2014 Smart Grid R&D Program Peer Review

Project Summary

Project Title:	**Complete System-Level Efficient and Interoperable Solution for Microgrid Integrated Controls (CSEISMIC)**
Organization:	**Oak Ridge National Laboratory**
Presenters:	**Yan Xu, Guodong Liu**
FY 2014 Funding ($K):	**475**

Project Objectives, Significance, and Impact

Microgrids are the future of distribution system. The objective of the proposed project is to develop a microgrid controller with the complete functions. It is the central controller of the microgrid components, as well as the interface/agent between the distribution system and the microgrid by utilizing the most advanced technologies such as controls, power electronics, communication, and multi-objective energy management to fulfill the microgrid function requirements and support distribution system operation.

The CSEISMIC microgrid controller is the complete and integrated solution for microgrid control, operation, energy management and protection. It provides the solution to microgrid standardization, and reduces the total costs which will lead to large amount of deployment and commercialization.

The major benefits of the CSEISMIC microgrid controller is to improve the microgrid reliability, stability, efficiency and economic. In addition, the implementation of CSEISMIC can accommodate high penetration of distributed energy resources (DER), energy storage, electric vehicles, and demand response in microgrid, and transforms the conventional distribution systems more intelligent, more flexible, and more controllable smart grids. The most advanced technologies are adopted as well as incorporating legacy components and architecture since a microgrid will be likely upgraded from an existing system.

Technical Approach

This project is to develop the Complete System-Level Efficient and Interoperable Solution for Microgrid Integrated Controls (CSEISMIC). CSEISMIC is a microgrid controller which is consisted of MicroSCADA and MicroEMS. The MicroSCADA collects the real-time microgrid data, set the operation modes of the generation and loads to maintain system stability. It also communicates with the MicroEMS to send microgrid measurement data to it and receive optimization dispatch from it. The MicroEMS performs optimized power dispatch to meet operation objectives, receive commands from the upper stream distribution system operator to provide ancillary services. Therefore, the CSEISMIC is the interface/agent between the distribution system operator and the microgrid, and the control and management center of the microgrid and its components.

The CSEISMIC microgrid controller has both real-time control and energy management functions, including:

- Grid-connected and islanded operation modes
- Automatic islanding transition from grid-connected to islanded to provide uninterrupted power to microgrid loads during abnormal bulk power system conditions
- Resynchronization and reconnection from islanded mode to grid-connected mode
- energy management to optimize both real and reactive power generation and consumption
- provide ancillary services by participating in the energy market and/or utility system operation
- adaptive protection to overcome the drawback and ineffectiveness of the conventional distribution un-directional overcurrent protection

Technical Progress and Results

A three-bus microgrid including two smart inverters, one PV, one battery, and three R-L loads has been developed at the ORNL Distributed Energy Control and Communication (DECC) lab. The real-time control and operation functions, including on-grid and islanded operation, unintentional islanding, black start and reconnection have been implemented and tested in the microgrid.

Microgrid communication system with both polling and event functions has been implemented and tested in the DECC microgrid. The communication system is an Ethernet network and deploys different media including cable, fiber optic and wireless communication.

The ORNL microgrid system has been modelled in real-time digital simulator (RTDS), and different microgrid protection schemes have been implemented and tested in the hardware-in-the-loop test bed with SEL relays.

A coordinated three-stage MicroEMS including day-ahead bidding, hour-ahead dispatching

and real-time operation is under development. A hybrid stochastic/robust optimal day-ahead bidding strategy for microgrid has been developed considering the uncertainties of DERs, loads and market prices. The short-term dispatching algorithm co-optimizing real and reactive power of grid-connected microgrid has been developed.

Project Collaborations and Technology Transfer

ORNL has been collaborating with NIST on the microgrid standardized test bed development, and the NIST SGIP Subgroup C on microgrid standard framework development.

National Instruments (NI) is a partner with ORNL on the development of microgrid controller. Microgrid controller is being migrated from lab environment (dSPACE-based hardware) to NI's industrial embedded control modules which can be implemented in field testing in the future.

ORNL and the research institute of Hydro-Quebec (IREQ) are working on real-time modeling, microgrid protection and other microgrid R&D areas under a Memorandum of Understanding.