Control Architecture for Intentional Island Operation in Distribution Network with High Penetration of Distributed Generation

Currently, a high penetration level of Distributed Generations (DGs), such as Wind Turbines (WTs) and Combined Heat and Power plants (CHPs), has been observed in the Danish distribution systems, and even more DGs are foreseen to be present in the coming years. With adequate DGs available, how to utilize them for maintaining the security of the power supply under the emergency situations, has been of great interest for study. One proposal is the intentional island operation. This PhD project is intended to develop a control architecture for the island operation in distribution system with high amount of DGs. As part of the NextGen project, this project focuses on the system modeling and simulation regarding the control architecture and recommends the development of a communication and information exchange system based on IEC 61850.

This thesis starts with the background of this PhD project, followed by an overview of three existing activities that are related to island operation. Afterwards, the experience of the planned island operation both in Bornholm, Denmark and Canada is discussed. Thereafter, an Islanding Security Region (ISR) concept is established based on which the Islanding Control Architecture with its associated coordination scheme (ICA) is designed. Moreover, an investigation of different factors that affect the ISR concept is performed, and different case studies about the ICA demonstration are conducted in DlgSILENT/ PowerFactory. Both the 2-Dimension ISR (with one lumped generator and one lumped load) and the 3-Dimension ISR (with one generator, one WT, and one lumped load) are plotted. The influence of the Demand as Frequency controlled Reserve (DFR) on the ISR is investigated. A specific coordination scheme between WT and load is designed and implemented. Furthermore, the feasibility of the application of Artificial Neural Network (ANN) to ICA is studied, in order to improve the computation efficiency for ISR calculation. Finally, the integration of ICA into Dynamic Security Assessment (DSA), the ICA implementation, and the development of ICA are discussed.