The Perfect Power Prototype for the Illinois Institute of Technology

Progress Report

Year 1 (2009)

Award Number:	DE-FC26-08NT02875
Recipient:	Illinois Institute of Technology
Principal Investigator:	Mohammad Shahidehpour
Period Covered:	October 1, 2008 to September 30, 2009
Date of Report:	September 30, 2009

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1 Project Activities and Accomplishment

We divide our perfect power project at Illinois Institute of Technology (IIT) into two distinct groups of demonstration and research projects. The corresponding project reports are provided as follows:

1.1 Demonstration Update

The demonstration projects are led by Mr. Joseph Clair, Director of Campus Energy and Sustainability at the Illinois Institute of Technology (IIT).

1.1.1 Accomplishment

The following results have been accomplished in the first quarter of 2009.

- Had a meeting to provide input to the engineering team from the Facilities staff most familiar and experienced with operating the electric distribution system on campus.
- S&C expects to be on schedule with all deliverables for year 1. Will also provide data updates for research team on a regular basis through Joseph Clair. Currently working on data report via S&C team engineers, expected any day.
- The team will complete a visual inspection with Siemens in the next month to check the status of south substation.
- South substation may need to be completely redone rather than replacement/refurbishment of key parts as planned.
- The demonstration team has decided to conduct a reliability assessment using the industry standard study over next two weeks.
- If the south substation requires more work than originally planned, the demonstration plan may need to be revised.

The following results have been accomplished in the second quarter of 2009.

- Completed conceptual design of current scope for year one.
- Initiated manufacturer of switchgear for High Reliability Distribution System.
- Engaged construction manager to provide cost estimating of installation.
- Began underground location work and site coordination in anticipation of third quarter installation.

The following results have been accomplished in the third quarter of 2009.

- Purchased switchgear for High Reliability Distribution System.
- Hired construction team to complete installation.
- Completed underground work and scheduling for cutover from existing underground service to new HRDS loop service.
- Loop 3 Vista shipped September 25, 2009. Loop 3 commissioning scheduled after Loop 3 installation.

1.1.2 Key Insights

In many ways, a smart-grid installation resembles any infrastructure project, requiring significant planning and coordination with existing infrastructure. Due to the newness of the application, in hindsight, having an installation contractor as part of the initial team would have made sense in order to remain informed of the actual costs of the project, and how those costs are affected by time.

1.1.3 Next Steps

- Complete shutdown coordination with Facilities Maintenance and stakeholders.
- Test first HRDS loop and automation.
- Complete design of complete HRDS.
- Schedule delivering of loop one HRDS switches.
- Obtain pricing for complete project installation and procure loop 1 installation services.
- Design relocation of south substation and obtain pricing.
- Loop 1 Vista units scheduled to ship October 16, 2009.
- S&C will submit proposal for engineering services for Loop 2, 4, 5, 6, and 7.
- S&C will submit proposal for South Substation engineering based on replacing switchgear.

1.1.4 Percent Complete

- S&C Electric is 25% done with the full system design and 100% done with the modeling.
- Year one project installation is 90% complete.
- Loops 2, 4, 5, 6, and 7 design is approximately 10% completed.

1.2 Research Update

The research projects are led by Mr. John Kelly, Managing Director of Intelligent Power Solutions, LLC. There are four research tasks:

- Research Task 1: Advanced Distribution Automation and Recovery System led by Dr. Alex Flueck
- Research Task 2: Buried Cable Fault Detection and Mitigation led by Dr. Zuyi Li
- Research Task 3: Intelligent Perfect Power System Controller led by Mr. Greg Rouse
- Research Task 4: Advanced ZigBee Wireless

1.2.1 Research Task 1

Research Task 2.1 – Advanced Distribution Automation and Recovery System is led by Dr. Alexander J. Flueck of Illinois Institute of Technology. Dr. Flueck’s research group will develop and demonstrate an advanced system for sensing distribution system conditions and automatically reconfiguring the system to respond to disturbances. The new autonomous agent-based architecture will enable fault detection, location and isolation; service restoration; integration of renewables; feeder reconfiguration; volt/VAR management and emergency response.

Dr. Flueck is collaborating with Tom Tobin, VP Research, S&C Electric and Mike Ennis, Director Advanced Technology, S&C Electric. The team has met roughly every month since the project began in the Fall of 2008. During the summer of 2009, the team met roughly every two weeks. The focus of the Year 1 research effort has been on fault detection, location and isolation; service restoration and integration of renewables. All aspects of the Year 1 objectives have been met and several additional achievements have been accomplished in Year 1 of the project.

The Year 1 deliverables include enhancements to the existing autonomous agent-based smart grid controls and unbalanced three-phase distribution system simulator dNetSim as follows:

- Provide fault-tolerant communication of each receiving and transmitting device.
- Integrate additional distribution network equipment, such as open-delta-connected single phase regulators.
- Include additional load models, such as induction motors.
- Include distributed resource models, such as distributed generators.
- Confirm proper unbalanced three-phase distribution network solutions for the IEEE Test Feeders: IEEE 34 Node, IEEE 37 Node, IEEE 123 Node.

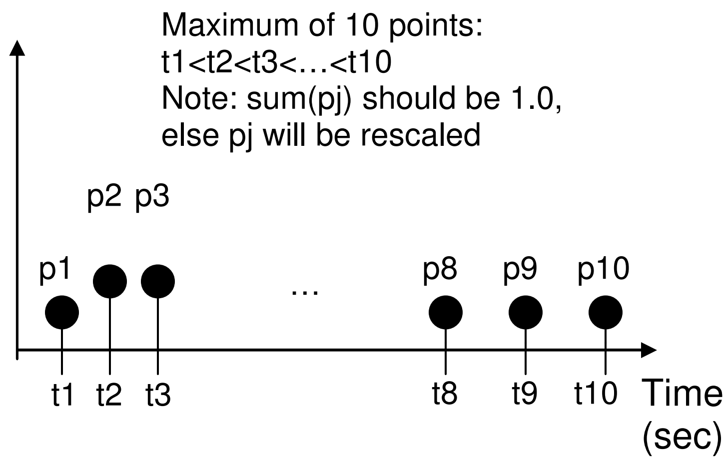
1.2.1.1 Communication Models

A novel flexible communication model has been implemented, which allows the user to define an arbitrary latency probability density function (pdf) for each sending-receiving pair of agents. In addition, dNetSim has been extended to allow the user to simulate an arbitrary change in the latency pdf, as well as a total communication failure between any number of pairs of agents. This capability enabled the testing of the initial fault-tolerant communication strategies.

The dNetSim platform consists of an unbalanced, three-phase distribution system simulator, capable of reading standard industry data, interacting with an autonomous agent framework, capable of modeling intelligent agents that can (1) sense local voltages and currents, (2) communicate with nearby agent team members, and (3) control various devices, including breakers, sectionalizers, and tie-switches.

Since realistic communication channels between agents will exhibit a time-varying latency, the first objective of Year 1 was to develop a stochastic latency model for all pairwise agent-to-agent communications. Several communication failure modes were grouped into two classes of communication disruptions: total failure (no communication possible between two given agents) and partial failure (delayed communication between two given agents). In addition, the team decided to implement a stochastic model of the communication latencies, rather than a purely deterministic model of the latencies.

For each unidirectional channel between a specific sending agent and a specific receiving agent, the user may supply a communication latency pdf as shown below:



For each message that is passed from the specific sending agent to the specific receiving agent, a "random" latency value is generated from the above pdf via a pseudo-random number generator.

1.2.1.2 Fault-Tolerant Communication Strategies

The initial implementation of the fault-tolerant communication strategies has been completed. Each agent is capable of transmitting and receiving messages to nearby agents on the same team. When an agent sends a message, it starts a countdown timer and waits for a response from the message recipient. If the countdown timer "times-out" by counting down to zero before it receives a response, then the agent "retries" by sending the message again. Both the "timeout" and maximum number of "retries" are configurable parameters in the agent input data. Depending on the message type and the action that an agent wants to perform, a failed communication can either result in an interrupted state (agent action is blocked due to safety constraints) or a partially successful state (agent action is permitted, but based on incomplete information).

1.2.1.3 Network Equipment Models

Two additional network equipment models were implemented in Year 1: three-phase and two-phase gang operated wye-connected regulators. In addition, two new regulator control schemes were implemented: regulator terminal voltage control and remote load center voltage control. These models and control schemes join the existing single-phase and multi-phase independently operated wye-connected regulators and the existing RX line drop compensation voltage control.

1.2.1.4 Load Models

A steady-state induction motor model was developed in Year 1. A motor starting mode is currently under development in Year 2. The starting mode will allow the user to simulate the larger startup currents of an induction motor as the motor is energized. In the future, there is potential for developing a stalled motor model, based on the starting motor model, as a more realistic load component model for fault-induced low voltage transients and other low voltage conditions. The induction motor model extends the existing static load models: wye-connected and delta-connected complex impedance (Z), complex current (I) and complex MVA (P), known as an arbitrary ZIP load model.

1.2.1.5 Distributed Resource Models

An electronic converter source model was developed for power electronic devices, such as battery storage systems. The electronic converter storage model operates in a PQ set point mode while connected to the utility grid. The model includes user parameters for maximum fault current, fault current rise time and a de-energized feeder shutdown timeout, in addition to the typical delta/wye connection, single-phase/three-phase options. For Year 2, an island mode is under development. The island mode will operate the device in a voltage magnitude set point mode. In addition, the island mode will allow the user to set an island-mode current overload limit and a maximum island-mode current overload duration for absorbing the transient demands of transformer in-rush currents and motor starting surge currents. The final component model completed in Year 1 was the independent generator model, based on a typical rotating mass prime mover. The rotating mass generator model operates in a PQ set point mode.

1.2.1.6 Test Feeder Verification

The dNetSim solution was verified against the IEEE reference report for the IEEE 34 Node Test Feeder system with unbalanced loads, long line sections with large voltage drops which can cause convergence problems, 2 switched capacitors and 2 regulators. In addition, the dNetSim solution was verified against the IEEE reference report for the IEEE 123 Node Test Feeder with unbalanced loads, 11 switches, 4 switched capacitors, 4 regulators and an underground cable network. Finally, the dNetSim power flow solutions for various custom feeder networks created by S&C Electric, without the autonomous agent-based controls, were verified against the output of the commercial distribution analysis tool known as “CYMEDIST” from CYME.

1.2.1.7 Visualization

The main deliverable for Year 2 of the Advanced Distribution Automation research project is a visualization platform for displaying the operating state of the distribution system modeled in dNetSim and the agent-based communication and control sequences implemented in JADE. To get a head start on the visualization platform, a team of student programmers was hired for the summer of 2009 to create a prototype. The prototype was developed using the international web standards body specification known as Scalar Vector Graphics (SVG). An SVG file containing a one-line diagram of a distribution system can be generated automatically via a set of Java routines by reading the same industry standard data files that are imported by dNetSim. The one-line diagram can be scaled up or down to reveal or hide the components’ details in the one-line diagram. The viewbox also can be panned across the one-line diagram, which is helpful when the user has zoomed-in on a specific portion of the diagram. The power system component symbols are defined in a separate SVG input file and may be changed by the user.

The prototype one-line diagram SVG files can be viewed in any web browser that implements the SVG specification, including Firefox, Opera, Google Chrome and other SVG viewers. The prototype SVG one-line diagrams will be used to gather feedback on the necessary features of the Year 2 visualization platform.

1.2.2 Research Task 2

Research Task 2 – Buried Cable Fault Detection and Mitigation is led by Dr. Zuyi Li of Illinois Institute of Technology. Dr. Li’s research group will develop and demonstrate a fault detection and mitigation system with the following features: sensitivity, reliability, selectivity, and speed.

