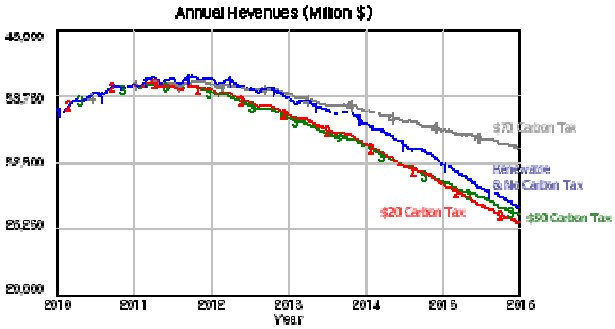

Figure 5. Change of Revenue according to the Different Carbon Price

3. Conclusion

This paper is to show the possibility how to analyze the effects of fuel price volatility on the merit order and effectiveness of economic carbon constraints like a adding it to the generation cost. Finally to be a LNG preferred to coal, LNG price has to go down as low as 50% of current price or carbon price has to go up much higher. In addition, economic constraint of carbon may not work better in the market as expected previously.

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Acknowledgement

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