

Dynamics and regional heterogeneity in power generation efficiency of PV power plants in Japan focusing on new market entrants

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In Japan, renewable energy sources supplied 21.2% of the total electricity generation in 2020. The Japanese government plans on increasing this ratio to around 36 - 38% by 2030. In this situation, Photovoltaic (PV) power generation will play a significant role and a large number of new entrants in the market is expected. On the other hand, it is widely known that electricity generation in PV systems fluctuates depending on factors such as weather conditions, seasonality, and location of the power plant. Moreover, in Japan, where the sites for building PV systems are limited, it is essential to improve and stabilize the power generation efficiency of PV systems at plant levels.

In the light of these research backgrounds, by applying a combined research framework of metafrontier Data Envelopment Analysis and global Malmquist index to the data on PV power generation in Japan at plant levels between 2017 and 2020, this study investigates the following three questions: (i) When dividing the whole of Japan into three parts (north, east and west), is there a significant regional gap in changes in power generation efficiency during the study period? (ii) Which of "catch-up"™ and "frontier technology shift"™ effects would mainly affect the changes in power generation efficiency? (iii) How new market entrants would have an impact on power generation efficiency?

During the study period, our results show that power generation efficiency in north, east and west regions is increased by 13.6%, 38.9% and 19.4%, respectively. The catch-up effect is the main driver of the substantial efficiency improvement in the east region, while the frontier technology shift effect mainly affects the changes in power generation efficiency in the north and west regions. Furthermore, new market entrants contribute to increasing the average power generation efficiency especially in the west region.