The trend of renewable energy integration, power system size and complexity growth, occurrence of line contingencies, and more stressed loading conditions for power systems increase the threat of voltage stability, which has recently been among the main problems in power systems. Those factors cause uncertainty in power system, which make the existing conventional systems and control strategy insufficient to warrant the secure operation. For obtaining securer operation, design of wide area monitoring system (WAMS), which has more reliable performance than conventional system, is proposed in this work. The originalities of this thesis are described in two major parts, which are WAMS applications and phasor measurement units (PMUs) configuration, including the state estimation process.

First, the WAMS application is focused on how to secure the voltage stability under the uncertainty scenario. Scenarios are built as the combination of line contingency and renewable energy (RE) power fluctuation for the upcoming time-slot. For that purpose, a multistage preventive scheme based on voltage stability and security monitoring and control is developed for securing all of selected scenarios for the upcoming time-slot. A stochastic security-constrained optimal power flow considering voltage stability and renewable energy generation uncertainty, reactive power compensator tap re-operation minimization, and load shedding minimization problems are hierarchically implemented. Considering huge number of scenarios, the optimization problem size will become huge, for that a hybrid computation approach for solving optimal power flow (HC-OPF) is proposed, which make the problem can be solved within reasonable computation time. Furthermore, the problem is extended for re-scheduling of energy storage system (ESS) operation if a power system operates the ESS.

Second, WAMS is correlated to the PMUs configuration since they are the main component to warrant the WAMS performance. PMUs have advantages comparing to the conventional measurement in sampling rate and uniform sampling time. Design for PMU-based WAMS and WAMS hybrid are described in the second part. For PMU-based WAMS, novel PMU placement and state estimation procedure for PMU-based WAMS are proposed. A new PMU placement algorithm, which can minimize the number of PMU, considering network connectivity, ZIB, N-1 line contingency, system reliability and voltage stability level is proposed. By introducing the concept of system reliability, the proposed method can effectively reduce the number of PMU while ensuring the observability for major contingencies. Furthermore, state estimation technique considering measurement errors to increase the estimation accuracy based on time-series PMU data LAV estimator is proposed. Proposed state estimation method can minimize the estimation error which has been proven in fast system condition. For WAMS hybrid, the procedure to upgrade SCADA into WAMS systems by installing sufficient number of PMUs in the existing SCADA system and state estimation for PMU-SCADA data combination are described.
Optimal PMU placement is subjected to the improvement of estimation accuracy under contingencies considering some important buses. State estimation for WAMS hybrid manages the initial state variable and modifies the weighting factor strategy which is suitable for hybrid system especially during fast system condition change.

Several cases based on a modified IEEE 57-bus test system are used to demonstrate the effectiveness of the contributions. The simulation results show that the proposed methods can make an important contribution to improve voltage stability and security performance under uncertainty condition. Furthermore, the estimation accuracy of the overall power system is also increasing, which can improve the preciseness of the monitoring and controlling process. Optimal PMUs placement in a power system can be flexibly decided since the proposed methods give some option in selecting the important consideration.