Enhance Business Case for CERTS Microgrid

Bob Lasseter

University-of-Wisconsin

26 May 2006

Research Team

American Electric Power

Lawrence Berkeley National Laboratory

Sandia National Laboratories

University of Wisconsin

Northern Power Systems

Tecogen

Youtility Inc

Microgrid Objective

Create a mature system approach which allows for high penetration of DER equipment by providing a resilient platform for plug and play operation, use of waste heat and intermittent sources and enhance the robustness and reliability of the T&D system.

CERTS Mircogrid Activities

CERTS Microgrid Test Bed Status

- Concepts
- Factory test results
- Status of AEP site
- Test plan

DOE Enhanced Business Case for Microgrid

- Objective
- Key tasks
- Schedule & cost

Challenges for CERTS Microgrid

Intentional islanding

- Seamless transfer
- Automatic load balancing

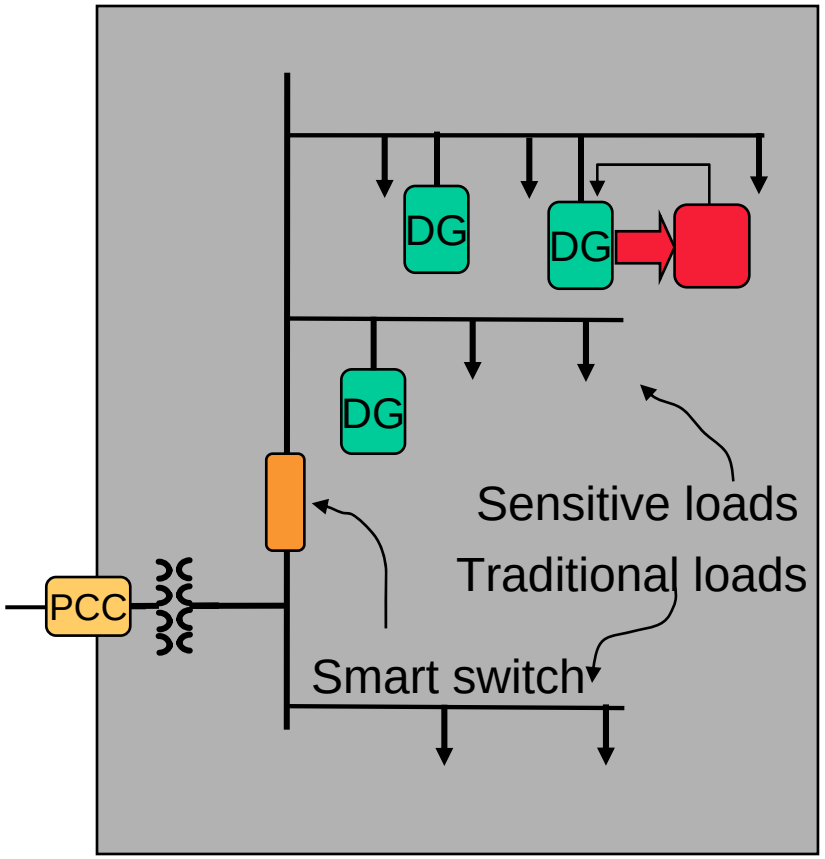
When in island operation

- Protection issues due to low short circuit fault currents
- Needs voltage and VAR support
- Automatic load tracking without using power dispatch

Reliability

- Plug-and-play & peer-to-peer source model
- Modularity (n+1 units)
- Independent of command and control system

