2012 Smart Grid R&D Program
Peer Review Meeting

The CERTS Microgrid Test Bed

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7 June 2012

The CERTS Microgrid Test Bed

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 microgrids

Life-cycle Funding Summary ($K)

Prior to FY 12	FY12, authorized	FY13, requested	Out-year(s)
2500K	1000K	1000K	2500K

Technical Scope

The CERTS Microgrid Test Bed is being expanded through the addition of new hardware elements: 1) a CERTS-compatible conventional synchronous generator ; 2) an energy management system relying on software as a service (SaaS) for dispatch; 3) a commercially available, stand-alone electricity storage device with CERTS controls; and 4) a PV emulator and inverter with CERTS controls.

The DER-CAM model is being enhanced and commercialized through an approach known as a “software-as-a-service.”

The International Microgrid Symposium is held annually

Significance and Impact

Microgrids can enhance the values that DER offer:

Customer benefits include: bill savings, price certainty, reliability (including power quality), energy independence

Grid benefits include: a well-behaved electrical “citizen;” in the future: a grid resource

Societal benefits include: more resilient local energy infrastructure, increased environmental benefits

The CERTS Microgrid Project is recognized internationally as one of the leading microgrid R&D activities

Significance and Impact

For smaller projects involving multiple distributed energy resources (< 10 MW total installed capacity), the “non-equipment” 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% or more, and dramatically reduce the uncertainties associated with estimating them in advance.

Significance and Impact

CERTS Microgrid concepts directly support OE's Smart Grid R&D long-term goals:

Self-healing Distribution Grid for Improved Reliability

- seamless islanding and resynchronization
- autonomous peer-to-peer voltage and frequency control

Integration of DER/DR/PEV for Improved System Efficiency

- autonomous peer-to-peer voltage and frequency control
- plug and play

The CERTS Microgrid Test Bed project seeks to achieve these goals by reducing the systems integration cost of smaller distributed energy systems through:

- lower site-specific, custom engineering costs for commissioning and lower on-going maintenance costs
- software-as-a-service for optimal (more cost-effective) equipment selection and efficient (lowest cost) dispatch

Technical Approach and Transformational R&D

The CERTS Microgrid Concept

Promotes intentional islanding

- Clusters loads with Distributed Energy Resources.
- Enables islanded DER units to coordinate output autonomously to meet load demand.
- Provides for load shedding when needed.
- Insures stability for multi-sourced systems.
- Seamlessly separates & automatically re-synchronizes with the grid.

Designed for high reliability

- Insures redundancy: n + 1 sources.
- Based on autonomous local control for fast events (No central controller)
- Minimizes engineering errors/cost/and maximizes flexibility: uses plug-and-play peer-to-peer models

Technical Approach & Transformational R&D

GENERALIZED TECHNICAL APPROACH

Analysis -> Detailed Simulation -> Bench-Scale Testing -> Prototype Specification -> Factory/Field Acceptance Testing of Prototypes -> Component and Full System Tests at AEP -> Field Demonstrations with External Partners (e.g., Santa Rita Jail)

KEY ELEMENTS OF TECHNICAL APPROACH FOR EACH TECHNICAL CHALLENGE

Synchronous generator – Acquire a synchronous generator; implement CERTS control algorithms in governor controls