1.2.2.1 Investigation of Incipient Faults

Read a dissertation on "Underground Distribution Cable Incipient Fault Diagnosis System." Incipient fault refers to the slowly developing fault. The work presents a methodology for a non-destructive and online incipient fault diagnosis system (IFDS) to detect incipient faults on underground cable. Non-destructive means no extern electrical source is needed to generate the diagnosis signal. Online means the cable remains in service. There are two aspects of the system: classification and detection. The system incorporates digital signal processing and pattern recognition methods to classify recorded data into designated classes. The classification functionality is achieved through several rule-based and supervised classifiers. In addition, the system utilizes several methods to detect when the cable is near failure. The detection functionality is achieved through incorporating a severity measure based on the temporal analysis of the arrival times of incipient abnormalities, which portrays the progressive degradation path of underground cable as the failure time approaches.

Regarding the input data. In one system reported, three basic electrical signals, namely voltage, phase current, and neutral current are observed. The system records the signals for one-second duration every 15 minutes. Moreover, various statistical and frequency parameters of these signals, namely average, maximum, minimum, standard deviation, and magnitude of the harmonics are calculated and recorded.

An underground distribution cable laterally installed in a residential area was chosen to collect on-line data. The data collection site includes the distribution transformer and the underground cable. The underground distribution cable lateral is fed from a standard 7200 V distribution feeder and supplies power to the 7200V/120V/240V, 100 KVA, 60Hz distribution transformers. This system is pretty similar to the IIT system.

Preprocessing tasks includes three important preprocessing operations namely, resampling, DC removal and denoising. Resampling is performed to eliminate the potential redundancy in the signals by resampling the signals at appropriate factor to yield an effective sampling rate. The removals of redundant signal samples help reduce the computational complexity and thus improve the processing speed. DC removal aims at suppressing measurement DC offset introduced inevitably in field recorded data. The denoising operation can be implemented based on wavelet analysis. The denoising increases the signal to noise ratio and reduces computation complexity, overall processing time, and enhance the performance of successive signal analysis steps by removing unwanted noise components. Once the preprocessing operations are performed, the data become ready for the classification and detection phases.

1.2.2.2 Other Activities

- Investigated two industrial applications of buried cable fault detection were reviewed. The first is with Progress Energy Florida, based on Time-domain reflectometer (TDR) technology, and the second is with CURRENT Group, LLC, based on measurements of voltages and currents using sensors throughout the distribution system. Further review of existing technologies will continue.
- Investigated the SEL PILC Fault Indicator, which is able to find faults faster on Paper Insulated Lead Cable (PILC).
- Investigated the Cable & Splice Center for Excellence in Bronx, NY dedicated to diagnosing the causes of cable failures.
- While investigating the EPRI's Cable Testing Network (ECTN), it is found that there is very limited information that is publicly available since IIT is not a member of EPRI.

- Investigated a non-destructive and online Underground Distribution Cable Incipient Fault Diagnosis System.
- Suggested that SmartSignal could collaborate on cable fault detection, especially to identify incipient faults.
- Power flow analysis and fault analysis have been performed based on the distribution network data in CYME format provided by S&C.

1.2.3 Research Task 3

Research Task 3 – Intelligent Perfect Power System Controller is led by Mr. Greg Rouse of Intelligent Power Solutions. Mr. Rouse's research group will develop and demonstrate Intelligent Perfect Power System Controller (IPPSC) for the IIT campus.

1.2.3.1 Project Activities and Accomplishments

- Completed campus walkdown of various campus energy systems and control systems.
  - This include walkdowns of the turbines and discussions with the turbine operator (DTE), and the company (On Power) recently hired by IIT to improve the turbine start times and is familiar with the controls.
  - Building controls were discussed with local Siemens representatives, technicians and engineers.
  - Communications interfacing with the campus electrical distribution system were discussed with S&C Electric.
  - Interfacing with the Zigbee controls were discussed with the IIT Research team and Siemens.
- Started writing the IPPSC software specification based on input from the campus walkdowns and interviews of key people.
- The IPPSC or any microgrid master controller will need to interface with controllers and protocols from several different industries. To make the IPPSC more useful as a generic microgrid master controller, and because some of the interfaces at IIT have little definition, the IPPSC specification will be written to make the control interfaces as general as possible, so that certain specifics, such as object names and address can be defined when the IPPSC program is setup on site. Actually the challenge here is not because there are limited choices; there are many choices which make the challenge to find the optimal solution in terms of reliability and security.
- Developed documents outlining communications and control between the IPPSC and the HRDS for the S&C Electric design team and other documents describing communications related to the IPPSC for IIT.
- Completed Version 1 of IPPSC software specification based on input from campus walk downs and interviews with key IIT people.
- Specification was reviewed by IPPSC programming team
- Visited S&C Electric for demonstration of the Vista Switch Control systems including communications.

- Currently sectioning of projects for dividing work among programmers

1.2.3.2 Next Steps

- Distributed and develop method for coordinating work among programmers
- Program modules required for Version 1
- Develop hardware requirements list and purchase hardware required for testing software
- Software quality assurance tests

1.2.3.3 Percent Complete

- The IPPSC team has completed on the Version 1, IPPSC specification.

1.2.4 Research Task 4

Research Task 4 – Advanced ZigBee Wireless is led by Dr. Chi Zhou of Illinois Institute of Technology. Dr. Zhou's research group will develop and demonstrate advanced ZigBee wireless technology for a robust wireless communications network to be utilized by the Perfect Power system in controlling loads for participating in load reduction and energy savings programs.

1.2.4.1 Project Activities and Accomplishments

Recent Zigbee research has been focusing on the performance evaluation of Zigbee under the Wi-Fi interference. First, Zigbee BER (Bit Error Rate) was theoretically analyzed under the Wi-Fi interference. The factors, including modulation, pass loss, SNR (signal to noise ration), etc., are considered. Since the Wi-Fi interference is strong, we ignore the noise in the analysis. We vary the distance between WiFi and Zigbee to find out the different effect caused by WiFi. Since the power density of WiFi is not uniform distribution, we calculate the BER of variant offset frequency. Based on CSMA (carrier sense multiple access), we calculate the average collision time, and consequently the average packet error ratio.

According to the theoretical analysis, the distance between WiFi and Zigbee should be larger than 7meters for BER 10^{-7}, where the interference of WiFi can be neglected.

We also build Zigbee and WiFi simulation in MATLAB. The simulation results closely match the analysis results. We find the result if the offset frequency is larger than 8MHz, zigbee can provide reliable communication even the distance is just 0.5m away from the WiFi. The better performance got by simulation is due to coding and filter used in the simulation system.

We will experimentally measure the performance using Zigbee and Wi-Fi equipment. In addition, we will propose the interference avoidance technique.

The performance evaluation of Zigbee under the Wi-Fi interference has been thoroughly evaluated. First, Zigbee BER (Bit Error Rate) was theoretically analyzed under the Wi-Fi interference. The factors, including modulation, pass loss, SNR(signal to noise ration), etc., are considered. We vary the distance between WiFi and Zigbee to find out the different effect caused by WiFi and also theoretically calculate the BER for variant offset frequency. We also built Zigbee and WiFi simulation in matlab. The simulation results closely match the analysis results. We find the result if the offset frequency is larger than 8MHz, zigbee can provide reliable communication even the distance is just 0.5m away from the WiFi. Moreover, real-world measurements were taken in residential environment, public place and laboratory. It is verified that the impact of WiFi interference depends on the distance between two networks as well as the offset frequency.

Recent research has focused on the design of frequency agility algorithm which can efficiently detect and mitigate interference. Specifically, interference avoidance algorithm based on Clear Channel Assessment (CCA) channel detection is proposed. It uses Beacon-based Interference Detection scheme to determent whether current channel is interfered or not. Once interference is detected, all devices in the network will call CCA channel detection to find out available channels according to priority of channel. When "safe" channel is found, all devices will change to that channel and call Beacon-based Interference Detection again to ensure the channel is "safe". After that the sender will begin to transmit packets. Through this algorithm, majority interference will be avoided and it's an effective algorithm in cluster-tree Zigbee networks. Currently we are implementing the proposed algorithm in the test bed for performance evaluation. We also plan to investigate how other interferences, such as Bluetooth, microwave, cordless phone, will affect the performance of Zigbee.

1.2.4.2 Other Activities

- Focus on survey reading on "Zigbee Smart Energy" available at www.zigbee.com. Established contact with Software Technologies Group (STG), a local company for Zigbee product development in Westchester, IL. STG donated Zigbee sensors for experimental testing, including setting up a simple Zigbee personal area network and enabling the two-way communications using two Zigbee chips.
- Writing a report on the most suitable ZigBee wireless devices and market technology.
- Christian Herzog, president of STG, visited the lab on 2/27/09 to provide input on challenges and possible solutions to interference avoidance research.
- Development kits for ZigBee are ordered and scheduled to be fully delivered within one week. Once all parts are received, the prototype will be built.
- Currently investigating techniques for frequency agility, frequency hopping, antenna diversity, and multi-radio coordinators.
- Suggest that SmartSignal could collaborate on the security intrusion detection module to track any abnormal behavior.

2 Project Budget and Schedule

Budget/Cost share update report is provided as Appendix 1 by the Project Accounting Office at IIT. The report summarizes what has been spent and how much cost share has been provided.

3 Issues and Project Changes

3.1 Demonstration Issues

Project budget is still under review based upon the feedback from year one pricing. The team will be completing the overall design and getting firm pricing for the remainder of the scope to fully understand the financial impact.

Infrastructure issues remain manageable. Working on one loop at a time poses issues for feeders that serve across the planned loop structure. They could become part of a new loop, but they need to remain in service for an existing building not on the loop, so the plan has to call for new cable where existing can be used.

3.2 Research Issues

There are no issues related to research that need to be reported.

3.2.1 Project Changes

John Kelly and Greg Rouse left Endurant Energy and joined the Intelligent Power Solutions (IPS), LLC. IPS will continue the work originally assigned to Endurant Energy.

3.3 Milestone Update

The following table shows the updated milestone log.

Phase/Task	**Milestone**	**Planned Completion Date**	**Current Status**
Phase I – Perfect Power Foundation	Milestone P1: Completion of Perfect Power Design	April 30, 2010	Completed
Phase II – Multi-year Research Phase			
Task 1.0 – Advanced Distribution Automation and Recovery System	Milestone P211: Completion of dNetSim Communication Model	September 30, 2009	Completed
	Milestone P212: Completion of dNetSim Visualization Platform	September 29, 2010	On schedule
	Milestone P213: Autonomous Agent Infrastructure for Real Time Control	September 29, 2011	On schedule
	Milestone P214: Autonomous Agent Infrastructure for Centralized and Distributed Control	September 27, 2012	On schedule
	Milestone P215: Pilot Demonstration of Autonomous Agent Infrastructure	September 27, 2013	On schedule
Task 2.0 – Buried Cable Fault Detection and Mitigation	Milestone P221: Completion of the Simulation on IIT's Distribution Network	April 1, 2010	On schedule
	Milestone P222: Identification of the Best FDM for IIT's Distribution Network	September 29, 2011	On schedule
	Milestone P223: Pilot Demonstration of FDM in IIT's Distribution Network	September 27, 2013	On schedule
Task 3.0 – Intelligent Perfect Power System Controller	Milestone 231a: Completion of IPPSC Version 1 Software Specification	July 15, 2009	Completed
	Milestone 231b: Completion of IPPSC Version 1 Software	December 31, 2009	On schedule

Phase/Task	Milestone	Planned Completion Date	Current Status
	Milestone 231c: Completion of IPPSC Version 1 Bench Testing	April 30, 2010	On schedule
	Milestone 232a: Completion of IPPSC Version 2 Software Specification	March 5, 2010	On schedule
	Milestone 232b: Completion of IPPSC Version 2 Software	July 21, 2010	On schedule
	Milestone 232c: Completion of IPPSC Version 2 Bench Testing	November 24, 2010	On schedule
	Milestone 233a: Completion of IPPSC Version 3 Software Specification	March 4, 2011	On schedule
	Milestone 233b: Completion of IPPSC Version 3 Software	July 11, 2011	On schedule
	Milestone 233c: Completion of IPPSC Version 3 Bench Testing	November 15, 2011	On schedule
Task 4.0 – Advanced ZigBee Wireless	Milestone P241: Completion of the Design and Development of Interference Avoidance Techniques	September 30, 2009	Completed
	Milestone P242: Completion of the Design and Development of Self-forming and Self-healing Cluster-tree ZigBee systems	September 29, 2010	On schedule
	Milestone P243: Completion of the Design and Development of MAC Layer Protocol to Achieve Energy-efficient Access for Cluster-tree Networks	September 29, 2011	On schedule
	Milestone P244: Completion of ZigBee Installation Plan and Energy Efficient Routing Algorithm	September 27, 2012	On schedule
	Milestone P245: Pilot Demonstration of ZigBee Wireless Technology for Implementing Energy Efficiency Programs	September 27, 2013	On schedule
Phase III – Ancillary Service	Milestone P31: IPPSC V1 Installed	February 18, 2011	On schedule

