Assessment of Large Scale Penetration of Variable Renewables in Japan Considering Suppression of Power Fluctuation

Hiroto Shiraki

National Institute for Environmental Studies (NIES), Japan

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The objective of this study is to estimate generation mix and generation costs under various penetration rate of renewable energy. Because most of renewables in Japan is variable renewables, such as solar and wind power, it is essential to assess large scale penetration of variable renewables considering suppression of power fluctuation. In this study, I developed a multi-regional generation planning model considering suppression of power fluctuation. Three countermeasures against power fluctuation, i.e. load frequency control of system power plants, output restriction/parallel off of variable renewables, and secondary battery, were explicitly considered. Because I distinguished short-term/long-term fluctuation of solar/wind power, battery for balancing short-term fluctuation (SBST) and battery for balancing long-term fluctuation (SBLT) were separately modeled.

According to the analysis using the developed model, generation cost in 90% emission reduction case would be 1.7 times higher than that in NO reduction target case. 40% of electricity would be supplied by variable renewables in 90% emission reduction case. In addition, installed capacity of batteries under various penetration rate of VRE penetration was estimated (Fig.1 and Fig.2). Threshold of penetration of wind and solar power with secondary battery would be about 4.8% and 8.7% of total power generation, respectively. It is necessary to develop low cost and high efficient secondary battery to realize large scale penetration of variable renewables in Japan.
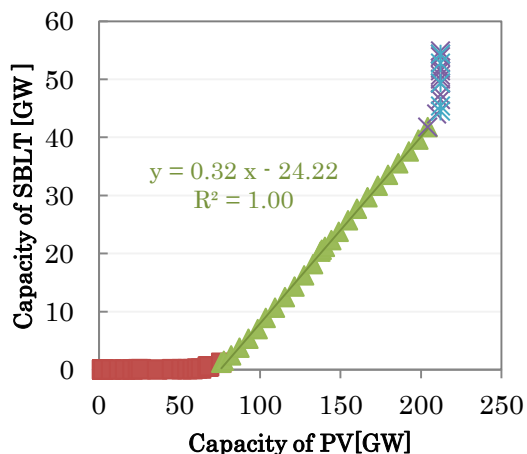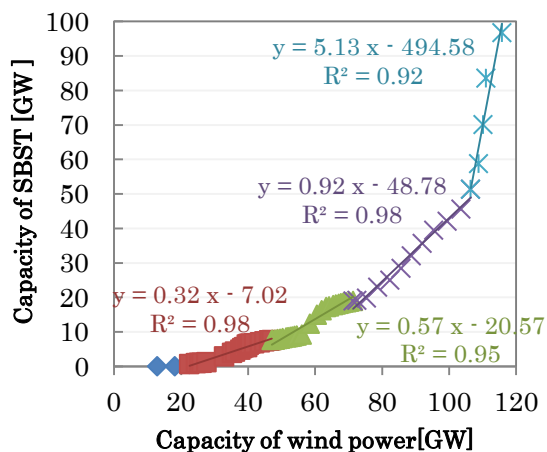

Fig.1 Installed capacity of SBST (vs. wind)   Fig.2 Installed capacity of SBLT (vs. PV)

(Plots were distinguished by the stage of VRE penetration)