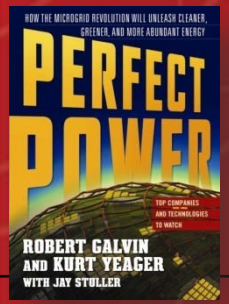
at ILLINOIS INSTITUTE OF TECHNOLOGY

Perfect Power Progress Report

Dr. Mohammad Shahidehpour

DOE Peer Review | June 2012

Perfect Power @ IIT




PERFECT POWER
at
ILLINOIS INSTITUTE OF TECHNOLOGY

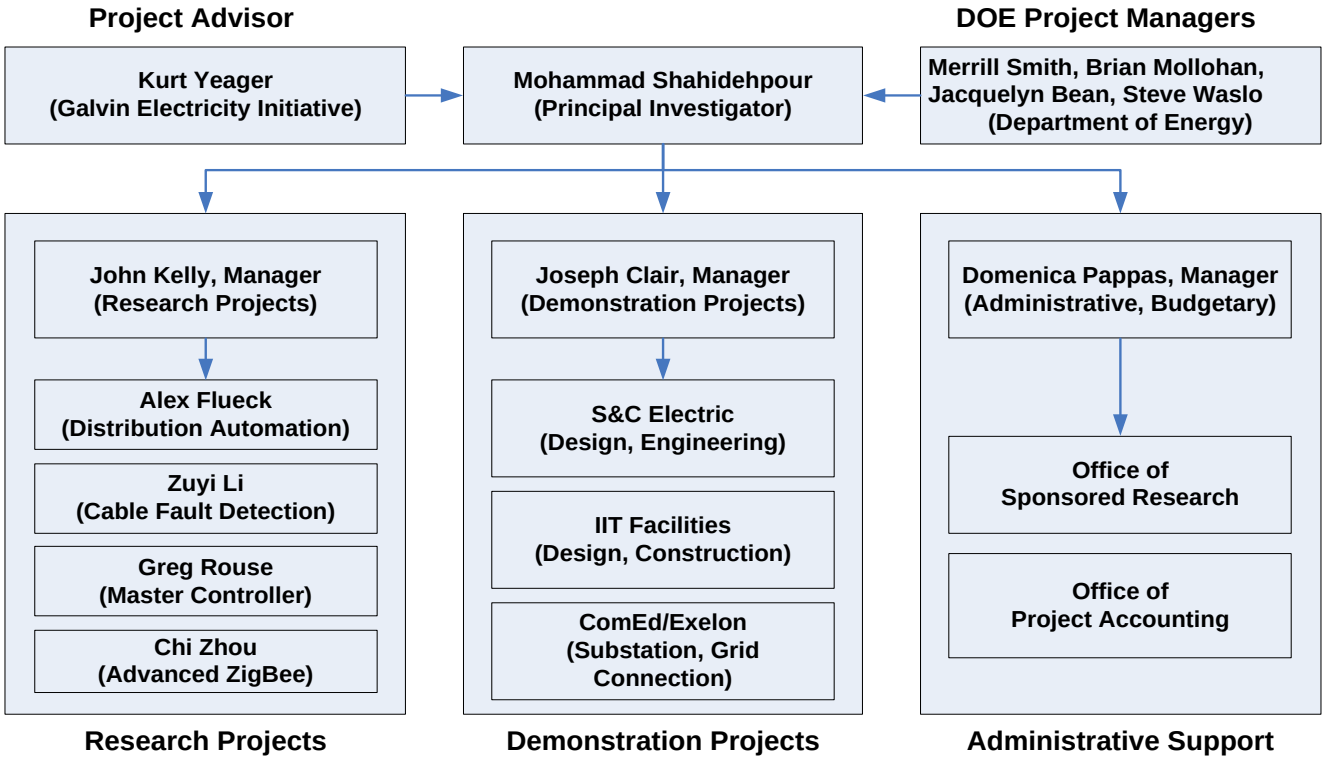
Perfect Power @ IIT

Funded by the U.S. Department of Energy

- $13.6M ($7.6M from DOE, $6M Cost Share)
- 5 year project
- Located at Illinois Institute of Technology (IIT)
- Involves the entire campus
- Partners: IIT, Exelon, S&C Electric, Schweitzer, IPS, Eaton Corporation, ZBB, CIYCOR, Continental Electric, Intelligent Generation

This project aligns with the OE mission and the Smart Grid program goals to develop technologies to modernize the electric grid, enhance security and reliability of the energy infrastructure, and facilitate recovery from disruptions to energy supply.

Leadership


Project Advisor
Kurt Yeager
(Galvin Electricity Initiative)
Mohammad Shahidehpour
(Principal Investigator)
DOE Project Managers
Merrill Smith, Brian Mollohan,
Jacquelyn Bean, Steve Waslo
(Department of Energy)
John Kelly, Manager
(Research Projects)
Alex Flueck
(Distribution Automation)
Zuyi Li
(Cable Fault Detection)
Greg Rouse
(Master Controller)
Chi Zhou
(Advanced ZigBee)
Joseph Clair, Manager
(Demonstration Projects)
S&C Electric
(Design, Engineering)
IIT Facilities
(Design, Construction)
ComEd/Exelon
(Substation, Grid
Connection)
Domenica Pappas, Manager
(Administrative, Budgetary)
Office of
Sponsored Research
Office of
Project Accounting
Research Projects
Demonstration Projects
Administrative Support

Project Objectives

- 50% peak demand reduction
- 20% permanent demand reduction
- Demonstrate the value of Perfect Power
  - Cost avoidance and savings in outage costs
  - Deferral of planned substations
- New products and commercialization
- Replicable to larger cities
- Promotion of energy efficiency and cleaner cities

Phase I

Perfect Power Foundation

PHASE I

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Task 1: Conceptual Model Development 

Task 2: ComEd/PJM Portal - Turbine Fast Start 

Task 3: Energy Efficiency Upgrades 

Task 4: Substation Supply Reliability 

Task 5: Perfect Power System Design & Engineering 

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Phase II

Multi-Year Research Phase

PHASE II (Research Phase)

Task 1: Advanced Distribution Automation and Recovery System

To develop and demonstrate an advanced system for sensing distribution system conditions and automatically reconfiguring the system to respond to disturbances.