CERTS Microgrid architecture



Objectives

- Promote CHP
- Provide for digital system reliability

Configuration

- Sources clustered with loads
- Smart switch
- Plug & Play sources

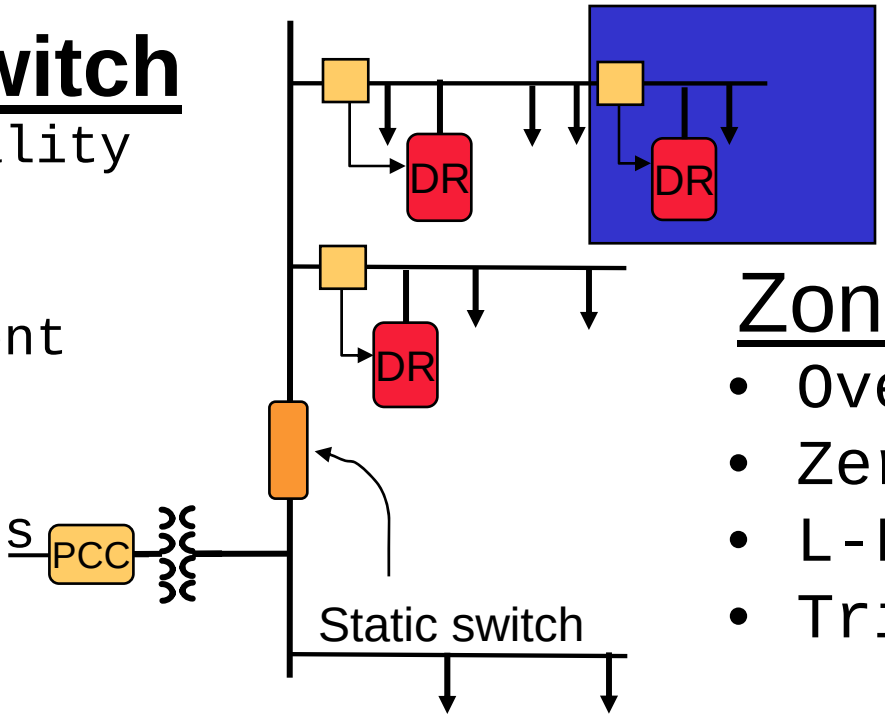
Operation

- Intentional islanding