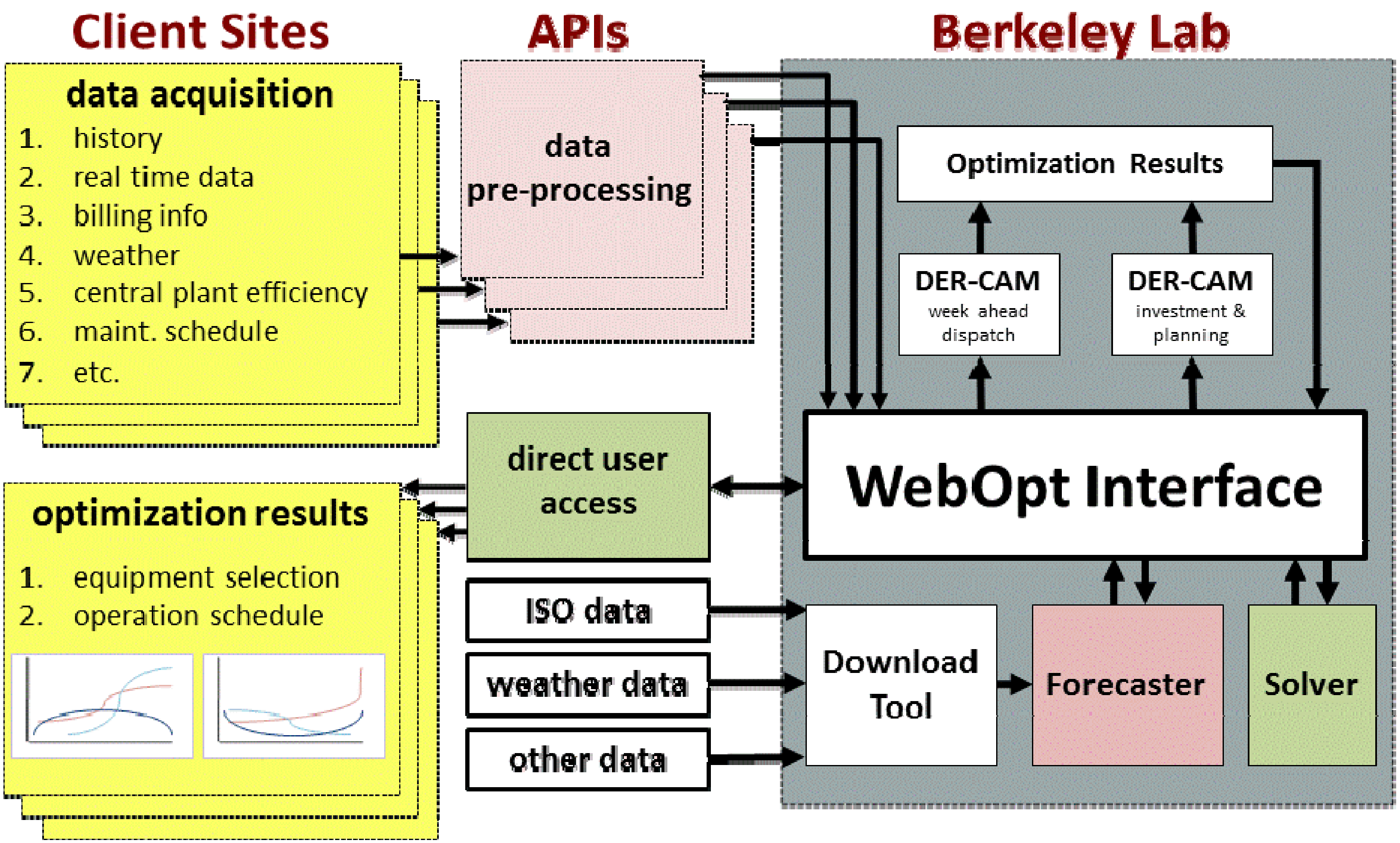
Intelligent load shedding – Install under-frequency relays with adjustable settings for amount of load shed, frequency trip points, and delay times

Storage – Install a conventional storage system (lead-acid batteries); implement CERTS control algorithms

PV – Acquire a PV emulator; implement CERTS control algorithms

Technical Approach & Transformational R&D

Access to DER-CAM via SaaS (WebOpt)



Technical Accomplishments

FY10 - Completed simulations and bench-scale testing for synchronous generator. Modified test bed, installed commercial-grade inverter-based generator (TeCogen Inverde), and repeated system tests. Established server to run DER-CAM optimization as a SAAS. Coordinated International Microgrid Symposium held in Canada.

