2014 Smart Grid R&D Program Peer Review

Project Summary

Project Title:	**Microgrids as a Resiliency Resource** (PNNL-SA-103187)
Organization:	Pacific Northwest National Laboratory/ Washington State University
Presenters:	Kevin Schneider & Chen-Ching Liu
FY 2014 Funding ($K):	PNNL-380 WSU-150

Project Objectives, Significance, and Impact

The objective of this work is to increase the resiliency of the nation's electric infrastructure via the integration of microgrids. Increased resiliency can be achieved by using microgrids to support their own critical loads, community critical loads, and/or to act as a black start resource. This objective arises out of the need to address the extreme weather events that are becoming more common, and for which the nation's electric infrastructure was not designed. Microgrids have proven to be an effective resource for critical loads during events that have disabled the utility power systems. Despite their ability to maintain continuity of service during extreme events, there are only a modest number deployed in the United States; around 200 depending on the specific definition of what constitutes a microgrid. This work is attempting to accelerate the adoption of microgrids by providing open source tools that will allow various stakeholders to better evaluate how microgrids can be designed and operated. The use of these tools represents a one-time, non-recurring engineering cost that will provide monetary benefit over the entire life cycle of the microgrid. By making the deployment of microgrids a more attractive proposition, the adoption rate will increase, and if properly coordinated, will increase the resiliency of the nation's electrical infrastructure.

Technical Approach

The technical approach for this project is divided into two main areas that are closely coordinated. The first is the development of openly available distribution-level dynamic simulation tools, which is led by Pacific Northwest National Laboratories (PNNL). The second is the use of microgrids to enhance fast recovery of distribution systems, which is led by Washington State University (WSU). The two focus areas are coordinated through the use of a common system model and plan to integrate their function in FY15. The overall goal is to develop the tools necessary to utilize microgrids as a customer resource, a community resource, and as a black start resource.

The dynamic simulation capabilities that are ubiquitous at the transmission level are nearly absent at the distribution and microgrid level. When dynamic studies are conducted, they often use simplified system models implemented in an electromagnetic type solver. The result is a limited set of studies that examine a small set of issues with a high level of detail. What is needed is a dynamic simulation capability similar to the transmission standards, which allows for a large number of full size detail models to be used to examine numerous issues. This broader capability will help accelerate the adoption of microgrids as a resiliency resource.

In addition to the need to properly analyze a system to best determine its design and operation, it is also necessary to best utilize the available resources. For a microgrid, this is essential during the restoration and recovery phase. Developing an optimal method for restoring the system, that includes constrains such as phase voltage, ensures the maximum amount of critical load is restored in the minimum amount of time.

Out year work will completely integrate this work by developing a restoration and recovery scheme that includes not only static voltage constraints, but also dynamic stability constraints. This will include operations not only within the microgrid, but also external to it to support the use of microgrids as a community and black start resource.

Technical Progress and Results

At this point a complete dynamic model of the WSU system, including portions of four Avista utility feeders, has been completed. This system is designed to be an example of a community resource where the generators on the WSU campus are used to augment the generating capabilities of the Pullman City hospital and City Hall; City Hall is where the emergency control center is located. This model has been used to test and evaluate the unbalanced dynamic simulation capabilities that have been developed in the GridLAB-D simulation environment. This same dynamic model has also been used by WSU to evaluate their spanning tree-based restoration and recovery scheme that can include multiple microgrids and single phase voltage constraints. Taken together, this work provides a set of tools that can be used to evaluate methods to integrate microgrids into an effective resiliency plan.

Project Collaborations and Technology Transfer

This project has been a joint effort between the PNNL, WSU, and support from Avista Utilities. This work has built on numerous prior collaborations that have included Iowa State University and Oak Ridge National Laboratory. The voltage constraint functionality of GridLAB-D has also been used in collaboration with Sandia National Laboratories and Lawrence Berkeley National Laboratories (LBNL) to support the Microgrid Development Tool.

The specific work conducted by PNNL and WSU has been made available to the greatest extent possible; the specific dynamic model that includes portions of the Avista Utilities feeders cannot be shared. Activities directed at increasing awareness of this work and transferring technology include:

1) **Journal Papers**: 1 accepted, 1 submitted, 2 additional in development
2) **Conferences and Workshops**: 2 workshop presentations
3) **Open Source**: all development work has been done in the open source GridLAB-D simulation environment. The base modeling capabilities are available through SourceForge.