Accomplishments

- Created of a communication model in dNetSim ✓
- Developed a visualization platform for dNetSim ✓
- Developed distributed Control Modes ✓

Future Work

- Pilot Demonstration of Autonomous Agent Infrastructure

PHASE II (Research Phase)

Task 2: Buried Cable Fault Detection and Mitigation

To develop and demonstrate a fault detection and mitigation system with sensitivity, reliability, selectivity, and speed.

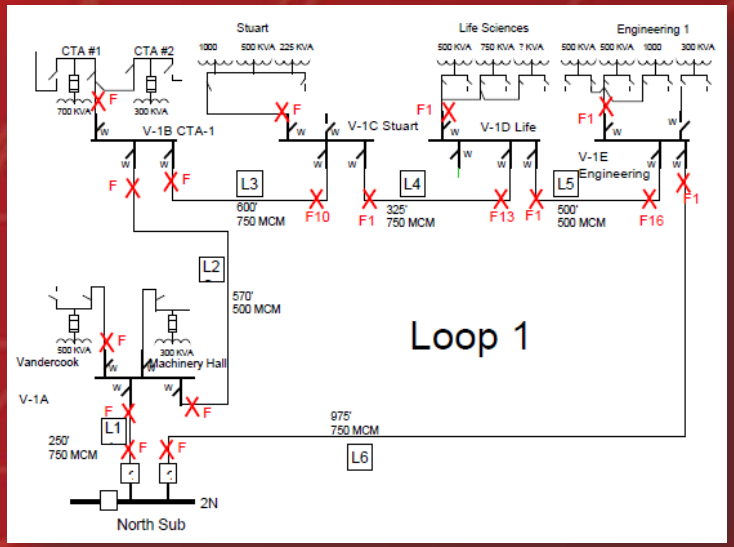
Accomplishments

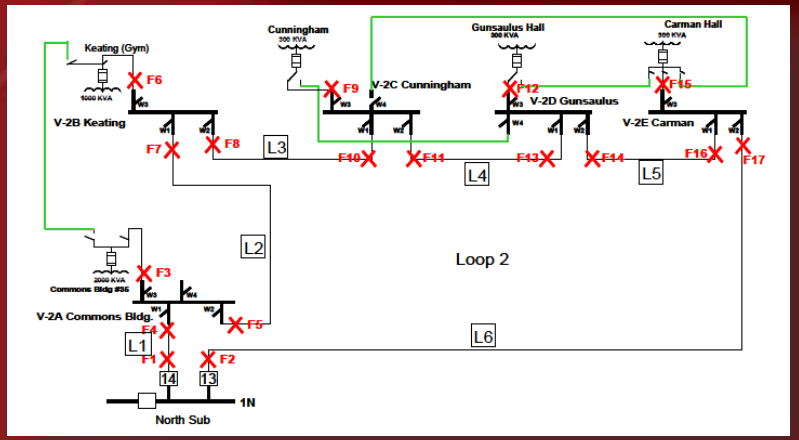
- Simulated IIT's distribution network ✅
- Simulated faults at selected locations to characterize the system ✅
- Identified an accurate, fast, and reliable approach for IIT's distribution cable network based on coordinated work of smart vista switches and IPPSC ✅

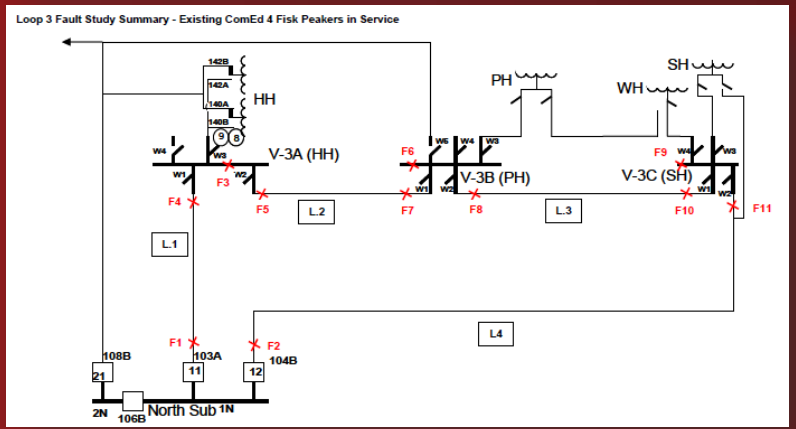
Future Work

- Pilot demonstrations

PHASE II | Task 2







PHASE II (Research Phase)

Task 3: Intelligent Perfect Power System Controller

Provide for island mode capability, manage system demand, minimize costs, automate and optimize ancillary services, minimize carbon consumption