Phase/Task	**Milestone**	**Planned Completion Date**	**Current Status**
Demonstration	Milestone P32: Engine Start to Full Load within 10 Minutes	August 2, 2009	Completed
Phase IV – Distribution System Automation Demonstration	Milestone P41: HRDS Installed	January 19, 2013	On schedule
	Milestone P42: Substation Automation Compatible to HRDS	January 19, 2011	On schedule
	Milestone P43: IPPSC V2 Installed	August 3, 2011	On schedule
Phase V – Distribution Level Peak Load Reduction Demonstration	Milestone P51: Load Reduction Controller Installed	April 5, 2012	On schedule
	Milestone P52: IPPSC V3 Installed	December 27, 2012	On schedule
	Milestone P53: Solar PV Installed	December 20, 2011	On schedule
	Milestone P54: UPS Installed at Critical Buildings	December 21, 2011	On schedule
Overall Project	Milestone PRO: 50% Peak Load Reduction Capability	September 27, 2013	On schedule

4 Products and Technology Transfer

4.1 Publications

- Perfect Power Fact Sheet, published by Illinois Institute of Technology. See Appendix 3.
- New Grid in Town, IIT Magazine report. See Appendix 4.
- Perfect Power Control Working Document, internal working report. See Appendix 5.

4.2 Websites and Media Report

- Chicago Sun Times had a report on this project on February 14, 2009. The title is “POWER SHIFT: Old name behind new design for IIT electricity delivery.” See Appendix 6.
- IIT's Perfect Power project, which implements smart grid technology, was featured in "In Search of Perfect Power" the cover story of Power Magazine's April 2009 issue. See Appendix 7.
    - http://www.powermag.com/issues/cover_stories/In-Search-of-Perfect-Power_1801.html
- The Perfect Power project at IIT was featured in the May 19, 2009 Economist article, "Smart Move: The push for a more intelligent grid." See Appendix 8.
    - http://www.economist.com/world/unitedstates/displaystory.cfm?story_id=13337902&fsrc=rss
- A Renewable Energy World story on August 12, 2009 discussing the U.S. Department of Energy’s funding announcements for renewable energy projects and initiatives, mentioned plans for IIT’s Perfect Power System. See Appendix 9.
    - http://www.renewableenergyworld.com/rea/news/article/2009/08/us-government-continues-to-fund-renewable-energy-r-d
- The Perfect Power Project at IIT has a permanent website to update news regarding the project. See Appendix 10.
    - http://www.iit.edu/perfect_power/

4.3 Networking Activities

- Hosted Dave Bell, VP Application Engineering, SmartSignal in the February monthly meeting (February 17, 2009).
    - D. Bell suggested that their expertise could be utilized in monitoring and data analyses for the IIT gas power plant. In addition, pharos measurement unit data management and the monitoring of overall grid are possible areas for SmartSignal to assist IIT in implementing the Perfect Power project.
    - M. Shahidehpour suggested that the cable fault detection, distribution automation, and possibly ZigBee wireless sensors are areas that IIT would be looking for additional partners as IIT proceeds with the DOE projects.

- Dr Chi Zhou hosted Chris Herzog, from Software Technologies Group, a local Zigbee company on February 27, 2009.
- Hosted Dr. Jaeseok Choi from Gyeongsang National University on March 18, 2009.
- Hosted Mr. Honggeun Kim and Mr. Byoungchin Ahn from Korean Power Exachange (KPX) on May 18, 2009.
- Hosted Tim Stojka from Agentis on June 10, 2009.
- Dr. Mohammad Shahidehpour gave a plenary talk on “Smart Grid: A New Paradigm for Power Delivery” during the IEEE PowerTech 2009 Conference, 28 June - 2 July 2009, Bucharest, Romania. See Appendix 11.
- Dr. Mohammad Shahidehpour attended the San Diego 2009 Symposium on Microgrids, September 17-18, 2009 and made a presentation titled “Perfect Power Prototype for Illinois Institute of Technology.” See Appendix 12 for the Agenda of the Conference (Page 4).
- Dr. Mohammad Shahidehpour attended the 2009 Meeting of Italian Federation of Electrical Engineering in Italy, September 27-29, 2009 and made a presentation on Electric Networks of the Future. See Appendix 13 for the Agenda of the Conference (Page 2).

Appendix 1

FINANCIAL STATUS REPORT

(Long Form)

(Follow instructions on the back)

1. Federal Agency and Organizational Element to Which Report is Submitted	2. Federal Grant or Other Identifying Number Assigned By Federal Agency	OMB Approval No.	Page of
U.S. Department of Energy	DE-FC26-08NT02875	0348-0039	1 of 1 pages

3. Recipient Organization (Name and complete address, including ZIP code)
Illinois Institute of Technology
Grant and Contract Accounitng, Room 502
3300 South Federal St., Chicago, IL 60616

4. Employer Identification Number	5. Recipient Account Number of Identifying Number	6. Final Report	7. Basis
1-362170136-A1	381261	Yes X No	Cash X Accrual x

8. Funding/Grant Period (See Instructions) From: (Month, Day, Year)	To: (Month, Day, Year)	9 Period Covered by This Report From: (Month, Day, Year)	To: (Month, Day, Year)
10/1/2008	9/30/2010	7/1/2009	9/30/2009

10. Transactions:	I Previously Reported	II This Period	III Cumulative
a. Total outlays	195,940.99	1,560,967.18	1,756,908.17
b. Refunds, rebates, etc.	0.00	0.00	0.00
c. Program income used in accordance with the deduction alternative	0.00	0.00	0.00
d. Net outlays (Line a, less the sum of lines b and c)	195,940.99	1,560,967.18	1,756,908.17
Recipient's share of net outlays, consisting of:			
e. Third party (in-kind) contributions	0.00	0.00	0.00
f. Other Federal awards authorized to used to match this award	0.00	0.00	0.00
g. Program income used in accordance with the matching or cost sharing alternative	0.00	0.00	0.00
h. All other recipient outlays not shown on line e, f, or g	92,441.70	797,109.15	889,550.85
i. Total recipient share of net outlays (Sum of lines e, f, g, and h)	92,441.70	797,109.15	889,550.85
j. Federal share of net outlays (line d less line i)	103,499.29	763,858.03	867,357.32
k. Total unliquidated obligations			0.00
l. Recipient share of unliquidated obligations			0.00
m. Federal share of unliquidated obligations			0.00
n. Total Federal share (Sum of lines c and f)			867,357.32
o. Total Federal funds authorized for this funding period			1,593,914.00
p. Unobligated balance of Federal funds (Line h minus line g)			726,556.68
Program Income, consisting of:			
q. Disbursed program income shown on line c and/org above			0.00
r. Disbursed program income using the addition alternative			0.00
s. Undisbursed program income			0.00
t. Total program Income realized (Sum of lines q, r, and s)			0.00

11. Indirect Expense

a. Type of Rate (Place "X" in appropriate box) ☐ Provisional ☒ Predetermined ☐ Final ☐ Fixed

b. Rate	c. Base	d. Total Amount	e. Federal Share
50%	40,961.37	20,480.69	19,509.39

12. Remarks: Attach any explanations deemed necessary of information required by Federal sponsoring agency in compliance with governing legislation.

13. Certification: I certify to the best of my knowledge and belief that this report is correct and complete and that all outlays and unliquidated obligations are for the purposes set forth in the award documents.

Typed or Printed Name and Title	Telephone (Area code, number and extension)
Elzbieta Obiedzinska, Assistant Director, Grant and Contract Accounting	312- 567-3186
Signature of Authorized Certifying Official E. Obiedzinska	Date Report Submitted 30-Oct-09

NSN 7540-01-012-4285 269-103 Standard Form 269 (REV 4-88)

Prescribed by OMB Circulars A-102 and A-110

Appendix 2

The Perfect Power Prototype
for the Illinois Institute of Technology

Project Management Plan

Table of Contents

1 Executive Summary

The Illinois Institute of Technology (IIT) was awarded $7.0M in funding from the Department of Energy (DOE) to provide research and install key elements of Perfect Power at the campus. IIT's cost share for the project is $5.1M. However, only the first two years of the project have been allocated by DOE to IIT.

IIT, in collaboration with Exelon, Galvin Electricity Initiative (GEI), and other key partners (the team) propose to develop, demonstrate, promote, and commercialize a system and supporting technologies that will achieve "Perfect Power" at the main campus of IIT. A "Perfect Power" system, as defined by GEI, is a system that cannot fail to meet the electric needs of the individual end-user. Different types of end-users will have different needs and a Perfect Power system will have the flexibility to supply the power required by each type without fail. The proposed Perfect Power Prototype design is replicable to campuses, complexes, developments, investor owned, and municipal electric systems.

The IIT project will demonstrate a new regulatory model for improving electricity service, one where the consumer and utility work together to lower cost, improve reliability, improve energy efficiency, and lower carbon emission. IIT is fortunate to be located in a restructured electricity market where the Independent System Operator provides real time pricing, day ahead hourly markets, demand response payments, capacity payments, and access to competitive wholesale electricity markets. These new markets provide IIT with the economic incentive to invest in demand reduction and energy efficiency. In addition, IIT owns the site distribution system thereby saving money on utility distribution charges. Essentially, IIT can control and invest the distribution charge savings into site distribution system improvements. In contrast, some cities in Illinois whose residents pay full distribution system charges have not had any improvements to the local distribution systems in 50 or more years.

The overall objectives of the project include:

1. The achievement of system-wide Perfect Power for IIT's electric power conditions and demonstration of its technological viability through the implementation of distributed energy (DE) and advanced sensing, switching, feeder configuration, and controls.
2. 50% peak demand reduction capability when called upon by Exelon/PJM Interconnection (PJM).
3. 20% permanent peak demand reduction from the 2007 annual peak demand.
4. Deferral of Commonwealth Edison (ComEd) planned substation upgrades due to the demand reduction achieved.
5. Demonstration of the economic value of Perfect Power, specifically the avoidance of outage costs, investment avoidance, and the introduction of significant savings and revenue from providing ancillary services in a restructured electricity market.
6. A design that can be replicated to any campus or community.
7. Promote the Perfect Power prototype.

The Perfect Power Implementation plan is based on a Failure Modes and Effects Analysis for the campus distribution system and the results of the Galvin Perfect Power research. The deployed Perfect Power model is capable of providing 10MW of demand reduction within 30 minutes of notification by ComEd or the PJM. This includes 5MW of firm demand reduction due to redundant distributed resource and distributed generation capability. This will allow ComEd to defer $2,000,000 in substation upgrades per their support letter[*]. The proposed project provides a unique opportunity to demonstrate the economic benefits of demand response by leveraging PJM's day ahead and real time markets. The proposed project reveals significant cost savings and revenue production opportunities by leveraging PJM programs. IIT with one of the few Power Engineering curriculum programs in the country and located near Chicago's Midway airport provides an ideal location for continued refinement and development of advanced grid systems and access to industry, utilities, and regulators for demonstration purposes. Through the Galvin Electricity Initiative the results, benefits, and impacts will be communicated to utilities, policy makers, and end users across the United States.

