Minimizing Downside Risk of Fluctuating Renewable Power Output in Hokkaido by Optimally Distributing Energy Sources

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(1) Overview

Assuming the future power supply system with a large share of renewable energy sources, measures against a downside risk of output from the energy sources need to be developed. The distribution of the energy sources can decrease the risk without additional facilities such as backup power plants and energy storages. There are two options for the distribution: among the energy types and locations with different weather conditions. This study clarifies the renewable energy portfolio with the least downside risk of power output in the Hokkaido island in Japan. Solar and wind energy in various locations are considered as the candidates of energy sources. Since weather condition in Japan varies by the seasons, the minimum-risk portfolio is estimated for winter, summer, and full-year.

(2) Methods

Although earlier studies use the variance as an index of the downside risk, this study instead use the conditional value at risk (CVaR) , defined as an average of data from zero to β percentile, as the risk index because the CVaR is more suitable to evaluate a risk of phenomenon with an asymmetric probability density function (p.d.f.), and can take into account the fat-tail risk of phenomenon. The mean-CVaR model, developed by Rockafellar and Uryasev (2000), is applied to the portfolio optimization in this study.

(3) Results

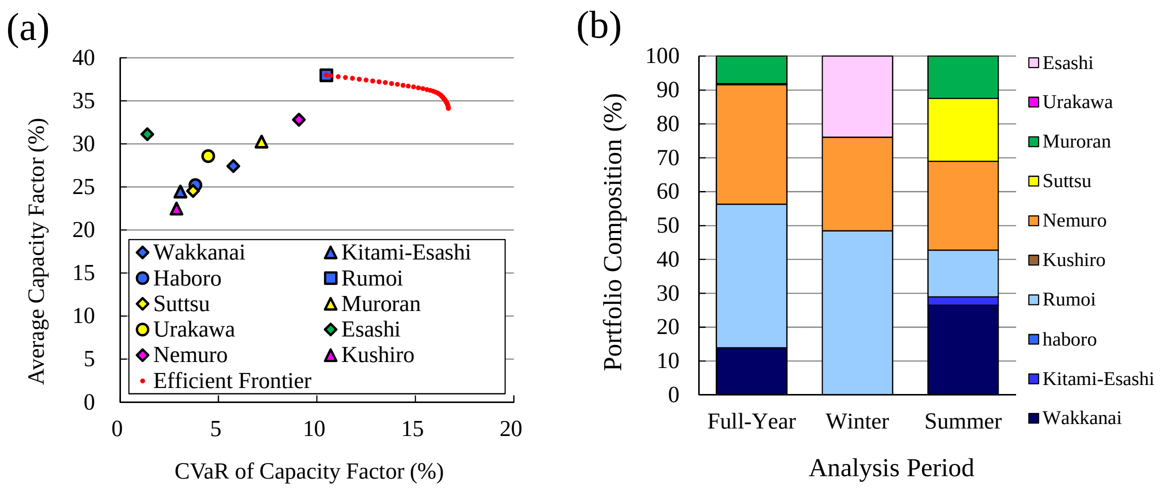

Fig. 1: (a) The result of full-year analysis (wind energy only, β = 50%). The horizontal and vertical axes indicate the average and CVaR of capacity factor; the larger average and CVaR indicate the better performance. Each dot corresponds to the values in each location throughout the Hokkaido island, and the red dotted line is an efficient frontier. Comparing the right and left side of the efficient frontier, the portfolio CVaR increases by 60% with just 10% decrease of the average. (b) Difference in the composition of minimum-risk portfolio against the analysis period. This large difference indicates an importance of strategy on which season should be focused as the target of minimizing downside risk. The results considering both the wind and photovoltaic power plants will be presented in the conference.

(4) Conclusions

This study clarified that the downside risk of renewable energy portfolio can be reduced by distributing energy sources. The season in which the downside risk is the most important should be identified before the portfolio optimization.

References

Rockafellar, R., Uryasev, S. (2000). "Optimization of value-at-risk". Journal of Risk 2 (3), 21–42.