Role of Electricity Grid Development and Storage Technologies under High Carbon Emission Constrain – Analysis using Grid Featured TIMES model

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Overview

There is major potential for on-shore wind energy generation in the northern and eastern regions of Hokkaido, but the areas are sparsely populated, and there is a lack of grid infrastructure to transmit the electricity generated in the region to Sapporo, the capital city of Hokkaido, and Tokyo. Under the geographic un-matching between electricity demand and renewbale potentials, current grid infrastructure will become a mjor burden to increase the share of VRE (Variable Renewable Energy) share in Japan. To indetify the benefits of grid development to achive a hight VRE share, I developed a detaied node TIMES based grid model.

Methodologies

The TIMES-based JMRT (Japan Multi-regional Transmission) model is a 47 sub-regional model which only includes inter-grid connections between 10 grids. As a result, the model cannot reflect the weak grid infrastructure within grid regions, although the model uses 1km2 mesh renewable energy potential data.

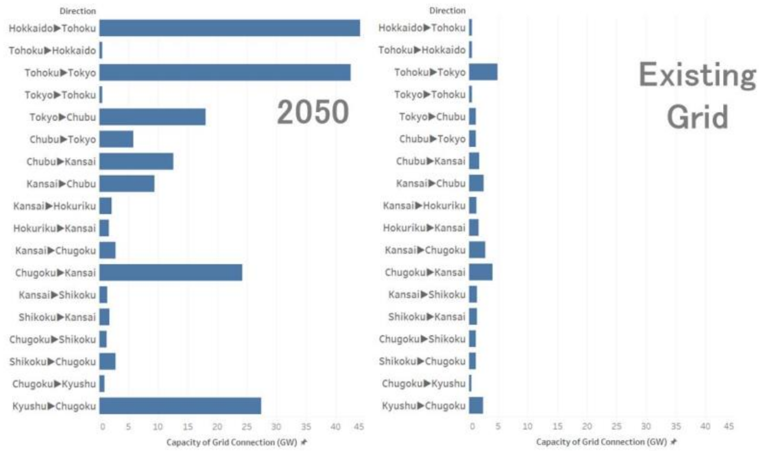
To reflect grid capacity constraints, we disaggregated Japan into 351 nodes, or sub-stations. Using the 351-node JMRT model, we have conducted 80% carbonmitigation by 2050 simulations with/without grid features.

Figure 1: Node and Grid Line

Results

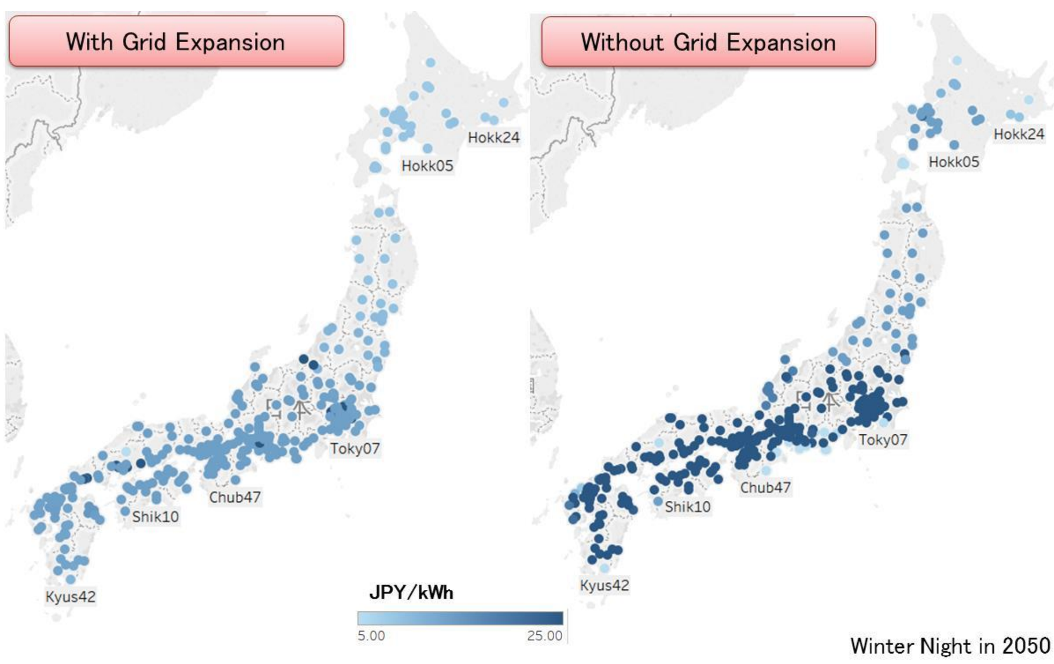
Figure 2 shows comparison between necessary capacity of grid connecteions in 2050 and exisiting capacity of grid connections. To make the most use of wind potential in Hokkaido and Tohoku and transmit to Tokyo, the biggest electricity consuming region, we need to further development grid from Hokkaido to Tohoku and from Tohoku to Tokyo.

Figure 2: Comparsion of Grid Connection Capacities between Grid Expansion in 2050 and Existing Grid



Without the grid expansion, we cannot make the most use of right site for wind turbine, Hokkaido and Tohoku and as a result, we have to build wind turbine close to big electricity consuming regions to meet carbon mitigation target. As Figure 3 shows, no grid expansion leads to marginal electricity generation gaps between regions.

Figure 3: Marginal Cost of Electricity Generation by Node With/Without Grid Expansion



Conclusions

Node level resolution of model reflects reality which is geological distribution of energy consumption and renewable energy potential and identify the burden of grid infrastructure under high carbon mitigation.Under the current electricity grid infrastructure, high carbon mitigation widen marginal electricity price between nodes. High electricity price in three major economic regions, Tokyo, Osaka and Nagoya. In Tokyo area, offshore-wind will be introduced to meet high carbon mitigation target. The current electricity grid is not suitable to meet high carbon mitigation and to expand grid connection and grid capacity will equalise the marginal electricity generation cost gap between nodes.

References

Lehtila, Antti and George Giannakidis (2013), TIMES Grid Modeling Features, TIMES Version 3.4 User Note.