Prior to submitting a proposal to DOE, the IIT had been working with the Galvin Electricity Initiative to develop Perfect Power prototype at the IIT campus. The Galvin Electricity Initiative (GEI) has been applying continuous improvement methods to the elements of the United States power grid, the initiative hopes to achieve the universal adoption of a system design that cannot fail to meet the power needs of every consumer. It calls this ultimate state Perfect Power. The GEI intends to demonstrate that delivering "Perfect Power" to the consumer not only attainable, but is ultimately the most cost-effective option. The cost of implementing the IIT Perfect Power Prototype exceed the budget limitations of the DOE solicitation, so the scope of the DOE project is reduced from the prototype described in the IIT Perfect Power Prototype report. IIT is working to acquire additional funding to cover the cost of fully implementing the Perfect Power prototype at IIT.

COMPARISON OF RECOMMENDED PERFECT POWER ELEMENTS AND DOE PROJECT ELEMENTS

Recommended Perfect Power Element from Prefect Power Report	Included in DOE Project
Redundant transmission supply	No, IIT wants to defer these costs using demand reduction and site generation
Redundant area substation or switch station supply	No, IIT wants to defer these costs using demand reduction and site generation
Self-sustaining infrastructure	Yes
Intelligent distribution system	Yes
On-site electricity production	Yes, but does not include the 4MW of backup engine generation proposed in the report. Building generation and demand response will provide sufficient capability for IIT to operate in island mode.[†]
Demand response capability (A/C, lighting, major loads)	Yes, but budget to add building controllers to all buildings has been reduced
Intelligent Perfect Power Systems Controller	Yes, some capabilities reduced

[*] $2,000,000 is ComEd savings for the work avoided at its area substation that is in addition to the IIT's $5,000,000 savings associated with avoiding a new site substation.

[†] The IIT Perfect Power Report included a provision for an additional 4MW of generation at the north substation to support the islanding of the campus. However, during the DOE proposal submission process it was determined that the existing 8MW of generation, building backup generators, energy efficiency improvements, and planned demand response capability would allow the campus to operate in the island mode without the additional generation. As a result, this feature was removed.

Recommended Perfect Power Element from Prefect Power Report	Included in DOE Project
Sustainable energy systems and green buildings/complexes	Yes, some EE features have been postponed
Technology ready infrastructure	No
Substation outage ride through capability	No. Insufficient budget to provide for UPS for all buildings

The project team will demonstrate a replicable model for leveraging advanced technology to create microgrids that automatically respond to utility, Independent System Operator, and electricity distribution system signals, changes, and interruptions in a way that provides key demand reduction support and increased reliability. The team provides a systematic approach to build a foundation for perfect power. The Team will engage in a five-phase research, development and demonstration project that will use continuous improvement methods to bring Perfect Power to the IIT campus and showcase Perfect Power principles to the industry. The phased approach provides utilities and campuses across the country with a means to achieve Perfect Power in economically viable steps.

1. The purpose of Phase I is to establish the basis for Perfect Power.
   1.1. Conceptual design.
   1.2. Substation supply reliability improvements.
   1.3. IIT campus wide efficiency upgrades.
   1.4. Develop the detailed designs for the campus distribution system.

2. The purpose of Phase II will be to address key technology gaps identified in the GEI Perfect Power research. The technologies developed in this phase will be demonstrated in later phases of the project.
   2.1. Develop advanced sensing, data processing and actuators that will enable the Perfect Power system. Demonstrated the technology on a ComEd circuit feeding IIT.
   2.2. Develop advanced distribution fault detection. This technology will be demonstrated on the feeders to the North and South substations on the IIT campus.
   2.3. Develop the Intelligent Perfect Power System Controller (IPPSC), an advanced distribution controller with features for Perfect Power adapted to the specifics of the IIT campus.
   2.4. Develop a ZigBee wireless infrastructure for the campus particularly suited for demand response control.

3. Phase III is intended to prepare IIT for real time pricing and ancillary markets.
   3.1. Upgrade two existing 4MW Allison natural-gas-fired engines. Upgrades will enable IIT to cover most of its near term projected electric loads and to enter real time and ancillary markets.
   3.2. Deploying version 1 of the IPPSC. This version will include the functions required for real pricing and ancillary markets.

4. The advanced campus distribution system will be deployed in Phase IV. This distribution system is intended to mitigate any faults that could occur within IIT distribution system.
   4.1. Deploy S&C Electric's High Reliability Distribution System (HRDS). This will include adding Smart Switches and controllers for the HRDS self-healing network.
   4.2. Adding the substation automation required for the HRDS loops. Currently seven HRDS loops are planned for the IIT campus distribution system.

4.3. Deploy Version 2 of the IPPSC. Version 2 will include the functions required for communicating with HRDS controllers and coordinating the switches in the distribution network with the existing gas turbines and engines installed in Phase III, and load some load shedding capability.

5. Phase V will be used to deploy campus distribution level peak load reduction and complete the IIT Perfect Power Prototype. Controls for key large building loads will be added to for demand response load shedding. Version 3 of IPPSC will be deployed for demand response control. IIT will add solar panels for additional peak load reduction. Uninterruptible-Power-Supply (UPS) systems will be added to critical building circuits where required.

2 Project Objective

IIT in collaboration with Exelon, the GEI, and other key partners (the team) propose to develop and demonstrate a system that will achieve “Perfect Power” at the main campus of the Illinois Institute of Technology. A “Perfect Power” system, as defined by GEI, is a system that cannot fail to meet the electric needs of the individual end-user. Different types of end-users will have different needs and a Perfect Power system will have the flexibility to supply the power required by each type without fail. This Perfect Power Prototype design, which exceeds the DOE solicitation requirements, is replicable to any municipality-sized system where customers can participate in electric power market opportunities. The specific objectives include:

- The achievement of system-wide Perfect Power for IIT’s electric power conditions and demonstration of its technological viability through the implementation of distributed energy (DE) and advanced sensing, switching, feeder configuration, and controls.
- 50% peak demand reduction capability when called upon by Exelon/PJM Interconnection (PJM).
- 20% permanent peak demand reduction from the 2007 annual peak demand.
- Deferral of Commonwealth Edison (ComEd) planned substation upgrades due to the demand reduction achieved.
- Demonstration of the economic value of Perfect Power, specifically the avoidance of outage costs, investment avoidance, and the introduction of significant savings and revenue from providing ancillary services in a restructured electricity market.
- A design that can be replicated to any campus or community.
- Promote the Perfect Power prototype.

3 Project Approach

In the pursuit of perfect power the team utilized the following Galvin Electricity Initiative documents as guidance in identifying solution to address energy system failure modes and IIT constituent power needs.

- Master Controller Requirements Specification for Perfect Power Systems, Revision 2, November 2006
- The Path to Perfect Power: New Business Opportunities for A Customer-Demand Driven Electricity World, November 2006
- The Galvin Electricity Initiative: Task 3 – Technology Scanning, Mapping and Foresight, March 2006

In developing the Perfect Power project for DOE, the team applied GEI guidelines to the IIT system to design the IIT Perfect Power prototype and included the most important elements. The DOE Perfect Power at IIT includes the following elements:

- Self-sustaining infrastructure
- Intelligent distribution system
- On-site electricity production
- Demand response capability (A/C, lighting, major loads)
- Intelligent Perfect Power Systems Controller
- Sustainable energy systems and green buildings/complexes
- Technology ready infrastructure

3.1 Design Assumptions

The following assumptions were made in designing the DOE Perfect Power Project at IIT. Additional assumptions may be identified as the project progresses.

- The onsite generators are already programmed and setup for black start capability but can run in parallel to each other in island mode.
- The existing onsite generation has its own protective relays and switch gear to handle protection from disturbances such as over/under voltage and over/under frequency.
- Power to buildings can be switched off using the HRDS. The design assumption is that the IPPSC will interface with the HRDS SCADA (Supervisory Control and Data Acquisition) and not to directly control the HRDS switches.
- The S&C Electric HRDS will handle distribution fault detection and isolation, not the IPPSC.
- IIT will install commercially available building controller in buildings to be controlled by the IPPSC. The IPPSCE will send a load reduction commands to the building controller and the building controllers will have their own logic for reducing loads within their respective buildings.

3.2 Design Overview

3.2.1 Redundant Supply and Power Generation

The Perfect Power Prototype at IIT does not include redundant transmission or area substation supply at this time. Instead, the plan is to use local generation at the site buses and UPS/backup generation at key facilities ensure that the campus can run independently of the utility or can backup the grid and provide ancillary services. However, the DOE project does not include the 4MW of backup generation described in the Perfect Power report for IIT. Budget limitations forced the team to rely instead on the existing turbines, building generators and demand response to provide for island mode capability. ITT upgraded its existing turbines for fast start capability so that the turbines can provide a substation amount of the campuses power requirements. Backup power generation is already installed at several of the critical buildings on campus. During the course of the project IIT will evaluate whether these backup generators can be used to reduce peak loads during demand response events.

IIT and ComEd were pursuing a redundant power feed from the Quarry substation to a new substation on the east campus which would support the new housing and other campus improvements. However, the need for an east campus substation can be eliminated through the implementation of the Perfect Power prototype. The increased reliability, demand response capability and the on-site generation provide the desired redundancy.

3.2.2 Self Sustaining Infrastructure

The Perfect Power prototype at IIT builds upon the High Reliability Distribution System design developed by S&C Electric, a loop system that provides redundant electricity to each building. In this system, any single fault on any or all of the feeder loops can be isolated without interrupting power. In addition, the Perfect Power prototype includes an Intelligent Perfect Power System Controller which manages the campus electricity distribution and usage. This includes coordinating with ComEd and the PJM ISO to provide ancillary services and demand response.

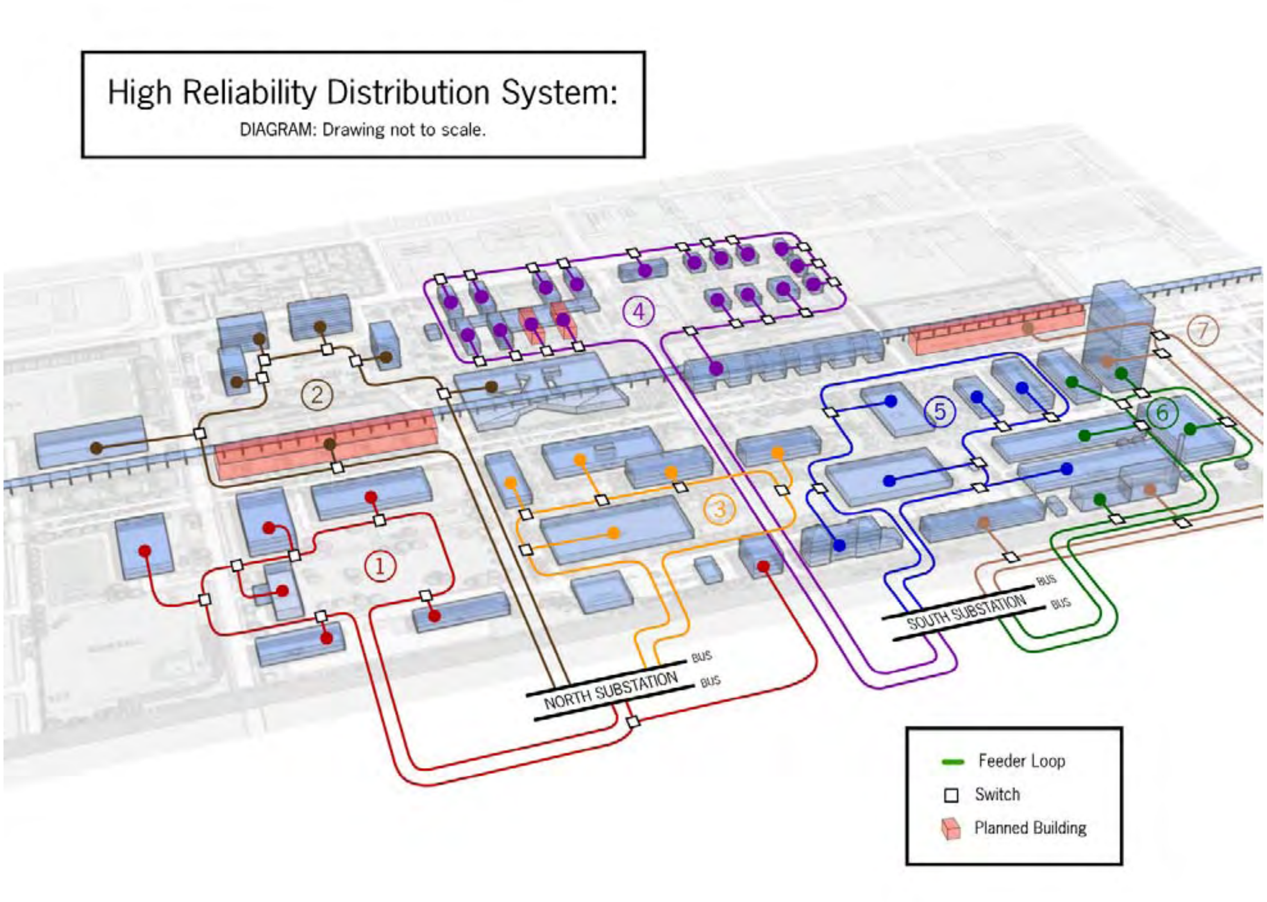
3.2.2.1 Feeder Redundancy

Feeder Redundancy will allow the re-routing of power to buildings in the event of a fault on a distribution feed. Used in concert with high-speed automated breakers and switches, redundant feeders allow for the instant reconfiguration of the system to keep power flowing to all buildings.

