2014 Smart Grid R&D Program Peer Review

Project Summary

Project Title:	**CERTS Microgrid Test Bed**
Organization:	Lawrence Berkeley National Laboratory on behalf of University of Wisconsin, American Electric Power, Sandia National Laboratories, Ohio State University
Presenters:	Joe Eto, Lawrence Berkeley National Lab Bob Lasseter, University of Wisconsin
FY 2014 Funding ($K):	380K (Note: LBNL research and funding for DER-CAM is the subject of a separate presentation at this peer review

Project Objectives, Significance, and Impact

Project Objective: To lower the cost and improve the performance of clusters of smaller distributed energy resources and loads when operated in an integrated manner, i.e., as a microgrid

Significance and Impact: CERTS microgrids have broad applicability in systems that require higher reliability (outage reduction for critical loads by >98%) at lower cost than the standard utility grid can provide. Specifically, CERTS microgrids can:

- Continue to operate with loss of the central control system.
- Reduce total costs through the inclusion of direct connected synchronous generators.
- When islanded, survive the unplanned loss of generation (or storage) through graceful degradation.

For smaller microgrid projects involving multiple distributed energy resources (< 10 MW total installed capacity) the costs associated with traditional approaches for equipment selection,

dispatch/operation, and field or custom engineering/project commissioning can easily represent 30-50% of total project costs. This project seeks to reduce these costs by up to 90%.

Technical Approach

The CERTS Microgrid Test Bed has been expanded through the addition of new hardware elements: 1) a CERTS-compatible conventional synchronous generator; and 3) a commercially available, stand-alone electricity storage device with CERTS controls. In addition, a smart load functionality has been implemented with existing equipment.

The technical approach for addressing each of the project objectives are as follows:

Reduce load outages by ~ 98% (similar to a UPS)

- Fast islanding (~1 cycle)
- Provides for a stiff voltage during all events (similar to an SVC)

Reduce complexity, provides greater modularity & lower cost

- Minimizes engineering errors/cost/and maximizes flexibility using plug-and-play concepts (plug-and-play allows for design & expansion with minimum engineering cost)
- Autonomous local control (independent of loss of central controller)
- Simplify design and construction of mixed DER microgrid
- Graceful degradation

Reduce emissions and improve energy efficiencies

- Increases effectiveness of Combined Heat & Power (CHP)
- Enables integration of local renewables (e.g., PV)
- No transmission and distribution losses
- Facilitates demand side management
- Supports provision of ancillary services

Technical Progress and Results

Direct connected synchronous generators:

- Installed and commissioned a CERTS governor and exciter (at the UW lab and Santa Rita Jail)
- Demonstrated use of an external controller (Woodward) on a standard NG gen-set to achieve CERTS performance. (at AEP test bed and by OSU through simulation)

Energy storage:

- Demonstrated effectiveness of CERTS controls (at the UW lab and Santa Rita Jail)
- Implemented non-CERTS controls to meet functional specifications (at Princeton Power factory; commissioning at AEP test bed has started).

Graceful degradation (through autonomous load shedding with loss of energy source)

- Completed smart load shedding without loss of a source.(at AEP test bed and by OSU through simulation)

CERTS PV:

- Wei Du, Qirong Jiang, M. Erickson, R.Lasseter, *"Voltage Source Control of PV Inverter in a CERTS Microgrid,"* Accepted for publication IEEE Transaction on Power Delivery, 2014
- Wei Du, R.Lasster, "*Voltage Source Control of PV Inverters in CERTS Microgrids Report,"* 6/20/2013

CERTS Electrical Vehicle Charging Station:

- Phil Hart, R.Lasseter, Investigation of Hybrid CERTS Microgrids with Droop-Controlled AC and DC Buses for Use in Electric Vehicle Charging Stations report, Jan 2014
- P.J. Hart, P.J. Kollmeyer, L.W. Juang, R.H. Lasseter, T.M. Jahns, *"Modeling of Second-Life Batteries for Use in a CERTS Microgrid"* ECCE 2014

Project Collaborations and Technology Transfer

The CERTS Microgrid Project Team consists of:

Lawrence Berkeley National Laboratory
University of Wisconsin
American Electric Power Company
Sandia National Laboratories
Ohio State University

Research partners currently include:

TeCogen
Woodward
Princeton Power

Project Team members are involved in a number complementary activities

SMUD microgrid field demonstration
Chevron microgrid field demonstration at San Ramon
Maxwell Air Force Base microgrid demonstration
International Microgrid Symposium
In addition the project team is in discussions with a wide variety of potential field demonstration partners and microgrid equipment manufacturers

The AEP Test Bed has hosted visits by over 30 domestic and international tour groups since 2011.