Numerical modeling of wind variability and its impact on the stability of the power system in the Philippines（風の変動に関する数値モデリング及びそれがフィリピンの電力システムの安定性に与える影響）

Hokkaido University, Graduate School of Environmental Science,
Division of Environmental Science Development, Course in Human and Ecological Systems
Kevin Ray Español Lucas

Globally, clean energy development has been focused on the potentials for variable renewable energy (VRE) generation from wind and solar. Often, the stability and reliability concerns associated with the utilization of VRE have been overlooked. For developing countries like the Philippines, power system operations are not ready or well-developed enough to keep up with the intermittency of VRE. Hence, VRE development targets in the Philippines have been conservative. This research aims to understand the variability of winds, specifically the hourly changes of onshore horizontal winds at 100-meter hub-heights, using the Weather Research and Forecasting (WRF) model. The sensitivity of simulated wind speeds to different settings and parameterizations was first tested to optimize the use of the model. The tests show that the simulated wind speeds are most sensitive to the combinations of surface layer (SL) and planetary boundary layer (PBL) schemes. An ensemble simulation having varying combinations of SL and PBL schemes accounts for different turbulent patterns that have been known to affect surface winds. Upon simulating the variability of winds using an ensemble of five combinations of SL and PBL schemes, results reveal that throughout one year, land-sea breeze, together with a complex topography over onshore coastal regions, modulates the hourly variability of wind speeds. Diurnally, wind speeds decrease during the transitional hours between land breeze and sea breeze, then increase during the subsequent hours. Decreases in wind speed, together with the succeeding increases, are most significant over coastal regions with high sloping topography. To analyze the impact of wind variability on the stability of the power system, hourly occurrences of extreme wind changes were compared to the hourly occurrences of extreme oversupply and undersupply of energy. Extreme decreases in wind speed occur at 8 am while extreme increases occur randomly after. Similarly, extreme energy undersupply events also occur at 8 am while extreme energy oversupply events happen later. Despite the coincidence between these occurrences, the extreme variability of wind speeds has an insignificant impact on the system stability. This weak impact is due to the small share of wind energy capacity in the system compared to the entire energy capacity. These extreme system instabilities are seen to be affected, instead, by the variability of the energy demand. However, as the share of wind energy generation in the Philippines increases in the future, the country's power system stability may become more sensitive to the variability of wind. The findings of this research hope to promote sustainability in the operation of existing wind reliant power systems and planning of future wind energy developments.