The proposed HRDS is designed to be reliable, versatile, upgradeable, and cost-efficient. The approach utilizes S&C Vista™ UDS fault-clearing switchgear in a closed-loop system with SEL-351 directional over current protection relays. To meet the Perfect Power design criteria, the following schemes will be implemented:

- A Permissive Over-reaching Transfer Trip (POTT) scheme will be used to protect the underground feeder cables. Using this scheme with the S&C Vista UDS and SEL-351 relays results in clearing of primary faults in less than 6 cycles. In addition, a Directional Comparison Blocking scheme is used as a back-up to the POTT scheme.
- Branch line faults will be cleared by the integral Vista Over-current Control, which can operate the fault interrupter to clear the fault in as little as 3 cycles.
- The system will use two substations in two closed-loop configurations to support load requirements as well as load equalization if a fault occurs on a feeder.

- To support new load growth, additional Vista units can be added anywhere along the loop system and will adhere to the system design without any changes in relay settings.
- The proposed design can support an additional source for future load expansion.



3.2.2.2 Automated Breakers and Switches

The isolation of faults will be executed by automated breakers and switches that will sense fault conditions and open within 1/4 cycle, simultaneously isolating the fault and allowing power to flow along a secondary feeder route. This system of automated breakers and switches will employ:

- High speed, fault interrupting switchgear for the north and south main buses
- Automatic high speed transfer system – either at the individual building level, mid-distribution loop level, or substation level
- Multifunction directional over-current relays
- S&C Vista switches with vacuum fault interrupters

3.2.2.3 Distributed Intelligence

The Perfect Power systems first line of defense is the deployment of intelligent components that can monitor system conditions and take action to sustain proper operation locally. Smart switches combined with UPS and on-site generation will automatically respond to abnormal system conditions to maintain system stability and normal operations. The distributed intelligence in the campus distribution loops will rely on existing S&C Electric technology. IIT will use its campus loops to test the technology developed in the Phase II, the research phase. To clarify, the fault detection technology developed in the research phase is intended to advance the state of the art. The IIT implementation will rely on existing technology.

3.2.2.4 Coordinated Communications

In order for the system to function as a whole, to be efficient and flexible while maintaining a system wide cohesiveness, distributed intelligence will need to be connected and coordinated. In certain fault scenarios, there will be various and competing solution strategies. The proper diagnosis of problems and often the proper *sequencing* of solution steps is crucial, so disparate intelligent parts will have to be both aware of each other and controllable by a system overseer that can orchestrate the actions of the whole system.

The IIT Perfect Power prototype will leverage the research and design capabilities of IIT and ComEd to develop an advanced power communications system. The team will explore technologies ranging from fiber optics that would follow cable conduit to highly flexible and cost-effective ZigBee wireless technology.

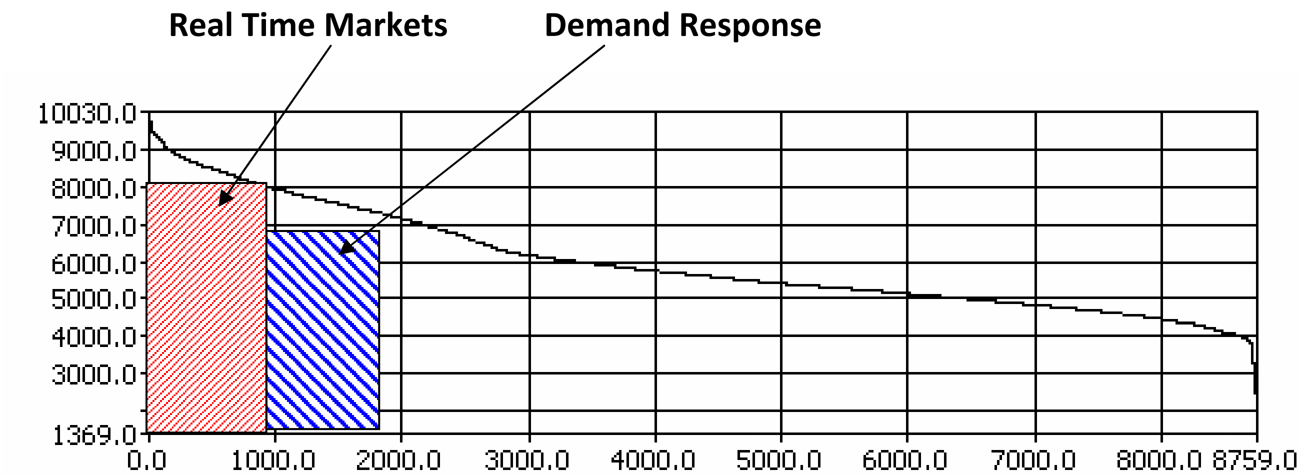
3.2.3 UPS and Electricity Storage

This product can be designed to carry the load of a system for up to 120 seconds - for minor outages on a system that cannot tolerate even milliseconds without power (such as data and server centers) and as such is an important part of a self-sustaining infrastructure. A UPS can be coordinated with generators to carry system load for more than 120 seconds - this would be coordinated with IIT's substation generators. The UPS would instantly assume the load during an outage event and supply ride-through power until the generators are up and synchronized.

3.2.4 Demand Response Capability

Demand response capability will be carried out using a two fold approach. In some cases, building circuits can be switched off by the HRDS controller. For more flexibility and precision, additional load controllers will be installed on certain loads and circuits for demand response control. The loads will be operated by a demand response load controller.

The following figure provides an electricity load duration curve for IIT. The x-axis is hours in the year and the y-axis is demand in kW. This curve reveals that IIT achieves a 10,000kW peak demand in one hour each year and uses a minimum of about 4,000kW in every hour of the year or baseload. This figure also reveals the projected impact of IIT participating in the real time pricing and demand response markets. Based on historic data, the real time price will exceed the operating cost of on-site generation 1,000 to 1,500 hours per year. IIT would run the on-site generation when the real time price exceeds the operating cost, reducing the peak demand for those days. In addition, IIT will deploy demand response capabilities to reduce another megawatt of IIT's peak demand. The combined generation and demand reduction strategies can reduce firm peak demand by 50% when called upon and at least 20% permanent peak demand reduction when combined with energy efficiency improvements.



Projected Impact of Entering Real Time Pricing and Demand Response Markets on Current Load Duration Curve

3.2.5 Intelligent Perfect Power System Controller

The Intelligent Perfect Power System Controller (IPPSC) will be designed to optimize system performance. This includes reconfiguring the Perfect Power system to respond to threats and economic conditions. The Intelligent Perfect Power System Controller will then remotely configure the Perfect Power system to maintain stability. The IPPSC will be developed by Endurant Energy under subcontract to IIT.

- Campus and building load prediction, based on seasonal and weather factors, for scheduling gas fired generation and Solar PV output.
- Load management and coordination for generation islanding and demand response. For instance, when the master controller is in island mode, generators will start and loads will be added based on a predetermined priority, expected loads, and safe limitations of generation. The original plan was to control loads through building controllers and distribution switches via the distribution controller. Load control through DR events will be planned to be through building controllers though we could use distribution switches for certain loads. For instance, if a large chiller plant is feed through a separate HRDS switch, it may be easier to control the chiller plant through the HRDS switch than through an additional system.
- Generation dispatching based on threats and fuel pricing
- Threat detection will include lightning detection. Endurant will investigate other threat detection modes based on available data and budget.

Although the following functions are often proposed in microgrid controllers, the IPPSC will not incorporate them since they where not included in the Perfect Power conceptual design. These functions, for the most part, are already included in existing systems on campus.

- Synchronization controls (handled through the genset controls).
- Power factor control (handled through the genset controls).
- Distribution fault detection and isolation (handled by the smart switches).

- Will not be the building load controller or primary data acquisition system for the buildings but will communicate with the building controllers. The building controller will have their own logic for reducing demand within their respective buildings.

IPPSC Requirements and Clarifications

Requirement	Clarification
1. Agent based control system	The primary advantage of the agent based control system from the prospective of the IPPSC is improved reliability. Endurant is considering putting most of the supervisory functions in all of the agents for redundancy purposes, which strictly speaking would no longer be an agent based control system.
2. IPPSC will be designed to optimize system performance and reconfigure system to respond to threats and economic conditions.	Functions will be programmed into the IPPSC but the scope of the demonstration may be limited by existing available equipment at IIT.
3. IPPSC will be able to remotely reconfigure system.	The IPPSC will have this functionality built in. The application of this functionality will depend on the ability of the connected system to do so. For instance, if the turbines are not configured to start automatically then the IPPSC will send a signal to the operator to start the turbines.
4. IPPSC will take action to mitigate threats to system reliability and performance.	Functions will be programmed into the IPPSC but the scope of the demonstration may be limited by existing available equipment at IIT.
5. IPPSC will coordinate with master controllers distributed around campus	The IPPSC will coordinate with the other IPPSC agents distributed around campus. These agents will be connected to master controllers for their respective systems.
6. IPPSC will select operating modes for other controllers	This should refer to other IPPSC agents, not other controllers or master controllers.
7. IPPSC will start and stop generating resources	No clarification required
8. IPPSC will start and stop storage devices.	The only planned energy storage at IIT is the UPS, which will have its own control system. The referring sentence said “generation and energy storage devices”. Endurant does not believe that requirement makes sense for this project as no long term energy storage is planned.
9. IPPSC will control loads based on predetermined sequence of operation and load reduction schemes	No clarification required

Requirement	Clarification
10. IPPSC will automatically switch loads to other transformers, feeds, and substations.	Originally the cross ties between substations and some of the feeds were planned but have since been removed from IIT's facility upgrade plans. The HRSD will still provide self-healing loops but the transfer of loads between loops, feeders, transformers and substations, will be limited to what is installed at IIT.
11. Placing a building or entire campus in island mode	This depends on the ability of the existing turbines and backup power generators to do so. It is Endurant's understanding that the turbines are capable of black starting though it may not be automatic. The original plan included adding natural gas fired engines that would have been specified to include island mode but these engines were removed from the DOE scope of work at the last minute before the proposal was submitted to DOE.
12. Will communicate across campuses using Zigbee wireless network.	Endurant incorrectly understood that the Zigbee network would be applied to the whole campus. The Zigbee network will only be applied in one building. Instead, campus wide communication will be conducted over the IIT's existing campus Ethernet network.
13. The IPPSC will control building loads	The IPPSC was originally planned to interface with a building SCADA (Supervisory Control and Data Acquisition), which was not yet in place when the proposal was written. The status of the building SCADA will be investigated as part of the information gathering for the IPPSC specification. If the building SCADA is not available, one will have to be installed as part of the implementation, though it may only communicate with one building or just a few buildings. Funds for bring the building controls up to standards for communicating with the IPPSC were eliminated in the budget revision.
14. HRDS SCADA	A budget exists in the implementation plan for an HRDS SCADA. If Endurant finds that it is relatively easy and safe to interface directly with the HRDS, Endurant may chose to develop a direct IPPSC interface for the HRDS and use the budgeted HRDS SCADA funds for the building SCADA.