- Automatic power balance (P vs. Fq)
- Voltage control (V vs. Q)
- Automatic re-synchronizing

Protection

Static Switch

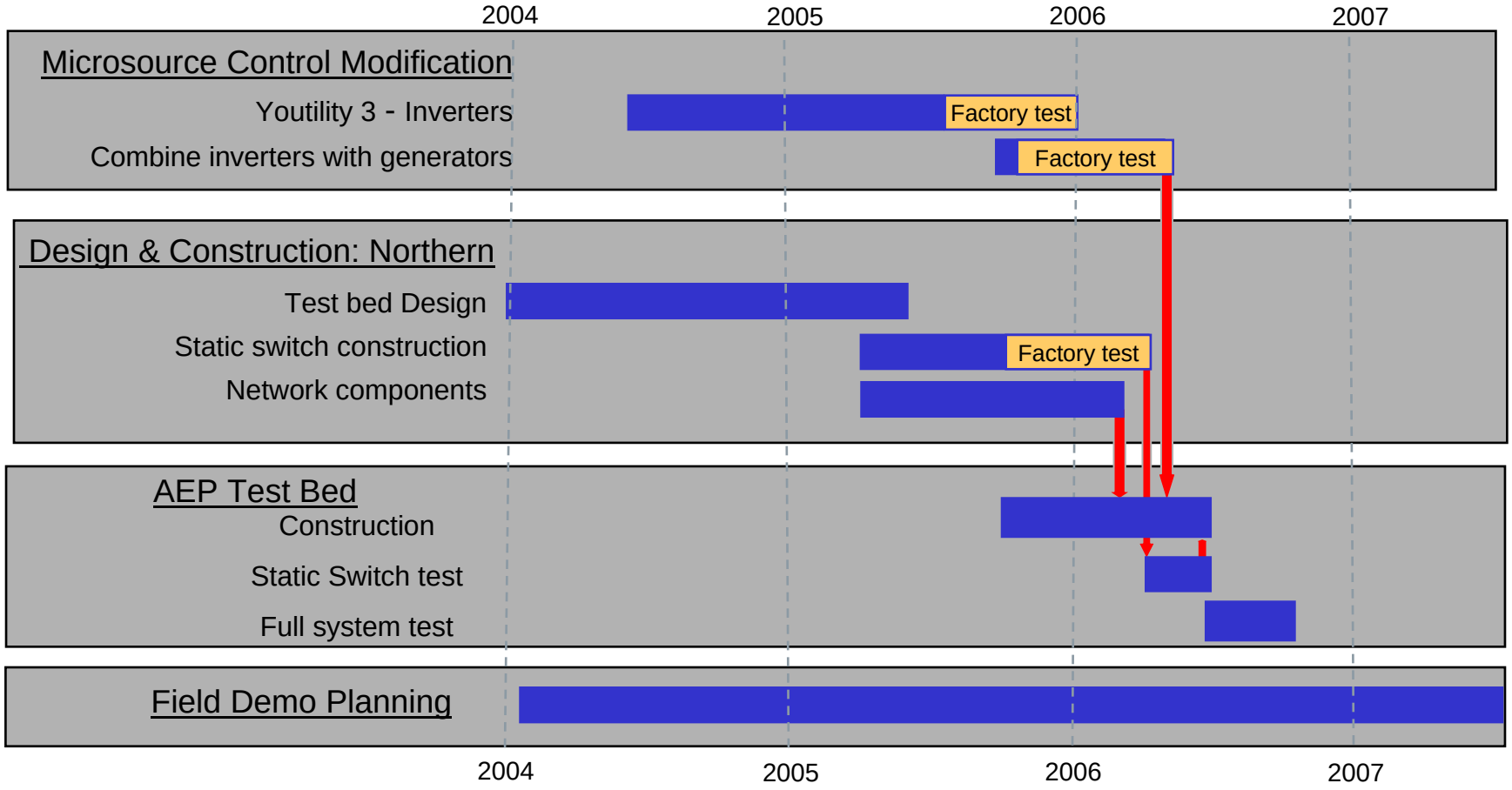
- Power quality
- IEEE 1547 events
- Overcurrent
- Zero seq. faults
- L-L faults