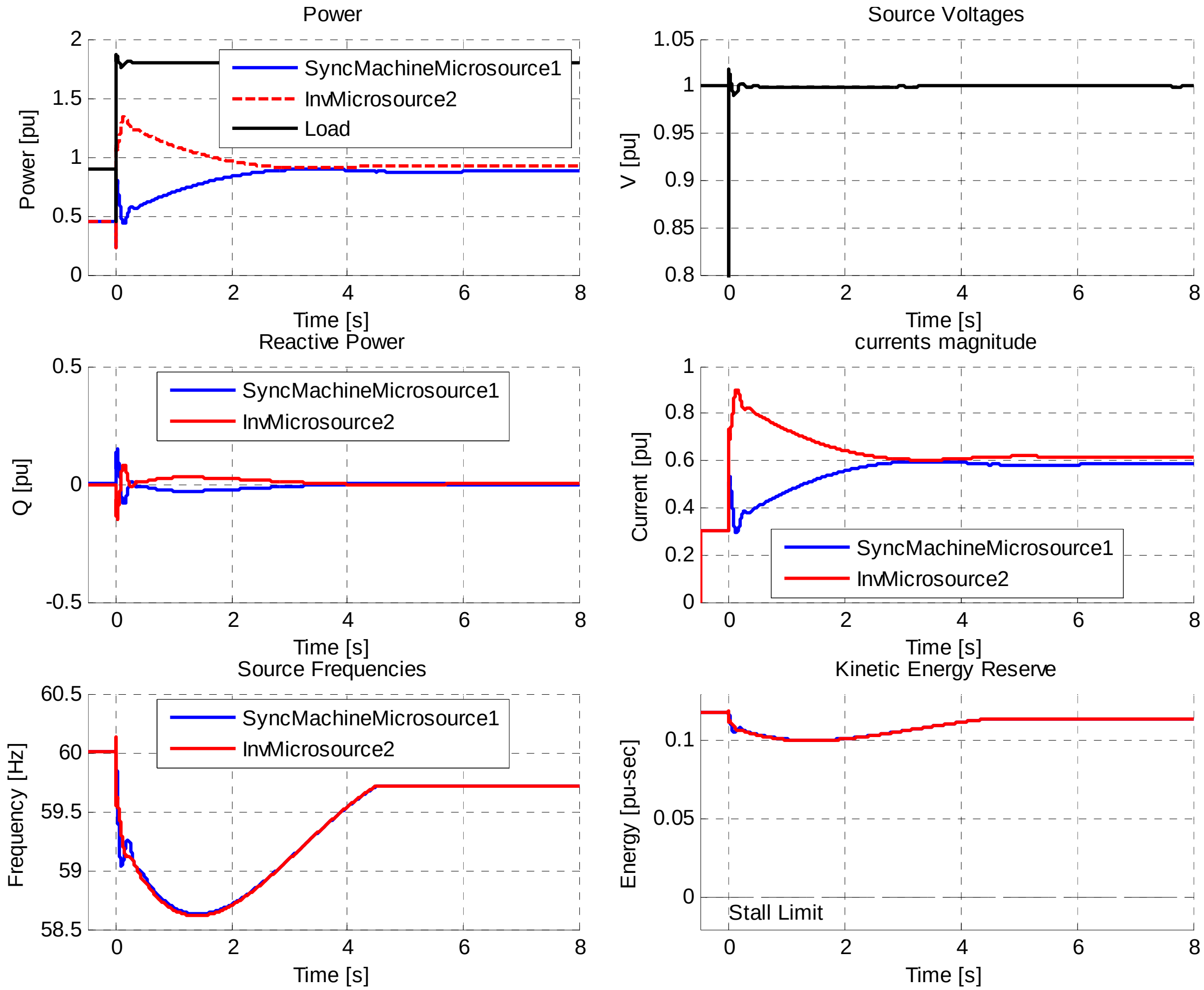
FY11 – Completed simulations on state-of-charge management approaches for energy storage. Installed mechanical switch, repeated static switch tests. Prepared specifications for synchronous generator and energy storage unit. Implemented remote interface between DER-CAM and AEP dispatch EMS. Coordinated International Microgrid Symposium held in South Korea.