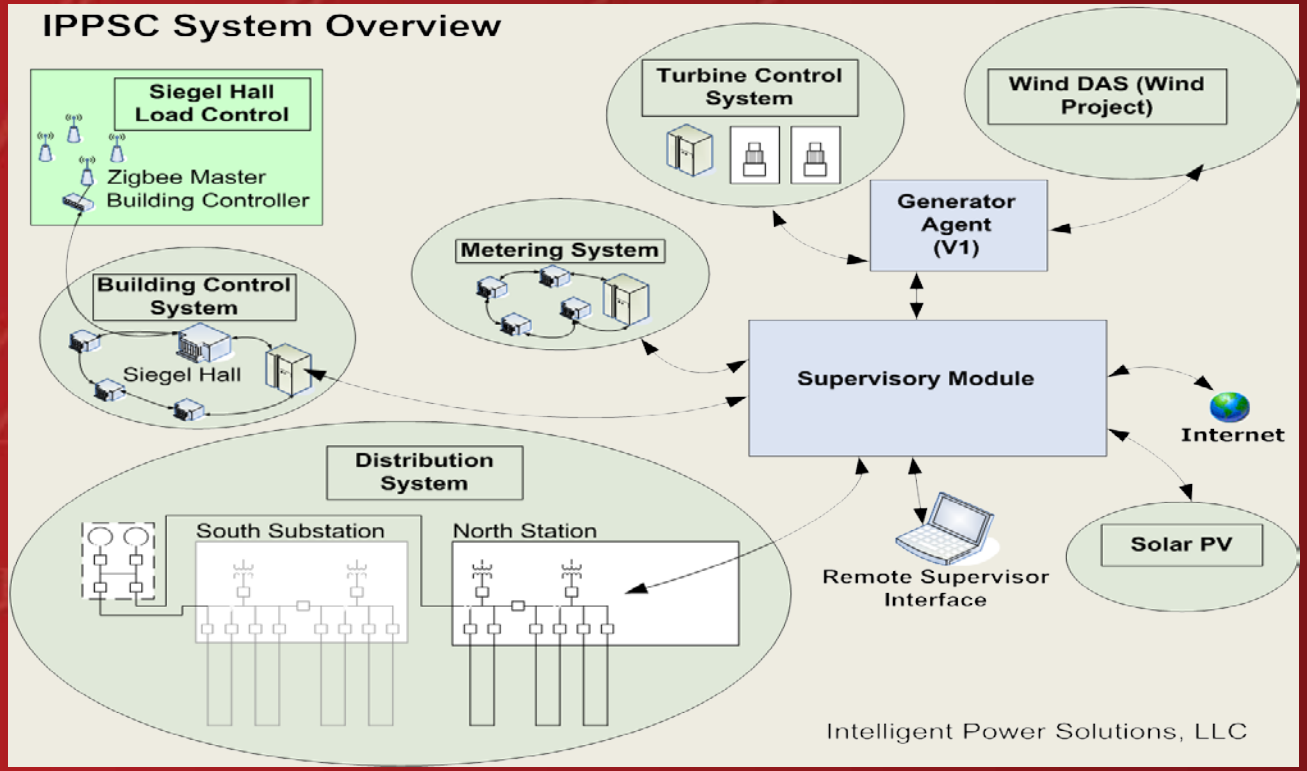
Accomplishments

- Designed the IPPSC specifications for IIT campus
- Developed the control logic and performed bench testing
- Developed and deployed Versions 1 and 2

Future Work

- Versions 3 software development and deployment

PHASE II | Task 3



PHASE II (Research Phase)

Task 4: Advanced ZigBee Wireless

To develop and demonstrate an advanced and robust ZigBee wireless communications network to facilitate and enable features of the Perfect Power System

