2014 Smart Grid R&D Program Peer Review

Project Summary

Project Title:	**Integrated Smart Distribution RD&D Project**
Organization:	Alstom Grid
Presenters:	S. S. (Mani) Venkata, Melanie Miller, Kevin Schneider, Glenn Brice
FY 2014 Funding ($K):	1,560

Project Objectives, Significance and Impact

The primary objective of this project is to leverage the intelligence of, and information provided by, sensors, energy boxes and smart meters to integrate DER with current DMS to enhance optimal performance of the emerging distribution system. This builds on the **DOE Vision** towards an Intelligent North American Grid by 2030.
Significance and Impact: The results of this project, when implemented, will improve the load factor, efficiency, reliability and safety to meet the **2020 DOE Smart Grid R&D** Cost and Performance Targets. This will be achieved by focusing the RD&D on 13 R&D areas described below. **Duke Energy** goals align well with this project thrust. One goal is to facilitate technical and market development for emerging technologies. Another is to explore new operational requirements and business models. Also the capability to integrate DER in real-time software and control systems, monitor/analyze distribution circuits and interoperability of solution using smart grid test tools need to be verified.

Technical Approach

The technical approach for 12 different research and development areas investigated are delineated below:
DER Modeling: Tested different charging electric vehicles (EVs) to develop a single generic load model. **Advanced and Adaptive Protection**: Analyzed problems and issues in smart distribution grids introduced by distributed generations and energy resources. **Fault Location Using PMUs:** Explored three-phase apparent impedance based fault location estimation and an iterative approach for resistive fault based fault location identification **Voltage VAR Control/Optimization Using PMUs**: Leveraging the characteristics of measurements from PMUs, such as high resolution and accuracy, phase angle information for both voltage and current singles. **Load Forecasting**: Focused on short-term load forecasts at a substation and feeder level. **Communication Architectures:** Explored communication schemes, protocols and interoperability standards. **Market Integration of DERs**: Analyzed the market rules and data

flows to determine the impacts and necessary changes to facilitate the integration of DERs. **Secondary Distribution Modelling:** Used Duke data and multistate load models in GridLAB-D **Microgrid Protection**: Focused on reducing costs of microgrid protection by minimizing the number of required protection devices. **Solar Swing Mitigation**: Analyzed the impact of photovoltaic (PV) active power and voltage swings within a distribution system. **Cold Load Pickup:** Looked at estimating load growth due to loss of diversity from an outage. **DG Back feed Mitigation:** Developed an engine to optimally raise the net load to prevent backed onto the transmission grid.

Technical Progress and Results

The technical progress and results for the 12 areas explored are described below:

DER Modeling: Testing of four different EVs has shown that a single generic load model cannot be made. **Advanced and Adaptive Protection**: Designed a new protection system which consists of several customized schemes for various conditions and scenarios for a distribution system. **Fault Location Using PMUs:** Developed synchrophasor based fault location methods. **Voltage VAR Control/Optimization Using PMUs**: Currently developing an optimal plan considers all types of equipment with capability of voltage and/or reactive power regulation. **Load Forecasting**: Developed neural networks trained by Kalman filters for short term load forecasting. **Communication Architectures:** Developed multi-tier, distributed intelligent communication nodes and corresponding architecture. **Market Integration of DER**: Determined the added value of DER production based on network conditions. **Secondary Distribution Modelling:** Modeled an entire Duke substation in GridLAB-D down to end use devices. **Microgrid Protection**: Developed an adaptive protection scheme based on distributed differential protection. **Solar Swing Mitigation**: Developed an algorithm to disconnect solar when its output swings cause voltage problems. **Cold Load Pickup and DG Back feed Mitigation:** Developed and deployed pilot software at Duke.

Project Collaborations and Technology Transfer

The project team is composed of **Alstom Grid**, the primary contractor and **Duke Energy** as the host utility; and three subcontractors: **University of Washington**, which is working on communication infrastructure and interoperability standards, network and market models; **PNNL**, which is developing DER assets and load models within GridLAB-D; and **University of Connecticut**, researching bottom-up load forecasting techniques for integration of DERs. Technology transfer has occurred through piloting software at Duke Energy on several substations for some selected use cases such as cold load pickup, DG backed, and DER visualization. This software is connected to live field data from SCADA and the Duke production DMS. Additional technology transfer has occurred in the form of 11 journal articles and conference presentations on several of the research topics including: Electric vehicle load modeling, microgrid protection, fault location with PMUs, and Cold Load Pickup.