Zone protection

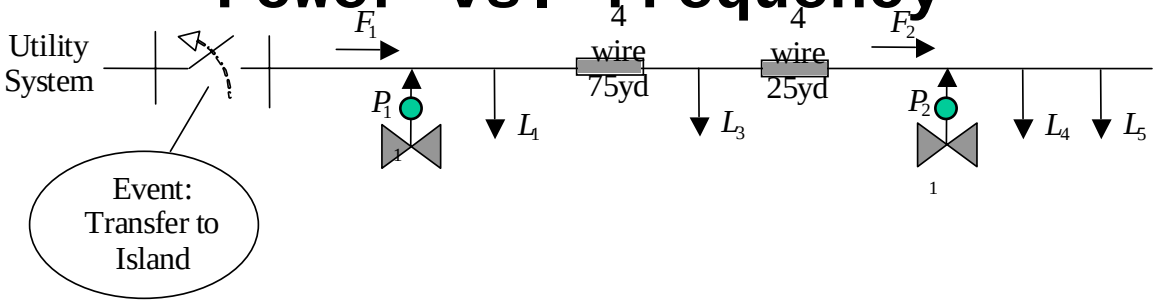
- Overcurrent
- Zero seq. faults
- L-L faults
- Trip unit

Microgrid Test Bed Timeline



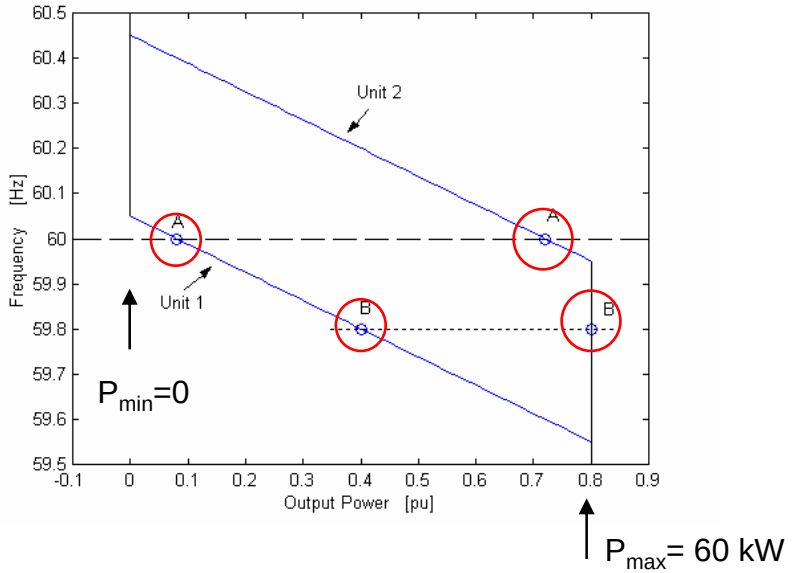
Youtility Factory test 2b-ii

Power vs. frequency

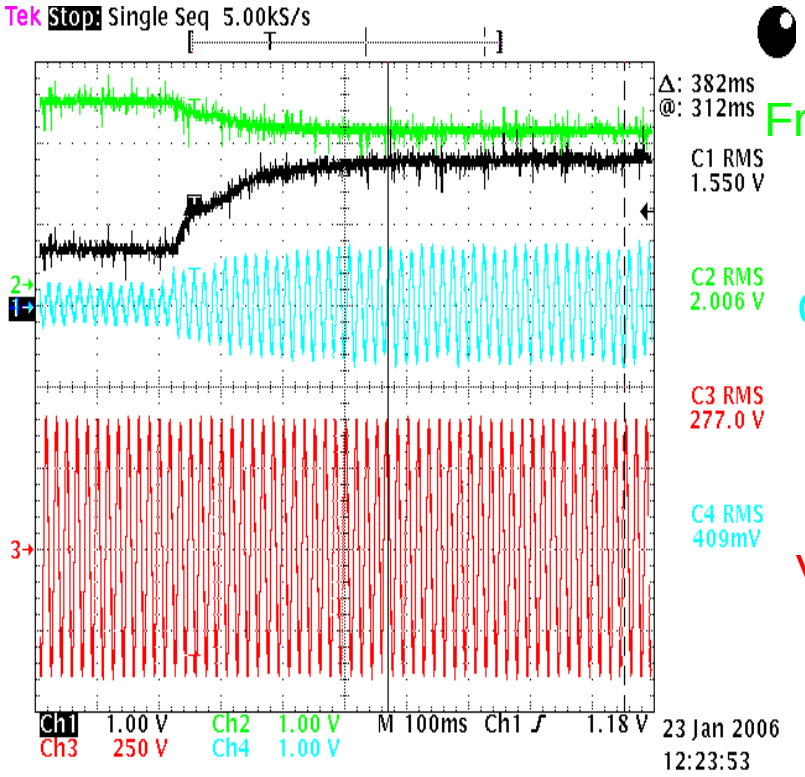


Event shows Unit 2 reaching maximum output power after islanding.

	A: Grid	B: Island
P_1 [pu]	6 kW	42 kW
P_2 [pu]	54 kW	60 kW
Frequency [Hz]	60.00	59.79
Load	102 kW	102 kW
Grid Flow	42 kW	0.0