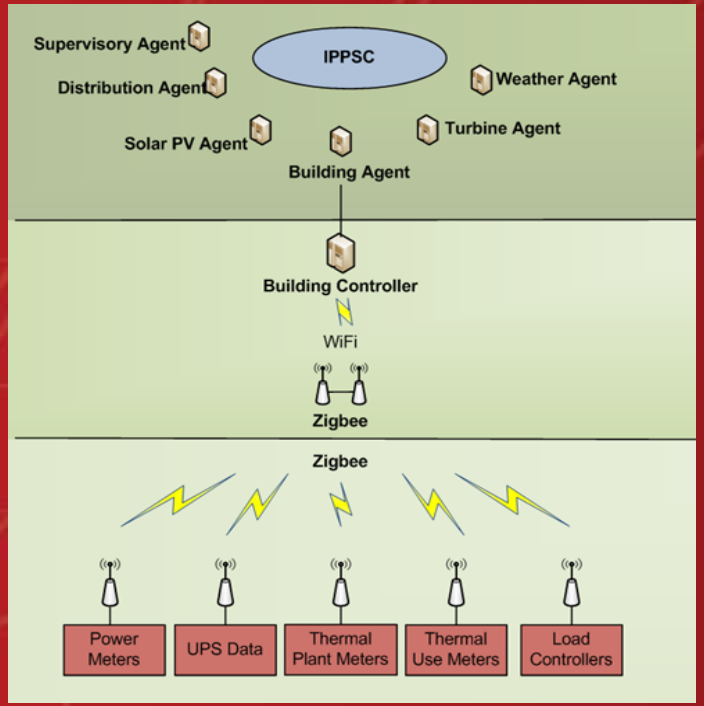
Accomplishments

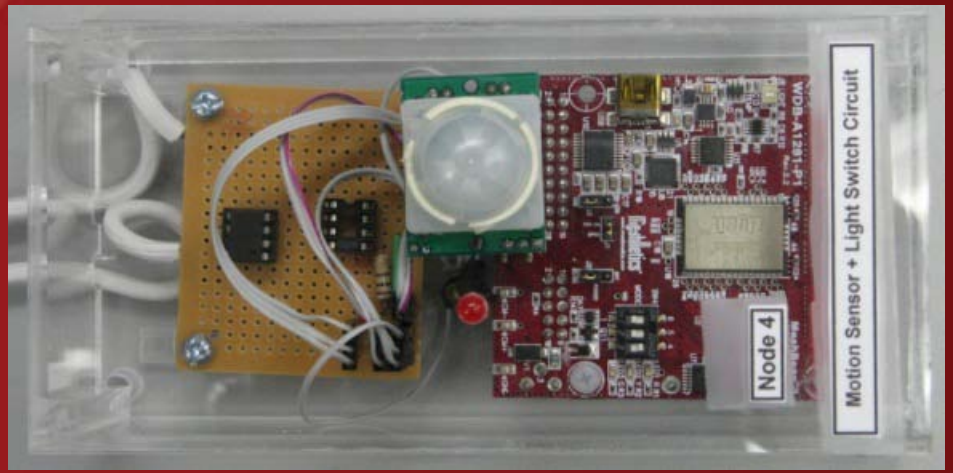
- Developed interference avoidance techniques
- Developed self-forming and self-healing Zigbee-based systems
- Developed energy-efficient algorithms for message routing
- Developed a plan to install the ZigBee-based wireless syste

Future Work

- Pilot demonstrations

PHASE II | Task 4





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Phase III

Ancillary Service Demonstration

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PHASE III (Ancillary Services)

Task 1.0 – IPPSC, Version 1 Demonstration

Create a demo version that demonstrates the capabilities and establish connection/communication with the turbines, meters, pricing.

Completed in February 2011.

Task 2.0 – Turbine Fast Start and ComEd/PJM Portal

Enable the two existing 4MW-Allison-Turbines to participate in the Perfect Power System.

Completed in August 2009.

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Phase IV

Distribution System Automation Demonstration

PHASE IV (Dist Automation)

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Task 1: High Reliability Distribution System Installation

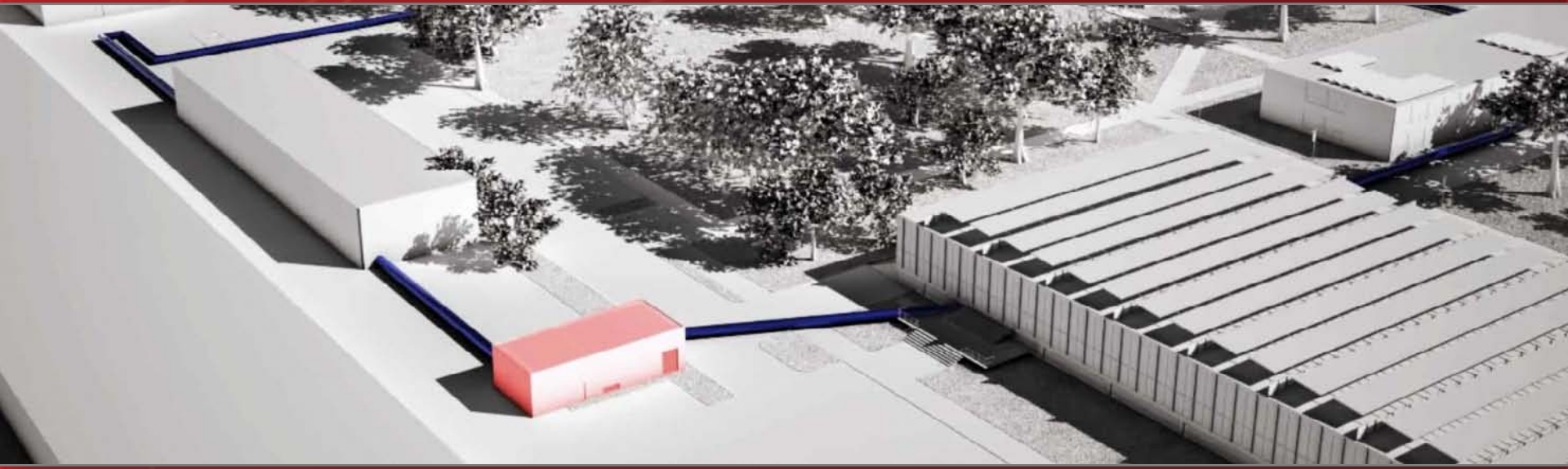
Loops 1, 2, 3 design and installation. Completed in February 2011.

PHASE IV (Dist Automation)

Task 2: Substation Automation

North substation automation. Completed in January 2011.

South substation automation planned. To be completed by June 2013.



PHASE IV (Dist Automation)

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Task 3: IPPSC, Version 2 Demonstration

Interface with the distribution system, SCADA system, and restoration management. To be completed by December 2012.

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Phase V

Distribution Level Peak Load Reduction Demonstration

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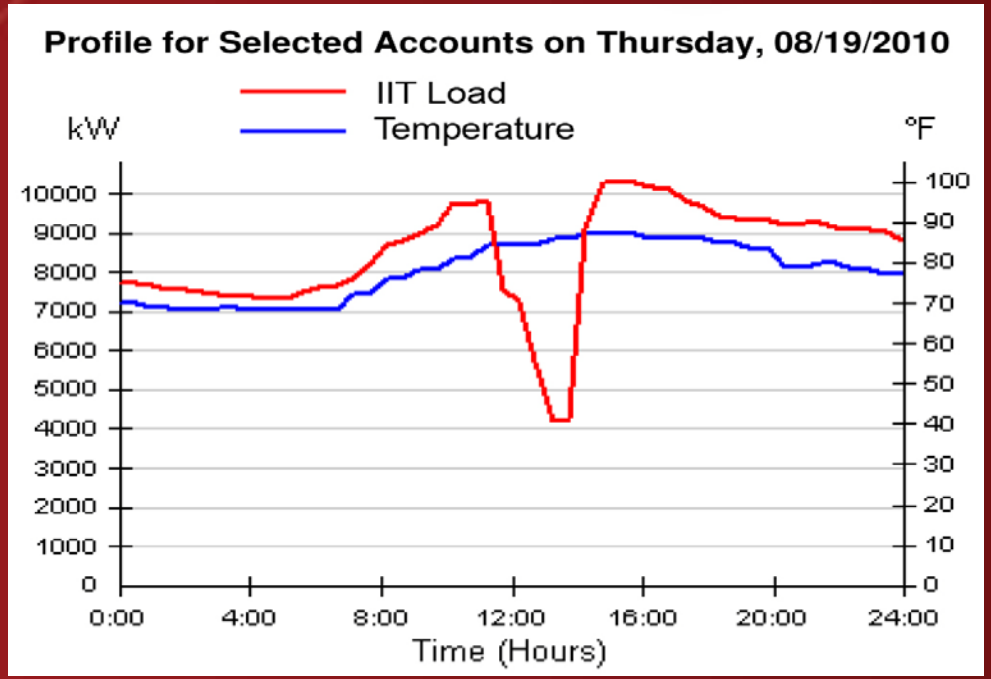
PHASE V (Peak Load Reduction)

