Modeling and Utilizing a Vanadium Redox Flow Battery for Easier Grid and Market Integration of Wind Power

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Abstract:	Power grid and market integration of wind energy is a challenge due to the fluctuating and intermittent power output resulting from the variable nature of wind resource. Energy storage is a promising alternative for effective grid integration of renewable energy. One storage technology which is under the spotlight in the recent years is the vanadium redox flow battery (VRFB) which could have certain advantages when utilized at large-scale grid connected applications. In this study, a megawatt scale VRFB was modeled based on experimental data with a kilowatt scale real life unit. The dependence of the overall system efficiency on the state of charge and power was determined. By using the model, optimal number of modules for certain power levels during charging and discharging operations were estimated for megawatt scale operations. In order to evaluate the power grid integration of wind power at a single wind farm level, a second simulation model which combines the megawatt scale VRFB model and a medium sized (10 MW) wind farm was developed and the battery was utilized to compensate for the deviations resulting from the forecast errors in an electricity market bidding structure. Using an existing electricity market model based on deviation penalties and penalty multipliers, economics of the system were evaluated by determining the payback periods for a dedicated VRFB installation at this medium sized, single wind farm level.