Factory test 2b-ii traces

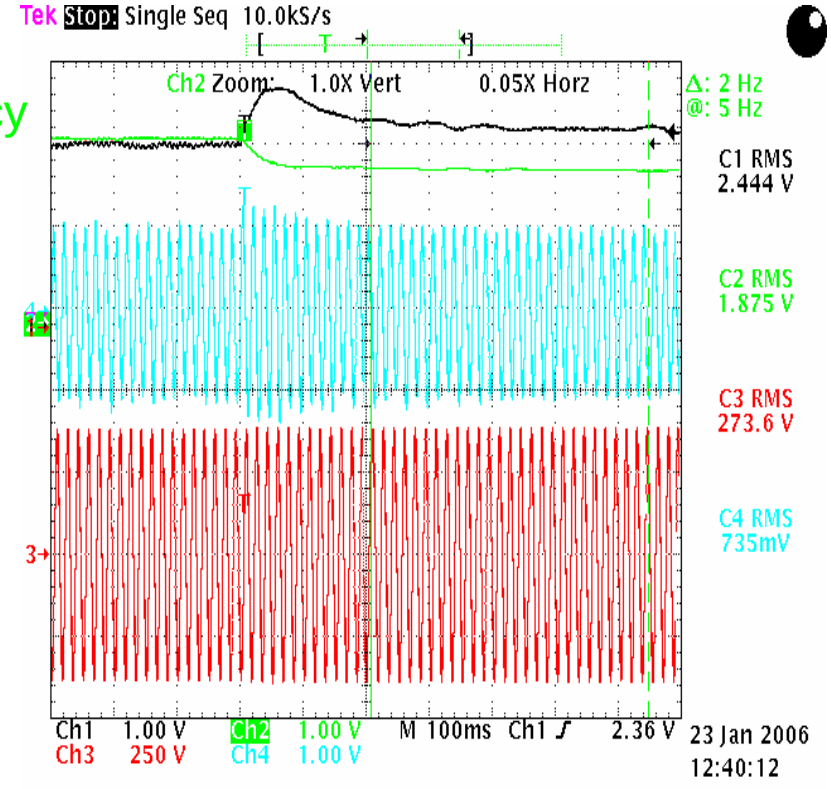


Frequency

Power

Current

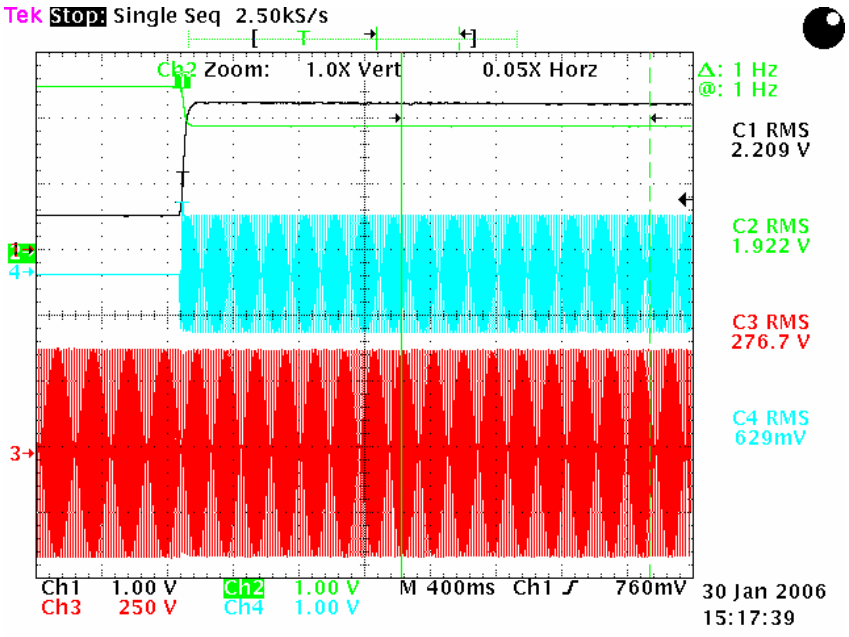
Voltage



Unit 1

Unit 2

Unit step load test (0 kW-50kW)

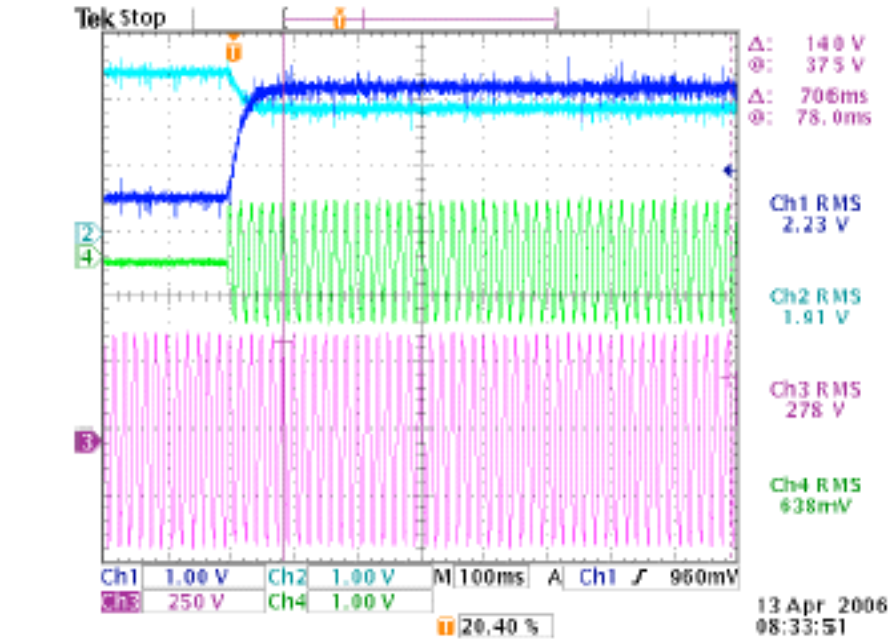


Youtility Factory test (no PM)

Youtility test	A (start)	B (end)
Unit (S.P/Pout) KW	20.0/0 KW Unit	20.0/53 KW Unit
Frequency Hz	60.16 Hz	59.74 Hz