FY12 – Completed simulations on PV inverter. Installed synchronous generator (Apr) and complete commissioning tests, including more detailed modeling of stalling behavior (Aug). Install energy storage unit (Sep-Oct). Conduct initial intelligent load shedding tests (Nov.). In discussion with vendors to license DER-CAM and offer it commercially as SAAS. International Microgrid Symposium to be held in Portugal (Sep).

Out-years through FY15 – Complete synchronous generator testing (FY13); complete energy storage testing (FY14); complete PV emulator testing (FY15). Commercialize DER-CAM SAAS (FY13) and ad full stochastic and non-linear (efficiency curves) capabilities. Coordinate International Microgrid Symposia (FY13, FY14, FY15).

Technical Accomplishments

Load transient with inverter and synchronous genset system. Power set point of the genset and inverter is 0.45 pu. Both utilize frequency droop.



Technical Accomplishments

- SaaS demonstrated at University of New Mexico (UNM) building, with closed loop to building control system. DER-CAM optimization data is channeled back to UNM building and interpreted by Delta controller and used to control local storage, absorption chiller, and solar thermal.
- first functional SaaS web-optimization (WebOpt) with heat pump capabilities deployed
- developed basic stochastic optimization framework and demand response (DR) capabilities and tested them with Santa Rita Jail conditions
- worked with Air Force and subcontractors to launch L.A. AFB ESTCP PEV demonstration project
- invited 7 international researchers and students to Berkeley Lab
- submitted 10 DER-CAM conference abstracts and three journal papers for review
- began work on an invited smart grid opinion piece for Nature magazine
- strengthened collaboration with industrial partners Bosch and NEC
- visited three universities in China (Tongji, Tianjin, and Hangzhou Dianzi) and the Institute of Electrical Engineering of the Chinese Academy of Science (IEE)
- continued chairmanship of CIGRÉ Microgrids Evolution Roadmap working group
- continued organizing the Microgrid Symposium

Project Team Capabilities & Funding Leverage

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 Santa Rita Jail
- Maxwell Air Force Base microgrid demonstration
- International Microgrid Symposium
- Bosch, NEC

In addition the project team is in discussions with a wide variety of potential field demonstration partners and microgrid equipment manufacturers

Project Team Capabilities & Funding Leverage

Visitors to AEP Dolan Test Laboratory since 2011

Hawaiian Electric + Texas A&M
Raytheon Microgrid
Ohio House Committee on Alternate Energy
KEMA + CPFL (Brazil)
Tokyo Electric
UCAIug OpenSG - 80 utility members
International Microgrid Consortium tour group
State Grid of China
Ohio Green Energy Open House
Tokyo Electric
Eisenhower Fellows
Arts Impact Middle School
Consert EMS Tour
HD Supply Tour
Battelle RTP Team
Energy Conversion Devices

Kyushu Electric and Hitachi
GE Energy
Cooper Power Systems
Energy Conversion Devices + Ovonics
Rexorce Waste Heat Recovery
Panasonic Home Energy Manager Team
Chevron
EPRI Intelligrid meeting - 50 members from various utilities
Ohio State Student Group
AEP Coop Students
University of Michigan Group
Columbus State University
Chung Yuan Christian University
Ohio Secretary of State

Contact Information

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Back-up Slides

CERTS Microgrid R&D Timeline

DOE Transmission Reliability Program – 1999-2002

Development of original concepts
Simulation and bench-scale testing
Assessment of potential test bed sites
Creation of software tools (DER-CAM, mu-Grid)

CEC PIER Energy Systems Integration Program – 2001-2006

Construction of AEP CERTS Microgrid test bed
Completion of proof-of-concept CERTS Microgrid tests

DOE RDSI – Chicago Program Office – 2006-2009

Value and technology assessment to enhance the business case

DOE Smart Grid Program – HQ – 2009-current

Integration of variable renewable generation/storage

Technical Approach & Transformational R&D

"A **microgrid** is a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode."

