



Center for High Performance Power Electronics

Microgrids Research

Department of Electrical and Computer Engineering



Sept. 19th, 2014



- Mahesh Illindala
- Assistant Professor
- Microgrids and *distributed energy resources* (DERs)



- Jin Wang
- Associate Professor
- Power electronic circuits and control, interface for renewable energy sources

- ❑ **Power system reliability, quality and resilience against unforeseen events is a serious concern to various customers.**
- ❑ **Microgrids are nowadays being considered by industries, utilities, military, campuses and municipalities.**
- ❑ **Research focus is on various aspects of microgrids**
 - Design
 - Operation
 - Control
 - Power quality
 - Protection relaying
 - Analysis of specific application scenarios for industrial distribution systems

- ❑ **Seamless transfer between islanding and grid-connection**
- ❑ **Peer-to-peer, autonomous coordination without high bandwidth communication**
- ❑ **Plug-and-play operation (no custom engineering)**

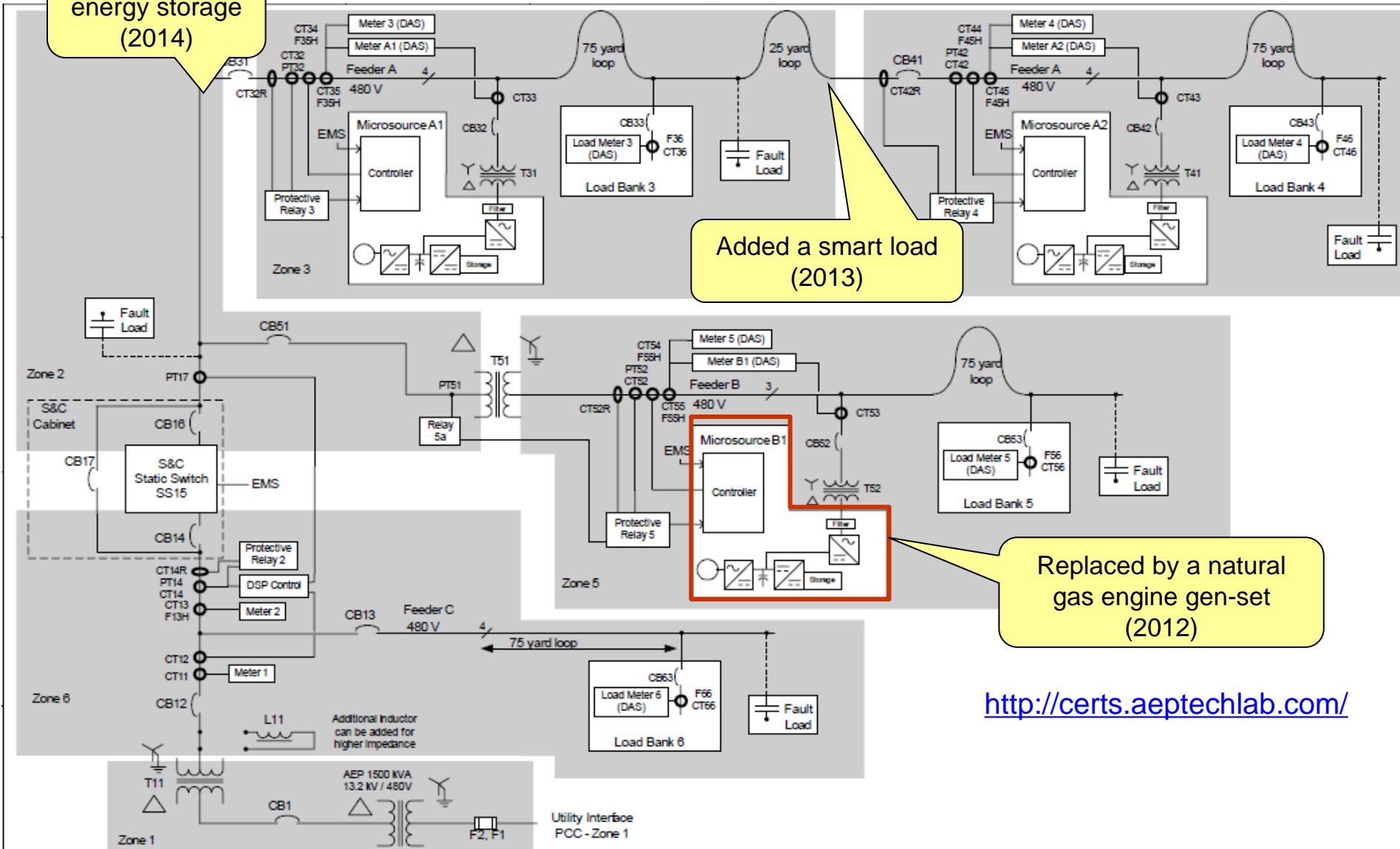
Modeling and Analysis for CERTS (AEP) Microgrid