iia. 0 – 50 kW Step Load –Surge Module- Variable Speed

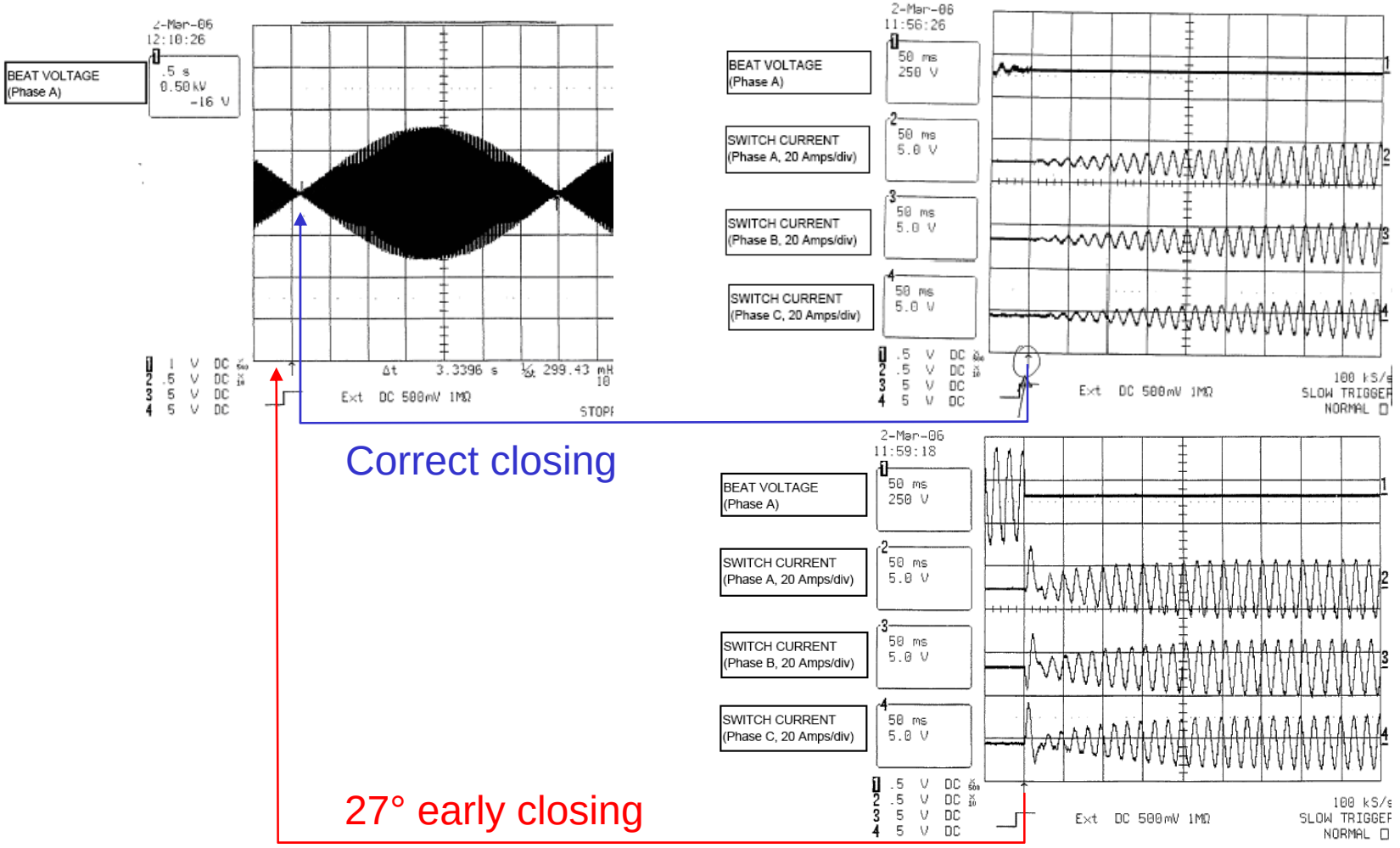
Graph #1



TeCogen Factory Test with ICE

TeCogen Unit #2	A (start)	B (end)
Unit (S.P/Pout) KW	20.0/00 KW Unit	20.0/509 KW Unit
Frequency Hz	60.16 Hz	59.74 Hz
Engin Speed (Hz/rpm)	60/1800	67.7/2031

Static Switch Factory Test Re-closing



AEP Site: 9 May 2006

Spring/Summer 2006 Testing at AEP

Preliminary tests

- ***Component Commissioning***
- ***System Checkout***
- ***Repeat Youtility Factory Test (2 units)***

Full System Tests with Islanding

- ***Control of Power Flow***
- ***Protection***
- ***Power Quality***
- ***Difficult loads***

Enhance the Business Case; CERTS Microgrid

Objective:

Prioritize, develop, and, as appropriate, demonstrate at bench-scale needed additional technology enhancements required to further *optimize the microgrid from the explicit perspective of enhancing the business case for microgrids*

