Arnold Schwarzenegger
Governor

CERTS MICROGRID LABORATORY TEST BED

Technical Advisory Committee Meeting Summary and Review Comments

APPENDIX O

Prepared For:
California Energy Commission
Public Interest Energy Research Program

Prepared By:
Lawrence Berkeley National Laboratory

CERTS
CONSORTIUM FOR ELECTRIC RELIABILITY TECHNOLOGY SOLUTIONS

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Fifth Meeting of the
Technical Advisory Committee for the
California Energy Commission Public Interest Energy Research
CERTS Microgrid Test Bed Project

30 April 2008
Lawrence Berkeley National Laboratory
Building 90 Room 4133
1 Cyclotron Road, Berkeley, CA

Meeting Summary

Participants

Technical Advisory Committee	
	Merrill Smith and Steve Waslo, U.S. Department of Energy
	Ben Kroposki, National Renewable Energy Laboratory
	Mohammed Vaziri, Pacific Gas and Electric Co.
	Tom Dossey, Southern California Edison
	Mark McGranaghan, EPRI Solutions
Guests	Eric Wong, Cummins
	Dave Potter, Chevron Energy Solutions
CEC	Bernard Treanton, Steve Ghadiri
CERTS	Joe Eto, LBNL
	Ben Schenkman, Sandia National Laboratories
	Robert Lasseter, University of Wisconsin/PSERC
	Ed Linton, Northern Power
	Bob Panora and Jean Roy, Tecogen
	Dave Klapp and Ray Hayes, American Electric Power

Meeting Purpose: Introduce test bed results; initiate technical review process

Summary of TAC, CEC, and guest's overall impressions/comments

Concepts are elegant, yet simple. Simple translates to more affordable.

Demonstration that static switch can comply with 1547, with non-compliant generation behind it, is a major accomplishment. The team has confirmed that a static switch is very fast. It is recognized that ground fault testing on the utility side of the static switch is still missing from this aspect of 1547 compliance.

Inverter controls are impressive.

Test plan was well laid-out. A wide range of concerns that were identified have now been successfully addressed. In particular, motor starting was a challenging test and the results are very encouraging. Should be a major contribution to the literature.

The test bed platform should be used for future research.

Next Steps – CEC Final Report

Technical review comments due to J. Eto on May 23, 2008

Be careful to ensure consistent presentation of transient information alongside of steady state information in graphics and tables reporting testing results

Explain clearly why inverters were observed to put out such apparently high fault currents and what options do or do not exist to limit them within the current inverter design.

Next Steps – DOE RDSI award (as part of already specified tasks to: reduce internal protection costs, optimize DC storage, examine AC storage, and incorporate non-inverter-based synchronous generation sources)

Determine whether and how to conduct ground fault testing on utility side of static switch.

Conduct harmonic testing.

Conduct longer term tests in an effort to capture microgrid response to power quality events.

Next Steps - general

Conduct outreach. Publish results in refereed archival literature (e.g., IEEE Transactions). Prepare functional specifications defining core elements and performance requirements of the CERTS Microgrid Concept.

Support DOE and CEC in developing presentation materials they can use in describing work to lay- and non-technical audiences and to help defend research budgets.

Expand research focus to include role of energy manager. Consider, specifically, automatic adjustment of inverter power and voltage setpoints to regulate real and reactive power at the PCC

Examine flows onto the grid.

Explore physical and cyber security issues that might be addressed by microgrids.

Additional comments from Southern California Edison, received May 16, 2008

Thank you for the opportunity to review the tests that have been performed on the CERTS Microgrid. As demonstrated in the documentation provided and especially through the detailed procedures of the test plan developed by AEP, this testing appears to have been comprehensive and adequate to demonstrate the operational capabilities of the systems and designs.

We note that for the most part the components of CERTS Microgrid performed as expected, and could transition from a grid-connected to an autonomous operating mode without adversely affecting the quality of the power supplied to the test loads. This is an important step and such operation will be a necessary feature of a commercial system. We would also like to highlight the very desirable concept demonstrated through your project and testing: i.e. the use of simple existing communication and control concepts where applicable, such as the use of local/device frequency droop controls. We applaud your technical progress that supports an outlook that a smart grid is not necessarily a complex grid dependent on extensive custom engineering and systems.

We look forward to the next steps in the development trail and will be pleased to continue to support the concept and project.

Please feel free to contact either of us if you have questions.