Added an energy storage (2014)

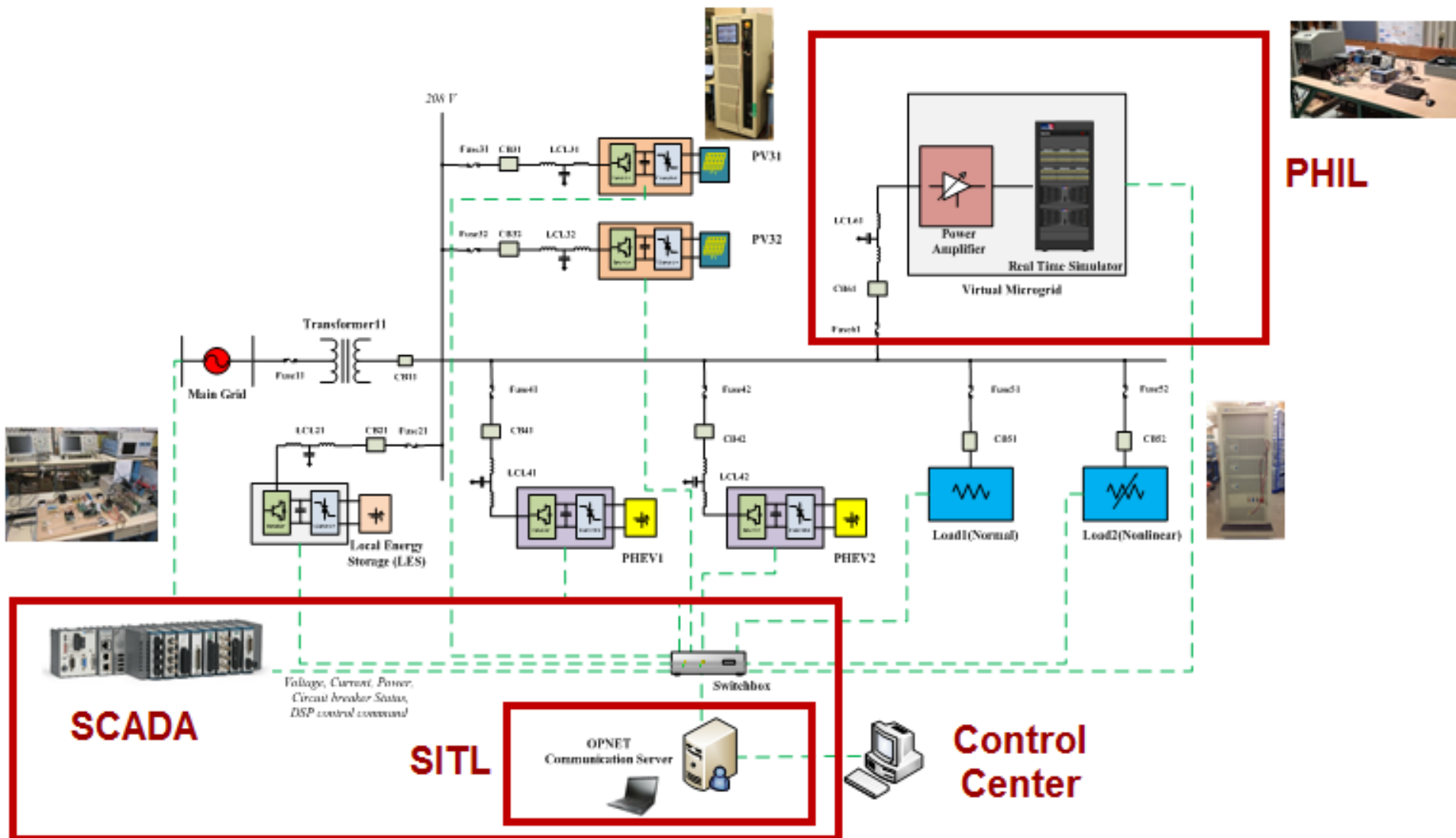
Added a smart load (2013)

Replaced by a natural gas engine gen-set (2012)

<http://certs.aeptechlab.com/>



Hybrid Microgrid Testbed at OSU



PHIL



Features of the Hybrid Microgrid Testbed

- ❑ Flexible and reconfigurable electric power network with real-time simulation based Power Hardware-in-the-Loop (PHIL) unit; the testbed can be easily reconfigured to form single-phase ac, three-phase ac, dc, and hybrid networks
- ❑ Flexible and reconfigurable communication network with System-in-the-Loop (SITL) unit to enable controlled latency, packet loss, and cyber attack
- ❑ Low latency real-time Supervisory Control and Data Acquisition (SCADA) system with high speed data acquisition



The High Power Area (Hybrid Microgrid Testbed)