Task 1: Peak Load Reduction Capability

The agents for the building controller and HRDS coordinate the optimal load shedding scheme depending on local conditions. **Completed** in April 2012.



PHASE V (Peak Load Reduction)

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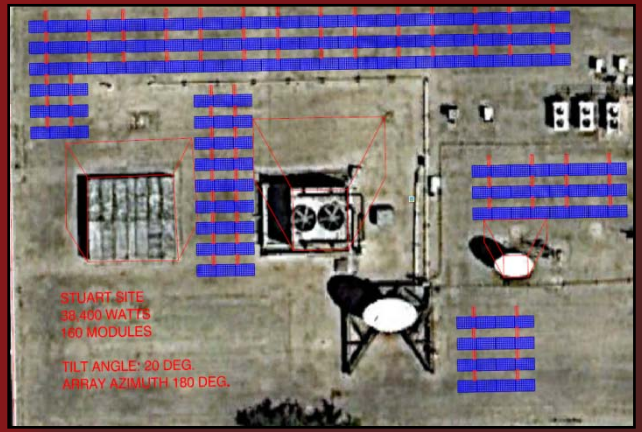
Task 2: IPPSC Version 3 Demonstration

Integration of building automation with demand response and some optimization. To be completed by June 2013.

PHASE V (Peak Load Reduction)

Task 3: Install Solar PV



Complete June 2012

PHASE V (Peak Load Reduction)

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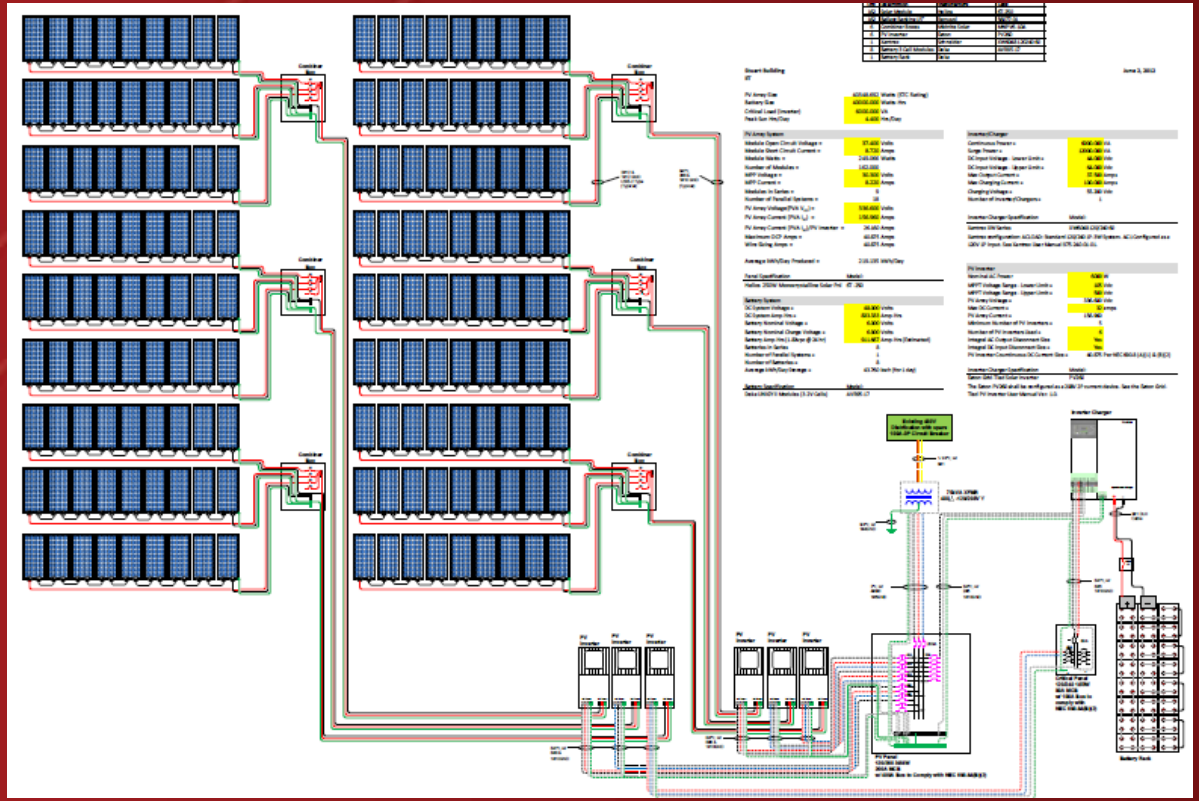
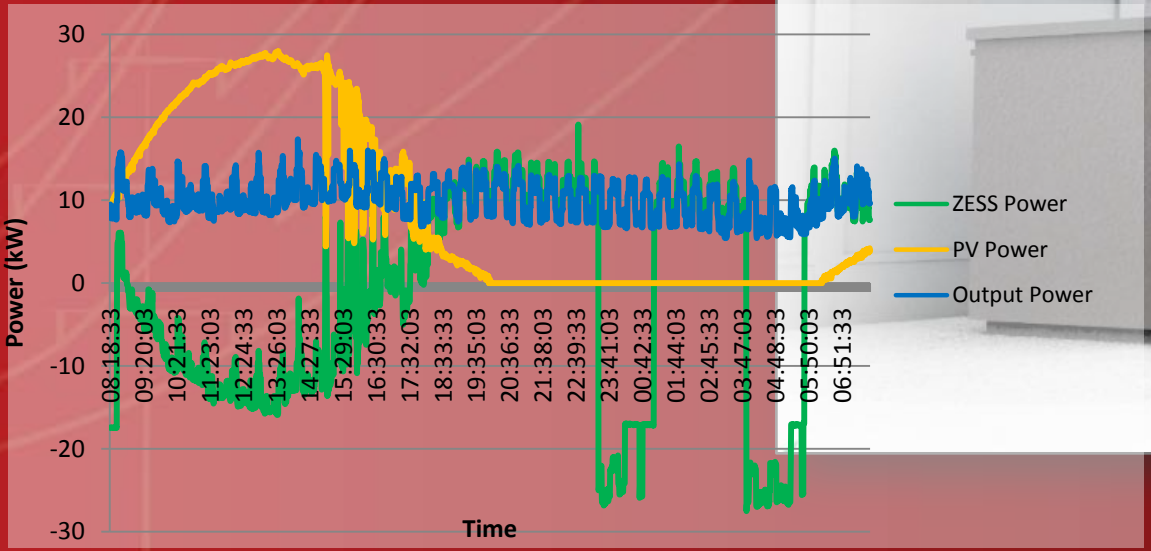
Task 4: Install UPS at Critical Buildings