4 Statement of Work

The IIT team will demonstrate a replicable model for leveraging advanced technology to create microgrids which automatically respond to utility, Independent System Operator, and electricity distribution system signals, changes, and interruptions in a way that provides key demand reduction support and increased reliability. The team provides a systematic approach to build a foundation for perfect power. The phased approach provides utilities and campuses across the country with a means to achieve Perfect Power in economically viable steps for phases.

The Team will engage in a five-phase research, development and demonstration project that will use continuous improvement methods to bring Perfect Power to the IIT campus and showcase Perfect Power principals to the industry.

Phase I – will prepare IIT's infrastructure for Perfect Power improvements. A conceptual design will be established and campus substation supply will undergo reliability improvements. IIT will conduct building energy efficiency upgrades and a detailed design will be completed for the campus distribution system.

Phase II – will address key technology gaps identified in GEI research. These include advanced distribution fault detection, ZigBee wireless infrastructure, demand response control, advanced sensing and advanced distribution controls. Technologies developed in Phase II will be available for testing on ComEd's system.

Phase III – will provide the capability for IIT to enter real time pricing and ancillary service markets with the fast start capability modification to the two existing 4MW gas turbines which will work in concert with the deployment of an Intelligent Distribution Controller. This new capability will provide for 50% load reduction when called upon.

Phase IV – will be the deployment of the advanced campus distribution system based on S&C Electric's High Reliability Distribution System (HRDS) design. This design leverages seven feeder loops working in concert with intelligent high-speed switches to isolate any single fault without interruption of power to buildings.

Phase V – will be the deployment of campus distribution level peak load reduction and will complete the IIT Perfect Power Prototype.

4.1 Tasks to be Performed

4.1.1 Phase I – Perfect Power Foundation

4.1.1.1 Objective

The objective of Phase I is to develop the Perfect Power concept and take the initial deployment steps which will allow the Illinois Institute of Technology (IIT) to provide ancillary services to Commonwealth Edison (ComEd). Phase I will provide a foundation for the proposed research and demonstration project. No DOE funding is requested for Phase I and costs will not be included in the proposed cost share for the proposed DOE project.

4.1.1.2 Scope of Work

In Phase I of the Perfect Power development and demonstration the team will develop a conceptual design for Perfect Power. In addition, the team will move forward with several initial deployment steps. This includes converting the two 4MW gas turbines to fast start capability, installing the ComEd/PJM Interconnection (PJM) communications gateway, and completing detailed Perfect Power system engineering. Phase I also includes completion of the IIT energy efficiency upgrades program. This includes the installation of advanced lighting, building management system, high efficiency HVAC, hot water building loops, and building re-commissioning.

Phase I is designed to build a foundation for the Perfect Power demonstration. In Phase I, ComEd will take steps to improve the reliability of the supply system. This includes moving the remaining overhead distribution lines underground and completing preventive maintenance activities.

4.1.1.2.1 Task 0.0 – Revise Project Management Plan

The project team will revise the version of the Project Management Plan that is submitted with project applications. The Project Management Plan and its functions and activities will further conform to the Generic RDSI Management Plan.

4.1.1.2.2 Task 1.0 – Perfect Power Conceptual Model Development

The following steps will produce a Perfect Power System vision that meets IIT's needs and that provides a plan for implementation that rationalizes the technical and economic impact of the recommendations:

- Document the vision for IIT's Perfect Power System and sustainable campus and establish a plan for developing a Perfect Power System model. This includes identifying the university's requirements as well as the resources needed to develop the Perfect Power prototype.
- Develop a Perfect Power System model for the subject study area. This includes an overview of items such as costs, benefits, and impacts of integrating advanced technologies - advanced sensing, communications, control, power quality devices, power electronics, breaker automation, energy storage, distributed energy, and efficient devices.
- Conduct a series of facilitated workshops to finalize the Perfect Power System plan, features, and functions.
- Modify the Perfect Power System model based on industry input. Develop conceptual design documents/bills of materials and cost/benefit analysis. Prepare a final report documenting the results and a phased implementation approach.
- Present the findings to IIT and Galvin Initiative management and revise the report to reflect management input and comments.

4.1.1.2.3 Task 2.0 – ComEd/PJM Portal and Turbine Fast Start

A new communications gateway to ComEd/PJM will be provided. The gateway will obtain price and ancillary service signals which will start local generators. To provide reliable duty for planned standby peaking service, the two existing 4MW-Allison-Turbine cogeneration packages will be retrofitted as required. This includes combustion controls and control logic for reliable fast starts, emission control, and communication. The work further undertakes all necessary steps for integration of the turbines into the Perfect Power system including balance of turbine equipment and decommissioning of HRSG components where necessary. The Project team will develop all protocols, processes, and procedures that will be necessary for 1) operational effectiveness in meeting planned technical and economic requirements, 2) environmental acceptance, and 3) safe operation of the turbines.

4.1.1.2.4 Task 3.0 – Energy Efficiency Upgrades

IIT's sustainability goals will be accomplished in part by reducing pollutant and carbon emissions through energy conservation, leveraging of renewable resources, and reduction of peak demand. These steps are necessary because un-attenuated peak demand challenges the capabilities of the distribution system, increases energy consumption, and raises costs.

4.1.1.2.5 Task 4.0 – Substation Supply Reliability

In coordination with ComEd, service feeders to the campus substations and the campus delivery circuits and relevant electrical distribution equipment will be examined, repaired, replaced, upgraded, and uprated as necessary and appropriate to ensure high availability and reliability of electric service, to lower the cost of maintenance, and to raise the energy efficiency of electric circuits on the campus.

4.1.1.2.6 Task 5.0 – Perfect Power System Design and Engineering

The team will develop a detailed design for the Perfect Power model developed in Task 1.0. The task will provide electrical schematics, wiring diagrams, bills of materials, and physical drawings suitable for installation.

4.1.1.3 Deliverable

- Report summarizing the detailed designs for the Perfect Power System at IIT.

4.1.2 Phase II – Multi-Year Research Phase

4.1.2.1 Objective

The objective of the research phase is to develop and demonstrate improvements to commercially available technologies and to provide key Perfect Power functionalities that are not currently available commercially.

4.1.2.2 Scope of Work

The project team will perform research, development, and demonstration to solve technology gaps of the Perfect Power concept. This includes but is not limited to the following R&D items:

- Advanced sensing, data processing, and actuators for improving distribution automation.
- Advanced distribution fault detection, location, and isolation scheme for protecting underground cables.
- A low cost Intelligent Perfect Power System Controller.
- Advanced demand response control systems based on a suitable wireless communications technology for implementing energy efficiency programs.

The implementation of these R&D items is discussed in the following tasks.

4.1.2.2.1 Task 0.0 – Revise Project Management Plan

The project team will revise the version of the Project Management Plan that is submitted with project applications. The Project Management Plan and its functions and activities will further conform to the Generic RDSI Management Plan.

4.1.2.2.2 Task 1.0 – Advanced Distribution Automation and Recovery System

The purpose of this task is to develop and demonstrate an advanced system for sensing distribution system conditions and automatically reconfiguring the system to respond to disturbances. The planned R&D will accelerate the deployment of new technologies for agent-based distribution automation for monitoring and controlling the integrated management of networks and services. The architecture will provide transaction capabilities that control transport, including fault detection, location and isolation; feeder reconfiguration; volt/VAR management; service restoration; emergency response; and integration of distributed resources. The technologies will be deployed in a pilot demonstration project within the Perfect Power Prototype at the Illinois Institute of Technology main campus.

Subtask 1.1: **Creation of a communication model** in dNetSim

The focus of this R&D task is to develop the communication modeling capability that is necessary to develop the autonomous agent-based control system. In this task, dNetSim will be extended to:

- Provide fault-tolerant communication of each receiving and transmitting device.
- Integrate additional distribution network equipment, such as open-delta-connected single-phase regulators.
- Include additional load models, such as induction motors.
- Include distributed resource models, such as distributed generators.

The effectiveness of the communication model will be tested against common data sets comprising the IEEE Test Feeders, including the IEEE 34 Node Test Feeder, the IEEE 37 Node Test Feeder, and the IEEE 123 Node Test Feeder.

Subtask 1.2: Development of a Visualization Platform for dNetSim

The visualization platform will 1) accelerate the internal process of developing autonomous agent-based control systems, and 2) illustrate to engineers and operators the distributed decision-making process of the autonomous agent-based controls. In this task, dNetSim will be further extended to:

- Incorporate the new communication models into the existing autonomous agent-based control system for fault detection, location and isolation, as well as service restoration,
- Create a visualization platform for displaying the dynamic network configuration.

Subtask 1.3: Development of an Autonomous Agent Infrastructure for Real-Time Control of Typical Distribution Systems

This task will develop a family of autonomous monitoring and switching agents, which will be tested and improved based on a series of use cases for dNetSim. The following features are targeted for development within the autonomous agent-based control system:

- Fault detection, location and isolation. This work will incorporate the results from the parallel work in Task 2 on cable fault detection and mitigation.
- Feeder reconfiguration to enable switching agents to transfer load from one feeder segment to another less loaded feeder segment.
- Volt/VAR management to enable switching agents to bring shunt compensation into or out of service.

- Service restoration that re-energizes non-faulted distribution feeder segments.
- Emergency response to shed non-critical load.
- Integration of distributed resources to provide a smart interconnection interface.

Subtask 1.4: Extension of the Autonomous Agent Infrastructure to Include Centralized Control Modes and Distributed Control Modes

This task will focus on creating an agent-based control system that will operate in two different modes: centralized or distributed. The centralized mode will coordinate all decision-making in a distribution network controller. The distribution network controller will be able to communicate with all monitoring and switching devices. The goal is to determine which of the two modes, centralized or distributed, yields the highest level of reliability under a variety of configuration and disturbance scenarios, including communication interruptions and outages.

Subtask 1.5: Evaluation of the Autonomous Agent Infrastructure During a Pilot Demonstration

The advanced monitoring and distribution automation development work will be evaluated during the pilot demonstration on the Illinois Institute of Technology (IIT) campus underground distribution network.

The integrated monitoring system will have the following measurement capabilities, based on existing products of suitable precision and accuracy:

- Voltage, three-phase to ground – sampled as a minimum every cycle of the power frequency with an accuracy of 2% or better
- Current, three-phase – sampled as a minimum every cycle of the power frequency with an accuracy of 5%.
- Control equipment status – sampled as a minimum once per second.
- Power consumption – average watts consumed by the controller will be less than 15 watts.

The sensing capabilities will have the following power and transmission specifications:

- Communication topology: a meshed radio communication system with peer-to-peer communication capability to provide a system tolerant of one or more communication modules being out of service.
- Power consumption: less than 15 Watts average power draw with less than 25 Watts peak during radio transmission.
- Transmission technology: spread spectrum frequency hopping in the 900 MHz unlicensed radio band
- Transmission latency: to be less than 0.1 seconds between units including 1 repeater.

<u>Deliverables</u>

- Report on the communication system modeling and the distribution equipment modeling
- Report on the visualization platform and the simple agent-based control system, with features such as fault detection, location and isolation, as well as service restoration

- Report on the advanced agent-based controls, such as feeder reconfiguration, volt/VAR management, emergency response and integration of distributed resources
- Report on the overall system reliability under centralized control modes and distributed control modes
- Report on the test, analysis, and refinement of the agent-based distribution automation controls during a pilot demonstration.

4.1.2.2.3 Task 2.0 – Buried Cable Fault Detection and Mitigation

The purpose of this task is to develop and demonstrate a fault detection and mitigation (FDM) system with the following features: sensitivity, reliability, selectivity, and speed.

Subtask 2.1: Simulation of IIT's Distribution Network

IIT's distribution network will be simulated. Simulated faults will be imposed at selected locations as necessary to characterize the system.