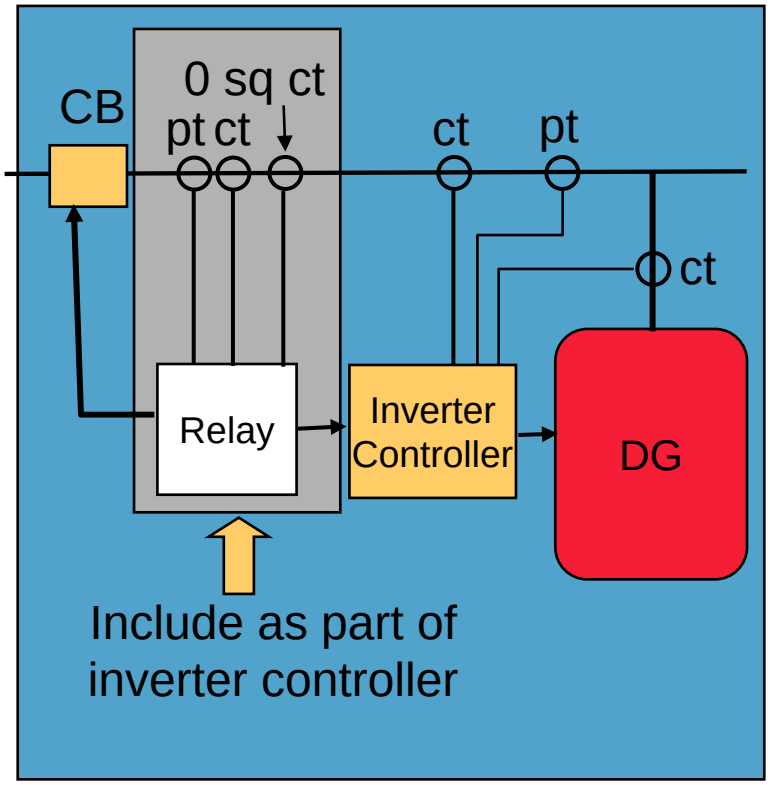
Task 1: Baselines for Microgrid Business Case Assessments

This initial phase will value and prioritize the microgrid research and development priorities for subsequent tasks (2-5). The baseline consists of traditional approaches to realizing similar quality and reliability levels without use of the CERTS Microgrid concept.
Some possibilities:

• Sensitive loads;	Microgrid to UPS systems
• CHP applications:	Microgrid to traditional including piping
• Coordination of multi-sources	Microgrid to traditional methods
• Back up power with CHP	Microgrid to traditional methods
• Intentional islanding	Microgrid to currently available equipment

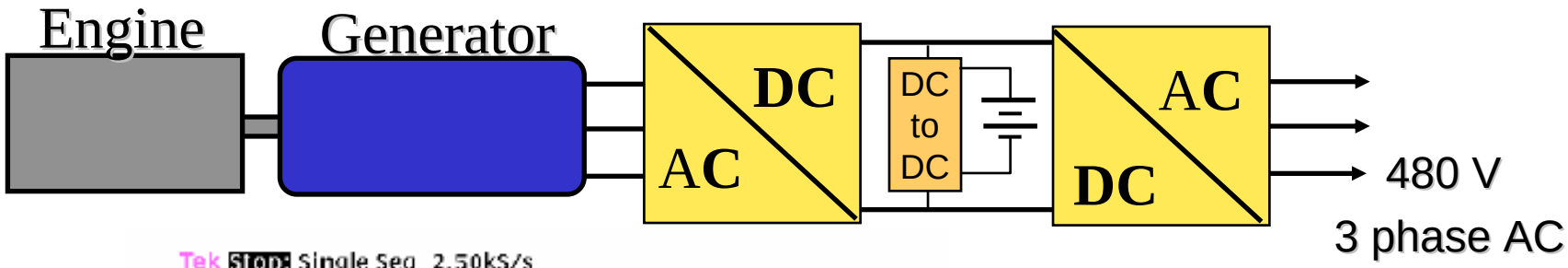
Include combinations of inverter based and synchronous sources, with and with out ac storage