PHASE V

Task 5: Install Energy Storage on Microgrid

Complete June 2012



PHASE V (Peak Load Reduction)

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Task 6: Install Electric Vehicle Charging Stations

6 Level 2 Stations | 1 DC Quick Charge Station (15-20 min.)

DEMONSTRATION STATUS

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HRDS Smart Loops

- Three loops commissioned.

50% peak demand reduction when called upon by PJM/ComEd

- Turbine fast start completed providing this capability

20% permanent demand reduction

- Collected baseline data and normalized, HDD/CDD

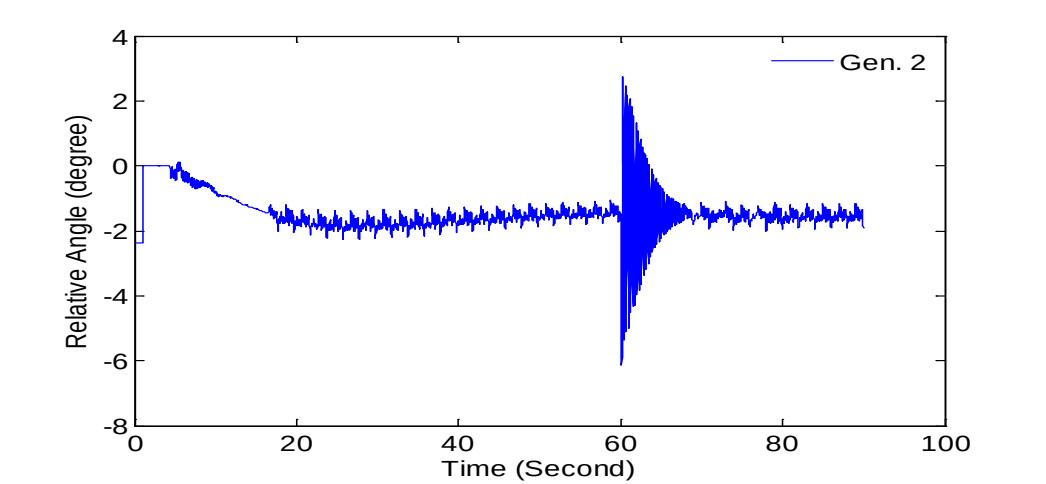
Demonstrate value of Perfect Power

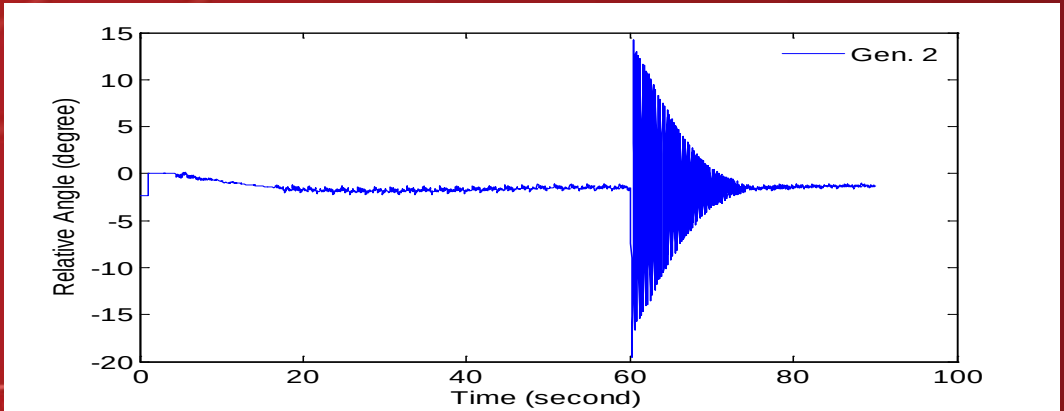
- $450,000 ComEd/PJM annual DR
- $500,000 outage cost annual saving
- $5,000,000 avoided capital cost

Microgrid Fault Analyses

- No HRDS
  - Fault takes 30 cycles to clear.
  - The system is radial. Once the breaker opens, all the downstream loads will be disconnected.
- HRDS
  - Fault takes 6 cycles to clear.
  - The system is looped. Once the breakers open, only the faulted cable is isolated.

