Energy Transformation in Taiwan- The Study of Optimal Electricity Portfolio

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Overview

Taiwan's import energy dependence is higher than 97 percent and most energy is used for electricity generation. For example, eighty percent of import is used for electricity generation. Taiwan is an island and hence the electricity grid is an isolated one so the energy supply situation is quite vulnerable. However, the energy policy of Taiwan is looking for nuclear-free homeland since May 20, 2016. After that the Legislative Yuan of Taiwan passed "The Electricity Act" in January 2017 and declared the nuclear-energy-based power-generating facilities shall wholly stop running by 2025. The government also planned the object of electricity mix by 2025. Taiwan government designed the ratio of coal-fired generation, gas-fired generation and renewable to total electricity generation should be 30 percent, 50 percent and 20 percent respectively but electricity structure of them was 39 percent, 36.7 percent and 5.5 percent respectively in 2016. This goal has high possibility leading to the problems of energy insecurity and electricity price surge. Hence, the purpose of the study is to build an econometric model that considers base load, medium load, peak load and auxiliary power under the condition of minimum cost and to evaluate the optimal electricity allocation. We also calculate the optimal electricity allocation in carbon tax scenario. Furthermore, we construct the other model that doesn't consider the characteristics of generators for comparison. The findings will be useful for government reference in adjusting electricity portfolio and determining the sustainable energy policies.

Methods

In order to estimate the optimal electricity allocation, we construct two electricity models by translog cost function. The first model with two tier structure considers the characteristics of generators. The first tier was base load, medium load, peak load, renewable and cogeneration. In the second tier, the base load was decomposed into coal-fired generation and nuclear. The medium load and peak load was mainly consisted of gas-fired generation, oil-fired and pumped-storage generation respectively. The auxiliary generator is renewable energy including hydro, wind, solar and so on. The second model we ignores the characteristics of generators by directly estimating the optimal electricity allocation between coal-fired generation, oil-fired generation, gas-fired generation, nuclear, renewable and cogeneration with minimum cost principle. Furthermore, we set a scenario of levying carbon tax (such as USD$40 per ton of CO_2) in order to internalize the external cost of fossil fuel generation. The CO_2 emission coefficient of coal, oil, gas and cogeneration was 0.926 kg/kwh, 0.772 kg/kwh, 0.415 kg/kwh and 0.552 kg/kwh respectively.

Result

We adopt the data of each generation units of generation cost and electricity that providing by Taipower Company. The electricity models follow the principle of minimum generation cost to calculate optimal electricity allocation in Taiwan by 2025. In the first model, without levying carbon tax the optimal electricity allocation by each generation unit will be coal-fired generation, 44.86 percent; oil-fired generation, 0.02 percent; pumped-storage, 0.31 percent; gas-fired generation, 31.64 percent; nuclear, 10.72 percent; renewable, 7.64 percent; and cogeneration, 4.80 percent. After levying carbon tax, the optimal electricity allocation will be coal-fired generation, 32.69 percent; oil-fired generation, 0.02 percent; pumped-storage, 0.36 percent; gas-fired generation, 37.11 percent; nuclear, 14.55 percent;

renewable, 9.79 percent; and cogeneration 5.48 percent respectively. In the second model, we find out that the optimal electricity allocation without(with) levying carbon tax will be coal-fired generation, 38.34 percent(27.16 percent); oil-fired generation, 0 percent (0 percent); gas-fired generation, 37.25 percent(43.55 percent); nuclear, 16.42 percent(20.06 percent); renewable, 4.13 percent(5.34 percent); and cogeneration, 3.86 percent (3.89 percent). The result shows significantly different from the energy transformation plan of the government by 2025.

Conclusion and Suggestion

For towarding sustainable electricity systems and diversify energy of Taiwan, we should leave the space for every possible low-carbon generation units especially nuclear. If we want to enhance the renewable in our electricity system, we have to consider its auxiliary characteristics (owing to intermittent supply) and accelerate its infrastructure investment such as storage and dispatch system. In addition, the development of gas-fired generation and renewable were restricted because of higher generation cost. However, we can elevate the ratio of low-carbon energy by levying carbon tax and reflect the real energy using cost. The decommission schedule of nuclear or coal-fired generation units should depend on the completeness and stability of renewable. To sum up, it is suggested that government should reconsider the structure and the path of energy transformation policy.

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