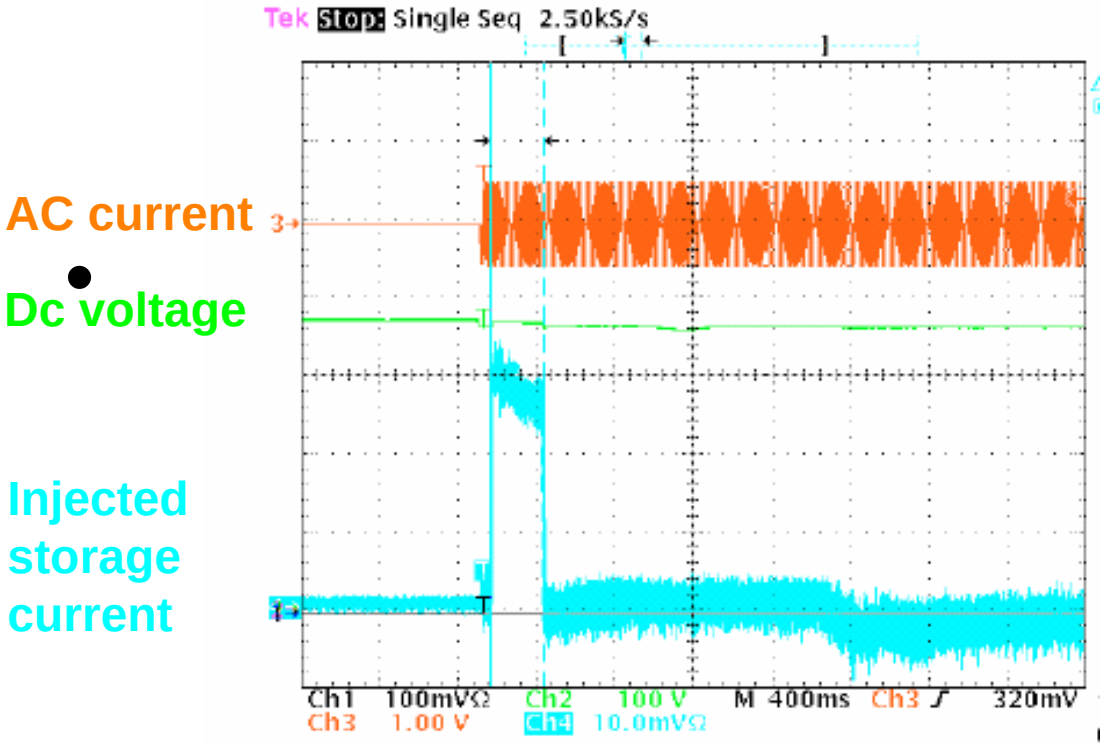
Task 2: Reduction of protection costs



At each microsource in the CERTS Microgrid, a shunt trip molded case breaker is used to isolate faults within the microgrid. Current implementation at the CERTS microgrid test bed of this designed scheme relies on Schweitzer digital relays with independent current and voltage sensors. In order to lower the overall cost of the CERTS Microgrid, the protection logic needs to become an integral part of the control logic within each inverter. This will allow for elimination of the external relays and enhance the plug-and-play functionality of the microsources.

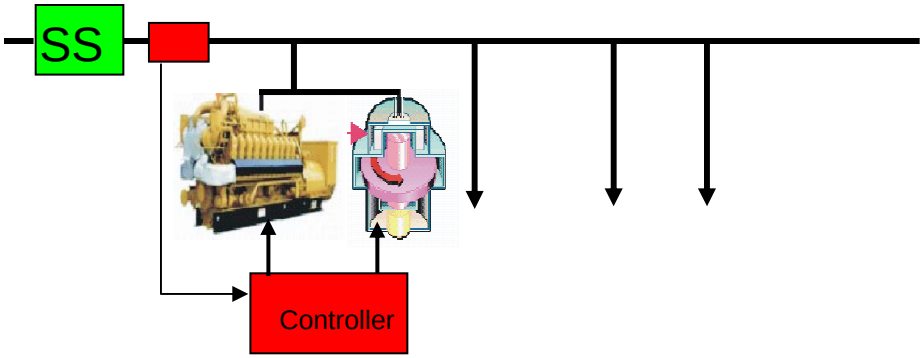
Task 3: Reduction of dc storage costs





The storage unit is designed to provide energy to the microgrid during islanding. The objective of this task is to reduce the size/rating of the storage module. Cost reduction becomes an optimization between engine speed (therefore efficiency) and storage size.

Task 4&5: Inclusion of AC storage and Traditional Generators



Inclusion of AC storage

The addition of AC storage to the CERTS Microgrid's architecture has the potential to enhance the functionality and business case for microgrids by enabling peak shaving, arbitrage of energy price and firming intermittent resources.

Inclusion of Synchronous Generators

The objective of this task is to develop techniques for successfully integrating synchronous generators that do not include inverter interfaces into the CERTS Microgrid system.

Schedule & Cost

Deliverable	FY04	FY05	FY06	FY07	FY08	FY09
Business Case						
Protection						
DC Storage						
AC Storage						
Synchronous Gen						
Total Budget: $1.7M			$0.6M	$0.8M	$0.3M	