NEW DESIGN TO IMPROVE MW-FREQUENCY PERFORMANCE:

RESERVE ADEQUACY AND RESOURCE FLEXIBILITY

With the high penetration of renewable energy resources such as wind and solar, the power system is facing the degradation of frequency response. The major reasons for the degradation of frequency performance can be summarized as following reasons: first, the cheap and clean renewable energy is displacing the conventional thermal generator. While the wind turbine is connecting with the bulk power grid with AC-DC-AC converter and the solar panel is connected to the grid via the DC-AC inverter. The power electronic device isolates the wind or solar unit from the synchronous bulk power grid, therefore, the wind and solar is not designed to response the frequency excursion naturally. Secondly, the wind and solar energy is highly dependent on the weather condition therefore is highly uncertain and variable. This uncertainty and variability increase the difficulties for balancing the generation and demand therefore causes the frequency performance deteriorate than before.

In this dissertation, the major contribution is to design the more efficient and effective frequency responsive reserve methods to ensure the reserve adequacy and resource flexibility in handling deteriorating frequency performance. The frequency constrained economic dispatch is first proposed to incorporate the frequency dynamic constraint into economic dispatch problem to ensure sufficient primary and secondary frequency reserve. Then the model is extended to a stochastic unit commitment model with inertial, primary and secondary frequency constraints and the demand side frequency responsive reserve. The method for regulation reserve requirement is also proposed to meet the satisfactory frequency performance under normal operation condition. The Multiple Linear Regression model is applied to determine the real time regulation requirement for satisfying the target CPS1 metric. For the slower time scale, the high penetration of renewable energy can cause the insufficient flexible ramping capability. In this dissertation, the stochastic look-ahead economic dispatch model with deliverable flexible ramping product is presented to provide the sufficient ramping capability so that the frequency performance is improved and real time price spike is reduced.