The Monitoring and Control Station

- ❑ **Operation of microgrid under islanding conditions is the most challenging part**
- ❑ **Research problems include**
 - Malfunction of power system relays in distribution systems
 - Systems with low inertia and spinning reserve
 - Stalling of engine prime movers
 - Stability and robustness
 - Interaction of controls of diverse kinds of DERs
 - Equipment lifetime deterioration under extremely harsh loads
- ❑ **Leading research activities**
 - Mitigation of protective relay malfunction in inverter based DERs
 - Graphical and analytical methods for stalling analysis for prime movers
 - Cycle life extension of distributed energy storage

Equalization of Battery Cycle Life in a Microgrid

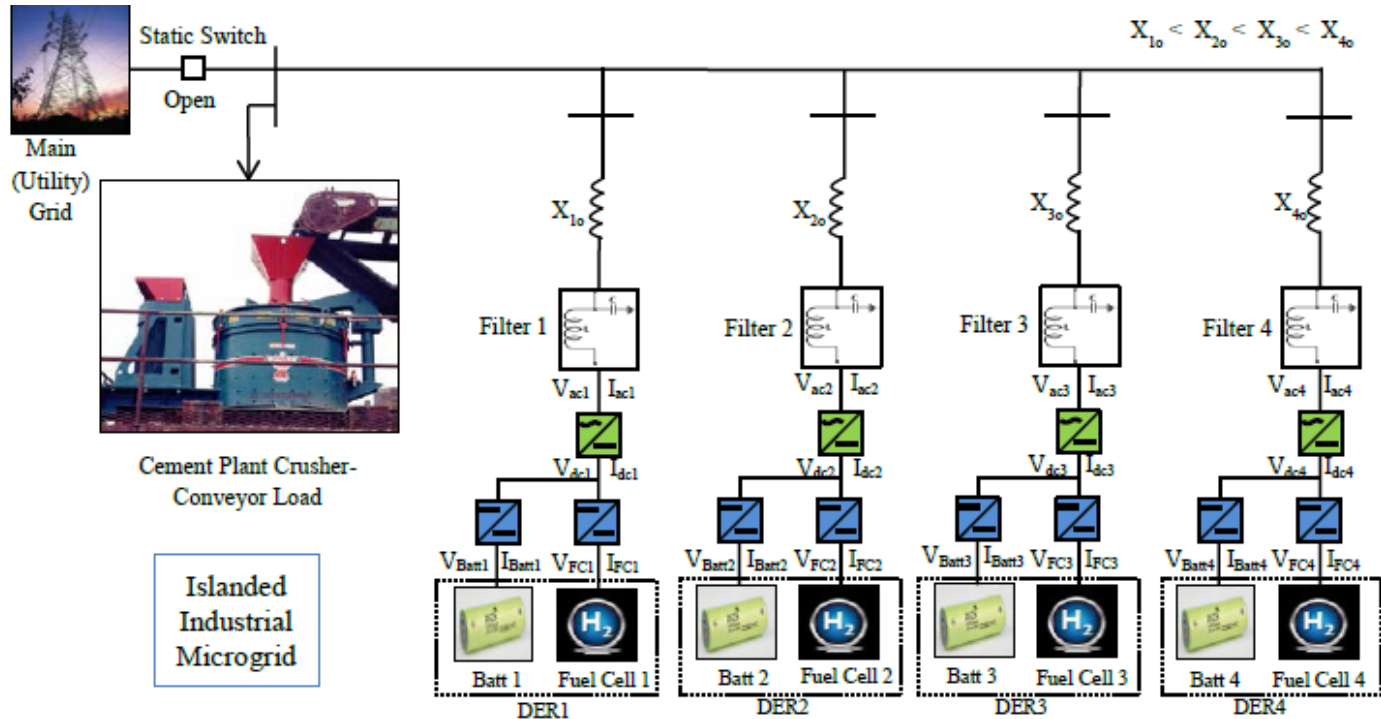


Table 1: Comparison of different approaches for balancing the lifetimes of batteries in a microgrid via FDERS technology

	Batt 1 EoL (in cycles)	Batt 2 EoL (in cycles)	Batt 3 EoL (in cycles)	Batt 4 EoL (in cycles)	Battery Life Extension
Status Quo [1],[2]	11627	16928	19791	25106	0%
Approach A [1]	17237	18995	20565	22278	48%
Approach B [1]	18561	20157	21353	20997	60%
Approach C [1]	21408	23111	20936	20453	76%
Approach D [2]	21191	21211	21089	20964	80%
Battery Life Equalization					

[1] H. J. Khasawneh, M. S. Illindala, "Battery Life Balancing in a Microgrid through Flexible Distribution of Energy and Storage Resources," *Journal of Power Sources*, vol. 261, Sep. 2014.

[2] H. J. Khasawneh, M. S. Illindala, "Equalization of Battery Cycle Life Through Flexible Distribution of Energy and Storage Resources," *2014 IEEE I&CPS Technical Conference*, 2014.



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Questions

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