Subtask 2.2: Identification of the Best Fault Detection and Mitigation (FDM) for IIT's Distribution Network

An accurate, fast, and reliable FDM approach for IIT's distribution cable network will be identified based on criteria such as the following:

- Sensitivity to detect different kinds of faults in distribution networks.
- Reliability to detect faulty cables and have a robust mechanism against other cable functions such as circuit breaker switching, load shedding, and external faults.
- Selectivity to be able to detect the faulty cable and the location of fault.
- Speed to detect and separate the faulty segment quickly.

Subtask 2.3: Pilot Demonstration of the Identified FDM in IIT's Distribution Network

The identified FDM structure will be implemented and demonstrated in IIT's distribution network and the collected data will be analyzed for enhancing the proposed structure. The pilot demonstration will accomplish important attributes of the proposed FDM system such as:

- Fault impact reduction by detecting and discriminating cable faults quickly.
- Increased reliability by accurate performance in representative scenarios to prevent unnecessary circuit breaker trips.
- Downtime reduction by focusing on actual predetermined fault locations.
- Operational cost reduction by reducing maintenance resources.

<u>Deliverables</u>

- Report on the simulation of IIT's distribution network
- Report on the testing, selection, and pilot demonstration of FDM in IIT's distribution network

4.1.2.2.4 Task 3.0 – Intelligent Perfect Power System Controller

The purpose of this task is to develop and demonstrate the Intelligent Perfect Power System Controller (IPPSC). The deployment of this research will be performed under Phase III – Task 3.0, Phase IV – Task 3.0, and Phase V – Task 2.0.

The IPPSC is a master controller comprising a supervisory agent and specialized agents. The IPPSC will be designed to interface, coordinate, and control the actions of slaved controllers distributed around campus such as controllers for the High Reliability Distribution System (HRDS), buildings, and generation controllers. The role of the supervisory agent is primarily to gather information from the outside world and to optimize the operation of the other slaved agents distributed around campus. The specialized agent controllers of the IPPSC are used to provide any advanced and unavailable functions and decision-making that will be needed for master control of generator sets, distribution systems, and building load management.

Subtask 3.1: Design the IPPSC Specifications for IIT Campus

The specifications for the IPPSC will be based on the agent based Master Controller Requirements Specification for Perfect Power Systems developed by the Galvin Electricity Initiative and adapted for conformance with existing subsystems planned or existing IIT campus. The specifications will include the inputs, outputs, decision making and processing required for central analysis, coordination, and supervision of all agents distributed about the campus.

Subtask 3.2: Control Logic Development

The Project team will dedicate a Supervisory Control and Data Acquisition (SCADA) system with a user-friendly Human Machine Interface (HMI). The specific modes of operation are to be determined. Features of the control logic will be compatible with the overall system IPPSC and its slaved agents.

Subtask 3.3: Control Logic Quality Assurance and Bench Testing

The control logic of the IPPSC will be bench tested by using the hardware and control logic for each of the slaved agents and using hardware-in-the-loop simulations to generate campus data and various operational occurrences.

Deliverables

- IPPSC Specifications for Versions 1, 2 and 3
- Report on development, findings and recommendations from software QA testing

4.1.2.2.5 Task 4.0 – Advanced ZigBee-Based Wireless

The purpose of this task is to develop and demonstrate an advanced and robust ZigBee wireless communications network to facilitate and enable all the features of the Perfect Power System. The research aspect will include the identification of the most suitable ZigBee wireless devices and technology in the market for the proposed energy efficiency programs and the modification of the available technology for specific applications at IIT.

Subtask 4.1: Design and Develop Interference Avoidance Techniques

ZigBee operates at three unlicensed and crowded frequency bands, specified by the IEEE 802.15.4 standard. Interference avoidance techniques will be designed and developed so that ZigBee can coexist with competing wireless networks derived elsewhere.

Subtask 4.2: Design and Develop Self-Forming and Self-Healing Cluster-Tree Zigbee-Based Systems

The Project team will design algorithms for the networking topologies consistent with self-organizing and self-healing in response to occurrences and events, of both the wireless and electrical systems, that directly require or indirectly recommend adaptations to the communication process.

Subtask 4.3: Design and Develop MAC Layer Protocol

The Project team will design and develop energy-efficient routing algorithms for energy-efficient routing of messages.

Subtask 4.4: Develop a plan to Install the Advanced ZigBee-Based Wireless system

The Project team will plan the installation of ZigBee wireless system with the objectives of extended range and lower cost.

Subtask 4.5: Pilot Demonstration of Zigbee-Based Wireless Technology For Implementing the Energy Efficiency Programs

ZigBee wireless technology for a robust wireless communications network will be implemented for the Perfect Power system in controlling loads for participating in load reduction and energy savings programs.

Deliverables

- Identification of the most suitable ZigBee wireless devices and technology Interference avoidance techniques
- Algorithms for forming cluster, selecting cluster head, automatically setting up, and self healing
- Energy-efficient contention-free MAC layer access protocol
- Installation plan of ZigBee routers and energy-efficient routing algorithm

4.1.3 Phase III – Ancillary Service Demonstration

4.1.3.1 Objective

The objective of this phase is to modify the on-site distribution system to allow IIT to provide demand response capability and spinning reserve capability, as well as advantageous positioning of IIT to participate dynamically in electricity market pricing.

4.1.3.2 Scope of Work

In Phase III of the Perfect Power system development and demonstration, the team will upgrade the existing 8MW of substation generation to provide fast start capability for demand response. The local generation will be controlled by the first version of the Intelligent Perfect Power System Controller which will monitor market signals and supply power conditions and configure the generation to respond based on market signals. The system will provide an advantageous opportunity to participate in real time pricing, spinning reserve, capacity, and energy demand markets of PJM. Specifically, the system will demonstrate a potential in the following market arenas:

- Real Time Pricing – The Project team will provide the ability to "Island" the entire campus as a hedge for higher peak electricity prices or purchase electricity from the real time markets when electricity prices meet appropriate thresholds.
- Spinning Reserve – The Project team will provide the capability of a reduction of load within 10 minutes of receiving a request from the PJM. To enable participation in this market, the Project team will retrofit and upgrade each of the two existing two 4-MW Allison turbines for reliable fast start, efficient operation, and emission control for extended periods of allowable operation.
- Day Ahead Economic Load Response – The Project team will provide the ability to participate in this market.

At the completion of the modifications and installations undertaken by this task, the Allison Turbines will be brought to a state capable of providing emergency back-up for the campus.

4.1.3.2.1 Task 0.0 – Revise Project Management Plan

The project team will revise the version of the Project Management Plan that is submitted with project applications. The Project Management Plan and its functions and activities will further conform to the Generic RDSI Management Plan.

4.1.3.2.2 Task 1.0 – Intelligent Perfect Power System Controller, Version 1 Demonstration

The Project team will demonstrate Version 1 of the IPPSC. The demonstration will include conformation of the functions required for entering the real time and ancillary service markets. This will include the ability for dispatch in the various markets mentioned above.

Features for demand response and load shedding will be added in later stages. Under this task, the Project team will provide the ComEd/PJM communications gateway to obtain the price and ancillary service signals which will start the local generators.

4.1.3.2.3 Task 2.0 – Turbine Fast Start and ComEd/PJM Portal

Based on the conceptual designs developed in Phase 1, the Project team will procure, install, and deploy the concepts developed in Phase 1 that enable the two existing 4MW-Allison-Turbines to participate in the Perfect Power System. The Project team will also procure and install a new communications gateway to handshake with ComEd/PJM. As a minimum, at the end of this task, the readiness of the turbines for the Perfect Power System will have been tested and the turbines will be available for emergency generation, demand response, spinning reserve, and other functions necessary to effect IIT's participation in dynamic electricity markets.

4.1.3.3 Deliverables:

- Report Covering installation, costs and results of operation form Phase III implementation

4.1.4 Phase IV – Distribution System Automation Demonstration

4.1.4.1 Objective

The objective of this phase is to complete a network distribution system that ensures power to all buildings in the event of a single failure to a cable, switch, or substation feeder breaker. In addition, all of the distribution system breakers and switches will be automated providing for rapid reconfiguration and demand response.

4.1.4.2 Scope of Work

Phase IV of the Perfect Power system development and demonstration project will design, purchase, and install required high-speed automated switches and sensors to enable the system to detect and isolate faults before they can adversely affect the system. The HRDS system will be able to tolerate a single fault on any or all campus feeders without loss of power to a single building.

4.1.4.2.1 Task 0.0 – Revise Project Management Plan

The project team will revise the version of the Project Management Plan that is submitted with project applications. The Project Management Plan and its functions and activities will further conform to the Generic RDSI Management Plan.

4.1.4.2.2 Task 1.0 – High Reliability Distribution System Installation

The Project team will design, develop, purchase, and install the HRDS for the IIT campus. The HRDS will be based on the Perfect Power system model and will leverage available industry concepts.

The Project team will separate the campus into logical groups of buildings that will each be placed on a HRDS loop. The HRDS loop will be continuously energized. In the event of a loss of one section of cable or a switch, the design concept will provide for the automatic isolation of faults without interruption of power to any loads. Re-closure is not necessary, but will be available. This system will include intelligent switching and breaker coordination technology that provides for rapid assessment and isolation of faults via a series of switches, breakers, advanced sensing, and advanced communications. The proposed High-Reliability Distribution System will be designed to be reliable, versatile, upgradeable, and cost-efficient.

To meet the Perfect Power design criteria, the following schemes will be implemented:

- A Permissive Over-reaching Transfer Trip scheme (POTT) will be used to protect the underground feeder cables. Using this scheme with the S&C Vista UDS and SEL-351 relays results in clearing of primary faults in less than 6 cycles. In addition, a Directional Comparison Blocking (DCB) scheme is used as a back-up to the POTT scheme.
- Branch line faults will be cleared by the integral Vista Over current Control, which can operate the fault interrupter to clear the fault in as little as 3 cycles.
- The system will use two substations in two closed-loop configurations to support load requirements as well as load equalization if a fault occurs on a feeder.
- To support new load growth, additional Vista units can be added anywhere along the loop system and will adhere to the system design without any changes in relay settings.
- The proposed design can support an additional source for future load expansion.

The HRDS system will provide redundancy across the campus in the event of failures in the campus distribution system. The HRDS will also include its own SCADA systems for displaying the status of the campus distribution system, controlling the switches and coordinating with the IPPSC. The HRDS controller will include modes compatible with the IPPSC. For example, when the IPPSC is in normal grid parallel mode, the HRDS will perform self-healing tasks. In the unplanned island mode, the HRDS will be programmed to open switches to shut off power to all buildings. As generation comes online, the buildings can be incrementally switched back on.

4.1.4.2.3 Task 2.0 – Substation Automation

The IIT North Substation was recently upgraded with new switches and breakers but needs to be automated so that it is compatible with the HRDS system. The Project team will complete the conversion of the North Substation including microprocessor relays, new electronic meters, and substation Remote Terminal Unit (RTU). Relays will be compatible with HRDS system when implemented.

Upgrades to the South Substation will include replacing existing circuit breakers with new vacuum breakers, conversion to microprocessor relays, electronic meters, and substation RTU. Relays will be compatible with HRDS system when implemented.

4.1.4.2.4 Task 3.0 – Intelligent Perfect Power System Controller, Version 2 Demonstration

The Project team will demonstrate Version 2 of the IPPSC that will include implementing the functions for communicating and setting the mode for HRDS controller. The demonstration will confirm expected performance in the event of events such as reaction to power outages and ability to coordinate with the HRDS concerning the sequence of restoring buildings as the generation comes online.

4.1.4.3 Deliverables:

- Report Covering installation, costs and results of operation form Phase IV implementation

4.1.5 Phase V – Distribution Level Peak Load Reduction Demonstration

4.1.5.1 Objective

The objective of this phase is to complete the Perfect Power system by providing local demand response capability, building UPS, and building solar power to reduce overall peak demand and provide uninterruptible power to critical facilities. This Phase will complete the initial Perfect Power Prototype and provide for 100% demand response.

4.1.5.2 Scope of Work

The scope of work includes providing local demand response capability, integrating uninterruptible power systems with electricity storage into critical buildings and adding solar PV as additional campus distributed generation. The IPPSC will be upgraded to achieve load shedding capability and to allow the coordination of demand response signals with the other controllers.