Tom Dossey, Charlie Vartanian
Southern California Edison
Distributed Energy Resources

Additional comments from Pacific Gas and Electric, received May 24, 2008

Based on the notes I took during our April 30, 2008 advisory committee meeting, my comments are as follows:
1 - The results from the tests conducted so far seemed reasonable and in many cases better than anticipated.
2 - The static switch seemed to have successfully paralleled the systems without any troubles or need for a centralized communication system. This is certainly a positive result with good potential.
3 - For the phase and ground fault tests within the micro grid system, the results seemed correct and reasonable.
4 - For documentation purposes, the conditions (such open/closed switches, loading conditions, etc.) for each test case should be identified on the corresponding diagram to avoid any confusion.
5 - There was some confusion about the maximum output from the inverter based units. In some cases, up to 6.0 P.U. outputs was reported and discussed which was surprising to some of attendees. Careful measurements should be taken during faults to clarify this.
6 - Still to be verified is the following:

Tests need to be conducted to verify "Detection and timely clearing of Phase-Phase, 3 Phase, and especially Line-Ground faults on the Utility System, while the micro grid is in parallel operation with the utility." With a "Delta" connection on the utility side windings of the main interface transformer, conventional detection of ground faults on the utility system would require a grounding transformer. This has been pointed out all along from the beginning of the project. All Generating facilities are required by IEEE 1547 to detect and isolate their systems from an electrical fault on the utility system.

Regards,
Moh

Response to Pacific Gas and Electric, sent by project team on June 4, 2008

Thank you for attending the TAC meeting at LBNL and your comments below. Let me see if I can help clarify some of the questions that you mention below regarding the testing done so far.

4 - For documentation purposes, the conditions (such open/closed switches, loading conditions, etc.) for each test case should be identified on the corresponding diagram to avoid any confusion.

We completely agree with this. We will be working on the information presentation for the future phases of the project so that its both easier to understand as well as explain to others.

5 - There was some confusion about the maximum output from the inverter based units. In some cases, up to 6.0 P.U. outputs was reported and discussed which was surprising to some of attendees. Careful measurements should be taken during faults to clarify this.

We have discussed this further with Tecogen and Youtility. Their position is that this test result was expected. The inverters are 125kW rated devices although we are artificially limiting them to half that. They are also currently setup to deliver ~2.5pu fault current. This works out to ~550A peak, close to the ~600A number we were discussing. Tecogen is formalizing a more detailed response for the TAC group which will be included in the final report for this phase. In the next phase we are planning to adjust the inverters and retest to prove that the inverter fault current can be controlled to a desired level as needed by installed application. If you have suggestions as to what this fault contribution should be please let me know.

6 - Tests need to be conducted to verify "Detection and timely clearing of Phase-Phase, 3 Phase, and especially Line-Ground faults on the Utility System, while the micro grid is in parallel operation with the utility." With a "Delta" connection on the utility side windings of the main interface transformer, conventional detection of ground faults on the utility system would require a grounding transformer. This has been pointed out all along from the beginning of the project. All Generating facilities are required by IEEE 1547 to detect and isolate their systems from an electrical fault on the utility system.

The detection and times of the clearing for the different types of faults on the system are in the CERTS Microgrid Report Section 7.0 that I have attached to this email. We will have to figure out how to test a single line-to-ground fault on the utility side because I don't think AEP will just allow us to deliberately put a fault on their system.

The protection testing performed to date does show that the microgrid detects; phase to phase, 3 phase, and phase to ground faults within the microgrid. As you know in a wye-wye system these types of faults would appear very similar whether in the utility or within the microgrid. The biggest difference would be the measured magnitude of the fault which depends on a large number of variables. To date the faults we have tested have also been very low grade faults better described as overloads to the system. This was done to minimize the risk to the system while we worked out the protection scheme. At some point in the future we will be performing higher grade faults up to and including bolted faults. This has been the plan all along but we have just not reached it yet. Your point about the delta transformer is also well taken and we are looking into alternatives, a grounding transformer is one possibility. My hope is to replace the delta this with a wye-wye and monitor the microgrid operation during unscheduled utility faults. As Ben stated our company will not let us intentionally fault our own distribution system but there is no reason we can't try to capture a naturally occurring one.

Ben Schenkman
Dave Klapp

Additional comments from National Renewable Energy Laboratory, received May 28, 2008

Sorry for the delay. I have been too busy getting ready for Kythnos. I am in Greece now, so my comments will be short.

1) Add labels to the components of the aerial photo of the CERTS microgrid. This would make the good photo used throughout the report more useful to people not familiar with the project.
2) Add conclusions section to Sections 6,7,8 and 9. In the conclusions section add a summary table that summarizes the tests and important results. This is in the text, but difficult to find as presently written.
3) Recommendations: additional test to determine fault current level and time from the DGs.
4) Overall this is very important work. I think it would be useful to include a report or link to a description of the droop control method that is being used by the DGs. Bob's presentation at the meeting discussed this a little but I don't see it included in the reports. This would make for a more complete package.

Ben Kroposki
NREL