Fault Simulation

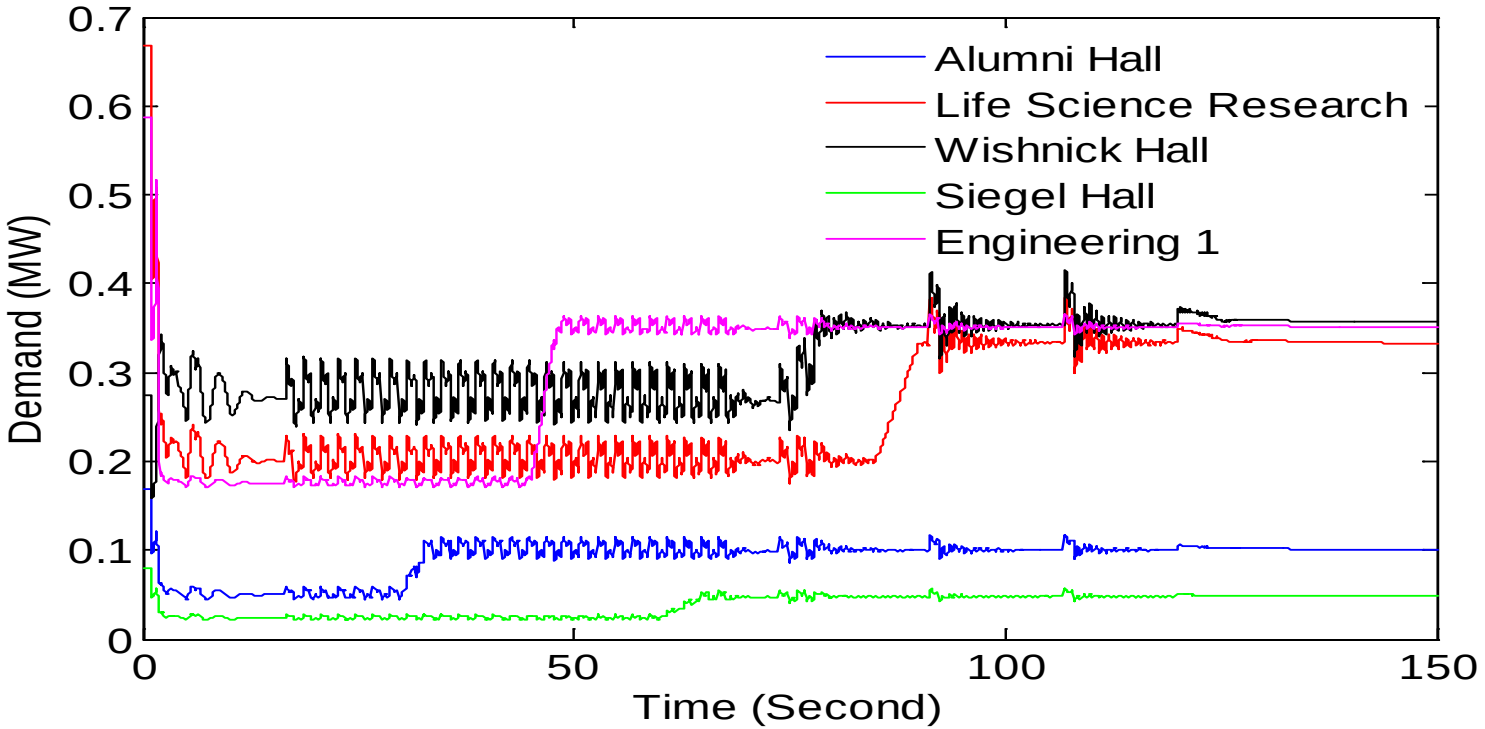




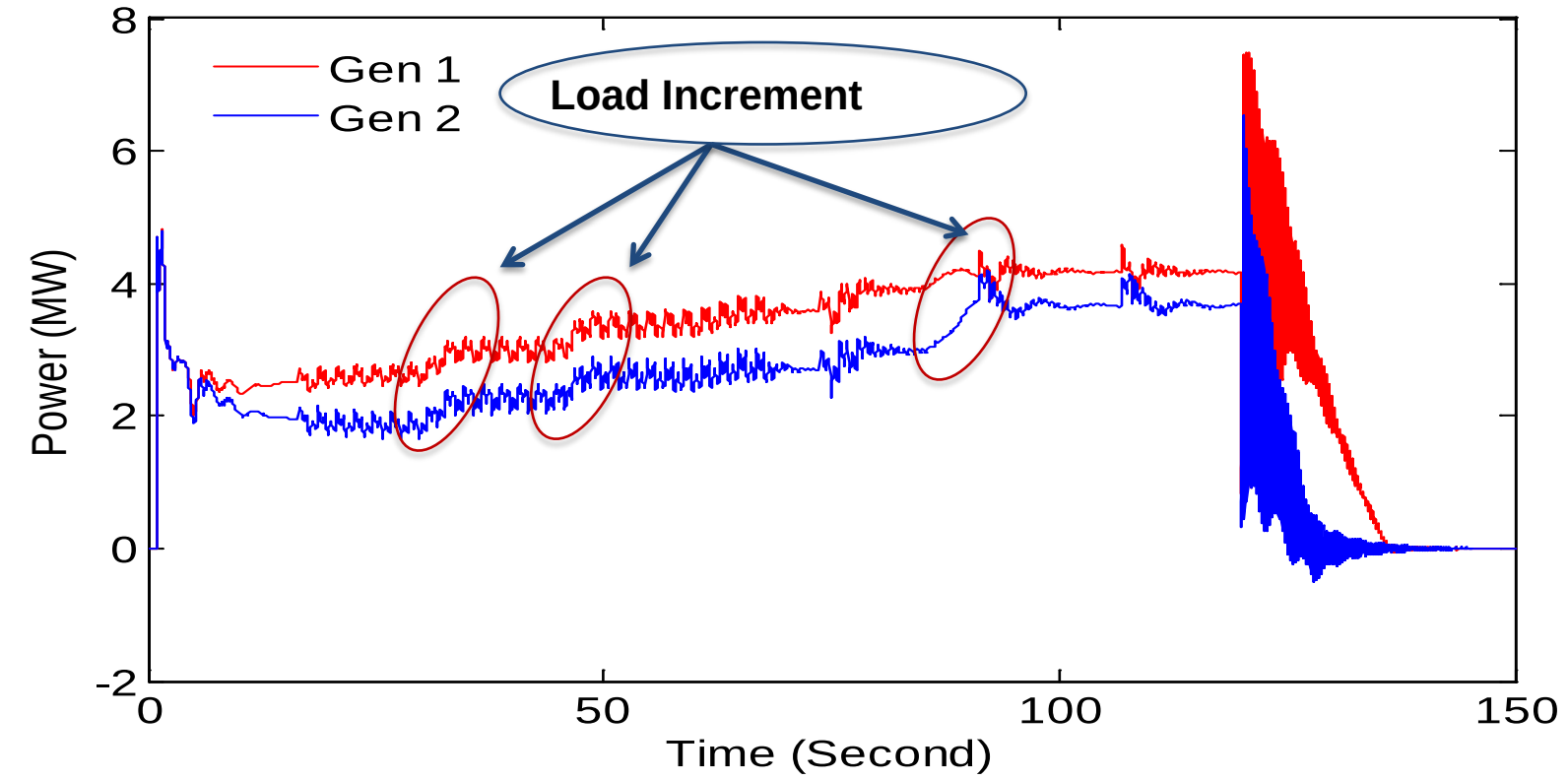
Building restoration sequence

T=30 sec	T=45 sec	T=60 sec	T=75 sec	T=85 sec
3410 Central	CTA Facility	Perlstein Hall	Stuart Bldg.	IIT Tower
3424 Central	Cunningham	Quad	TBC	Incubator
Alumni Hall	Eng1	S.R. Crown	TS3424	Keating
Carman	Galvin	Siegel Hall	Vandercook	Life Science
Carr	Gunsaulus	Metal S.1	Whishnick	Life Science Research
MTCC	Hermann Hall	Metal S. 2	SSV	Main
-	-	-	-	Metal N.

Load Restoration

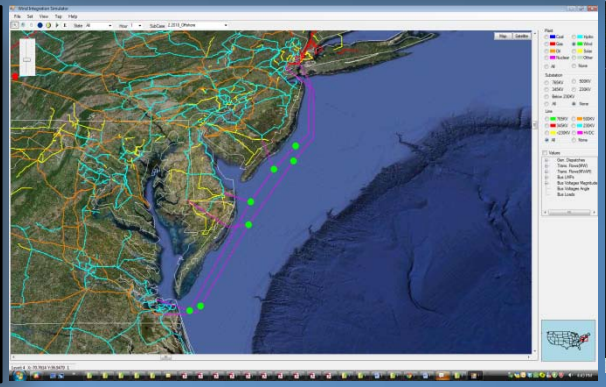


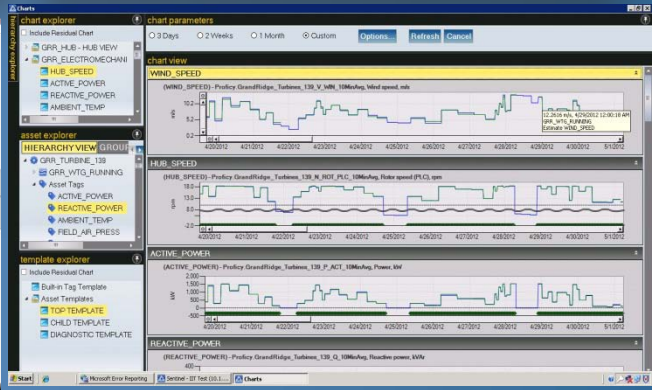
Load Sharing among Generators



State-of-the-Art Facility

Wind Consortium





Communication and Tech Transfer

Major Events

- First Great Lakes Symposium on Smart Grid and New Energy Economy, IIT, Oct. 18-19, 2011.
- IEEE Symposium on Smart Grid and Sustainable Energy Vision, IIT, November 2011.
- 2012 DOE Microgrid Workshop, IIT, July 30-31, 2012
- Second Great Lakes Symposium on Smart Grid and New Energy Economy, IIT, September 25-26, 2012.

Conclusion and Summary

- Assessment of the role of local and hierarchical control on the economic operation of microgrids is considered and improved reliability indices at load points are calculated.
- AC formulation of the master controller (for the provision of reactive power and voltage control) in microgrid unit commitment and economic dispatch is offered.
- Application of HRDS, local generation (solar, wind, gas, storage), and charging stations is presented and the reliability and economic evaluation of microgrid is evaluated.
- Integration of HRDS and evaluation of reliability and economic indices of microgrids are considered as compared to those in traditional distribution systems.
- Provision of stochastic solution to two proposed topologies (with/without microgrid) is considered for the comparison of reliability indices.

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