Microgrid Exchange Group. October 2010

Distinguishing features of the **CERTS Microgrid *Concept***

- Seamless islanding and reconnection via single Point of Common Coupling
- Peer-to-peer, autonomous coordination among micro-sources (w/o high bandwidth communications)
- Plug-and-play - no custom engineering
- Energy manager on arbitrary platform

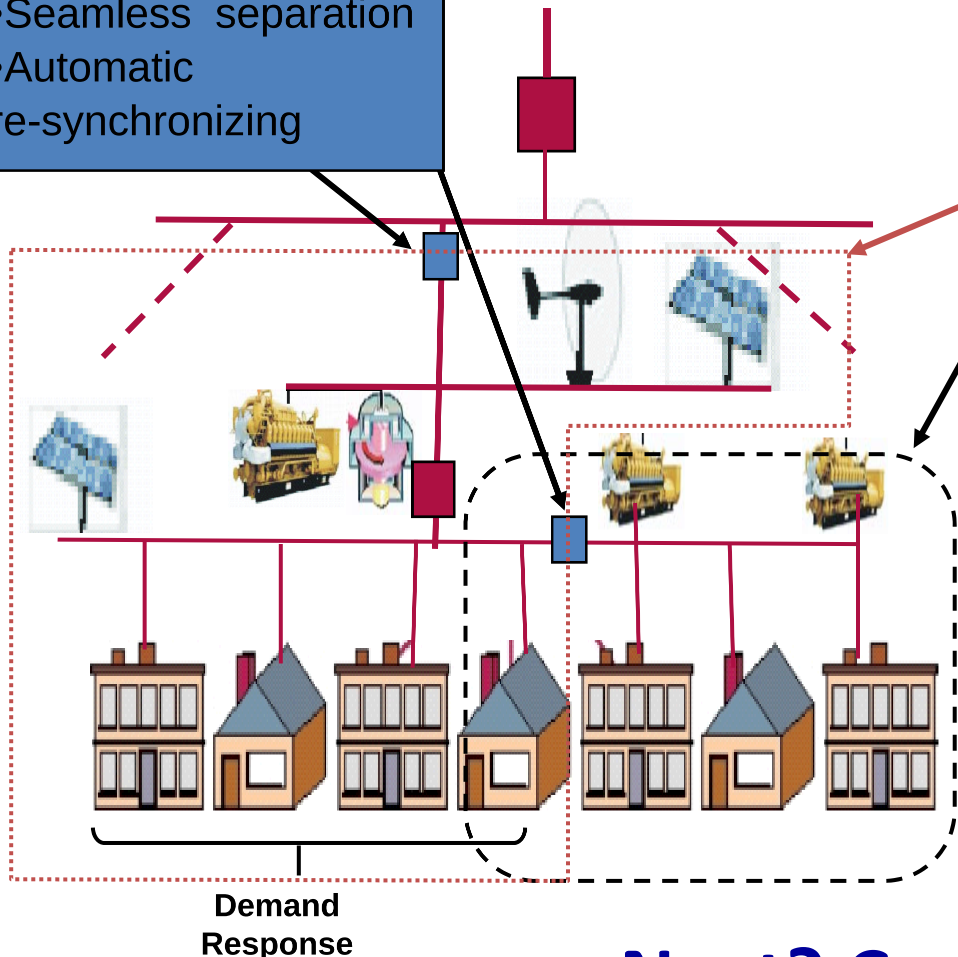
Distinguishing features of the **CERTS Microgrid *Test Bed Demonstration***

- Small sources (<100 kW each)
- No stand-alone storage (yet)
- No power flow onto the grid (yet)

Technical Approach & Transformational R&D

Smart Switch:
- Seamless separation
- Automatic re-synchronizing

Two coupled microgrids:
- Distribution level
- Customer level with high *Local Reliability & CHP*



Next? Coupled Microgrids