4.1.5.2.1 Task 0.0 – Revise Project Management Plan

The project team will revise the version of the Project Management Plan that is submitted with project applications. The Project Management Plan and its functions and activities will further conform to the Generic RDSI Management Plan.

4.1.5.2.2 Task 1.0 – Peak Load Reduction Capability

The Project team will provide load reduction capabilities for both blackstart during Island Mode and demand response during Grid Parallel mode. The agents for the building controller and HRDS will coordinate the optimal load shedding scheme depending on local conditions.

4.1.5.2.3 Task 2.0 – Intelligent Perfect Power System Controller, Version 3 Demonstration

The Project team will demonstrate Version 3 of the IPPSC that will include the implementation of additional functions for load shedding and coordinating demand response signals with the other controllers. In demand response mode, the IPPSC will shutoff loads according to predetermined load priorities. Part of the load shedding will be accomplished by shutting off power to entire buildings through the HRDS switches and the rest will be accomplished by communicating directly with specific loads distributed across the campus via the building controllers.

4.1.5.2.4 Task 3.0 – Solar PV

The Project team will purchase, install and integrate a Solar Photovoltaic System (PV) into the overall Perfect Power System. The PV will be used to reduce peak loads during the day. In the event of a demand response event, the output from the installed Solar PV will be forecasted and factored into the demand response scheme.

4.1.5.2.5 Task 4.0 – Install Uninterruptible Power Supplies (UPS) at Critical Buildings

Perfect Power requires meeting the electricity needs of each individual customer without fail. For customers such as research laboratories with sensitive experiments, uninterrupted power supplies will be needed. For these loads, the Project team will install UPS at the building and tied to the specific load where possible. In the event of a loss of utility power, UPS will support the load until on-site generation comes on line.

4.1.5.3 Deliverables

- Report Covering installation, costs and results of operation form Phase V implementation

5 Risk Management

Any project of this magnitude faces numerous risks. This includes technical, political, and financial. The IIT team over the past year has developed a thorough approach and established support from the highest levels within IIT. Each of the risk factors is discussed in detail in this section.

5.1 Political

John Rowe, the new Chairman of IIT's Board of Trustees, worked closely with Mr. Robert Galvin, the past Chairman of IIT's Board of Trustees, to initiate the Perfect Power prototype at IIT. Mr. Rowe provided ComEd support and helped educate the IIT Board of Trustees. In addition, Michael Galvin is a Board member and an ardent supporter of the Perfect Power project. Furthermore, IIT is embarking on several major housing and academic building additions which require increased electrical infrastructure. The Perfect Power prototype will ensure that IIT can meet projected demand growth while minimizing the impact on ComEd's distribution system.

5.2 Financial

The Illinois Institute of Technology is providing capital budget financing for the Perfect Power prototype. This five-year project is well within the financial capabilities of the university and provides a foundation for planned campus expansion.

5.3 Technological

The most significant technical risk is the Intelligent Perfect Power Controller System (IPPCS). The IPPCS will serve as the master controller coordinating all of the Perfect Power elements to provide for various campus modes of operation. However, the IPPCS will be backed up by local controllers that will ensure proper response to various system conditions. The local controllers will ensure that faults are isolated without interruptions to supply. In addition, the generators will start and synchronize locally upon the loss of power to a site substation.

6 Project Milestones

The project team will demonstrate a replicable model for leveraging advanced technology to create microgrids which automatically respond to utility, Independent System Operator, and electricity distribution system signals, changes, and interruptions in a way that provides key demand reduction support and increased reliability. The team provides a systematic approach to build a foundation for perfect power. The Team will engage in a five-phase research, development and demonstration project that will use continuous improvement methods to bring Perfect Power to the IIT campus and showcase Perfect Power principals to the industry.

The milestones in the proposed project are listed as follows.

Phase/Task	Milestone	Planned Completion Date
Phase I – Perfect Power Foundation	Milestone P1: Completion of Perfect Power Design	April 30, 2010
Phase II – Multi-year Research Phase		
Task 1.0 – Advanced Distribution Automation and Recovery System	Milestone P211: Completion of dNetSim Communication Model	September 30, 2009
	Milestone P212: Completion of dNetSim Visualization Platform	September 29, 2010
	Milestone P213: Autonomous Agent Infrastructure for Real Time Control	September 29, 2011
	Milestone P214: Autonomous Agent Infrastructure for Centralized and Distributed Control	September 27, 2012
	Milestone P215: Pilot Demonstration of Autonomous Agent Infrastructure	September 27, 2013
Task 2.0 – Buried Cable Fault Detection and Mitigation	Milestone P221: Completion of the Simulation on IIT's Distribution Network	April 1, 2010
	Milestone P222: Identification of the Best FDM for IIT's Distribution Network	September 29, 2011
	Milestone P223: Pilot Demonstration of FDM in IIT's Distribution Network	September 27, 2013
Task 3.0 – Intelligent Perfect Power System Controller	Milestone 231a: Completion of IPPSC Version 1 Software Specification	July 15, 2009
	Milestone 231b: Completion of IPPSC Version 1 Software	December 31, 2009
	Milestone 231c: Completion of IPPSC Version 1 Bench Testing	April 30, 2010
	Milestone 232a: Completion of IPPSC Version 2 Software Specification	March 5, 2010
	Milestone 232b: Completion of IPPSC Version 2 Software	July 21, 2010

	Milestone 232c: Completion of IPPSC Version 2 Bench Testing	November 24, 2010
	Milestone 233a: Completion of IPPSC Version 3 Software Specification	March 4, 2011
	Milestone 233b: Completion of IPPSC Version 3 Software	July 11, 2011
	Milestone 233c: Completion of IPPSC Version 3 Bench Testing	November 15, 2011
Task 4.0 – Advanced ZigBee Wireless	Milestone P241: Completion of the Design and Development of Interference Avoidance Techniques	September 30, 2009
	Milestone P242: Completion of the Design and Development of Self-forming and Self-healing Cluster-tree ZigBee systems	September 29, 2010
	Milestone P243: Completion of the Design and Development of MAC Layer Protocol to Achieve Energy-efficient Access for Cluster-tree Networks	September 29, 2011
	Milestone P244: Completion of ZigBee Installation Plan and Energy Efficient Routing Algorithm	September 27, 2012
	Milestone P245: Pilot Demonstration of ZigBee Wireless Technology for Implementing Energy Efficiency Programs	September 27, 2013
Phase III – Ancillary Service Demonstration	Milestone P31: IPPSC V1 Installed	February 18, 2011
	Milestone P32: Engine Start to Full Load within 10 Minutes	August 2, 2009
Phase IV – Distribution System Automation Demonstration	Milestone P41: HRDS Installed	January 19, 2013
	Milestone P42: Substation Automation Compatible to HRDS	January 19, 2011
	Milestone P43: IPPSC V2 Installed	August 3, 2011
Phase V – Distribution Level Peak Load Reduction Demonstration	Milestone P51: Load Reduction Controller Installed	April 5, 2012
	Milestone P52: IPPSC V3 Installed	December 27, 2012
	Milestone P53: Solar PV Installed	December 20, 2011
	Milestone P54: UPS Installed at Critical Buildings	December 21, 2011
Overall Project	Milestone PRO: 50% Peak Load Reduction Capability	September 27, 2013

7 Project Timeline

The latest project timeline is shown as follows.

Task Name	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	2010	2011	2012	2013
dNetSim Communications model	■	■	■	■	■	■	■	■	■	■							
Visualization platform											■	■	■	■			
Real time autonomous agent															■		
Centralized/decentralized control modes																■	
Demonstration																	■
Fault detection simulation at IIT	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
FDM for IIT															■	■	
Pilot demo																■	■
IPPSC V1 specification								■									
IPPSC specification all versions			■	■	■	■	■	■	■	■							
V1 software programming								■	■	■	■	■					
V1 Software QA and bench test													■	■			
IPPSC V2 development														■	■		
IPPSC V3 development															■	■	
Zigbee interference avoidance		■	■	■	■	■	■	■	■								
Self forming/healing cluster trees										■	■	■	■	■			
MAC layer protocol														■	■		
Routing algorithm																■	
Pilot demo																	■
IPPSC V1 Demo														■			
Turbine fast start																	
Loop 3 engineering	■	■	■														
Loop 3 construction bid				■	■												
Loop 3 installation						■	■	■	■								
Loop 3 startup										■							
Loop 1														■			
Loop 4														■			
Loop 6														■			
Loop 2															■		
Loop 5																■	
Loop 7																■	

Task Name	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	2010	2011	2012	2013
South sub automation eng	■	■	■	■													
Procurement					■	■	■										
Construction bid					■	■											
Installation							■	■	■	■							
Startup											■						
North sub automation														■			
IPPSC V2 Demo															■		
HRDS SCADA														■			
IPPSC V3 Demo																■	
Solar PV															■		
UPS														■			

8 Funding and Costing Profile

The following table shows the latest cost estimate for each task related to the implementation (Phase III, Phase IV and Phase V).

	Proposed	Current			Current Budget		
Item	**Total**	**Total**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
All Phases	**$500,000**	**$1,682,565**					
Project Management	$500,000	$450,000	$150,000	$150,000	$50,000	$50,116	$49,884
Engineering	Included in equipment	$1,232,565					
Phase 1 Engineering		$482,565	$482,565				
Phase 2 Engineering		$550,000		$395,000	$155,000		
Phase 3 Engineering		$200,000			$200,000		
Phase III Costs	**$1,500,000**	**$150,000**					
Turbine Upgrades (Fast Start)	$1,000,000						
HRDS Engineering							
IPPSC, V1	$500,000	$150,000		$150,000			
Phase IV Costs	**$5,600,000**	**$6,169,856**					
IPPSC, V2	$400,000	$200,000			$200,000		
North Substation Automation	$500,000	$250,000	$250,000				
South Substation Automation	$900,000	$450,000		$450,000			
LOOP 1 Switches and Cable	$3,800,000	$5,269,856	$440,000	$234,236			
LOOP 2					$1,020,574		
LOOP 3			$599,566				
LOOP 4				$1,187,520			
LOOP 5					$583,026		
LOOP 6				$598,212			
LOOP 7						$456,722	
HRDS Controller			$75,000	$75,000			
Phase V Costs	**$1,100,000**	**$750,000**					
UPS/Storage	$200,000	$200,000		$200,000			
IPPSC, V3, Demand Response	$500,000	$450,000			$245,000	$205,000	

Solar PV	$100,000	$100,000		$100,000			
Advanced Transformers	$300,000	$0					
Demonstration Budget	$8,700,000	$8,752,421	$1,997,131	$3,539,968	$2,453,600	$711,838	$49,884
DOE Research Budget	$2,659,192	$2,659,192	$596,156	$617,319	$573,068	$452,740	$419,909
Total DOE Budget	$6,999,497	$6,999,497	$1,593,914	$2,362,344	$1,798,651	$774,794	$469,793
DOE Funding Request	$4,340,306	$4,340,306	$997,759	$1,745,025	$1,225,583	$322,055	$49,884
IIT Cost Share	$4,360,000	$4,412,115	$999,373	$1,794,943	$1,228,017	$389,783	$0

The following table shows the detailed budget for research (Phase II).

Personnel	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Total**
Dr. Mohammad Shahidehpour (IIT)	$30,397	$31,309	$32,248	$33,215	$34,212	$161,380
Mr. Joseph Clair (IIT)	$0	$0	$0	$0	$0	$0
Dr. Alex Flueck (IIT)	$23,149	$23,844	$24,559	$25,296	$26,054	$122,901
Dr. Zuyi Li (IIT)	$22,530	$23,206	$23,902	$24,619	$25,357	$119,614
Dr. Chi Zhou (IIT)	$15,430	$15,893	$16,370	$16,861	$17,366	$81,919
Graduate Student 1 (IIT)	$34,002	$35,022	$36,073	$37,155	$38,270	$180,521
Graduate Student 2 (IIT)	$34,002	$35,022	$36,073	$37,155	$38,270	$180,521
Graduate Student 3 (IIT)	$34,002	$35,022	$36,073	$37,155	$38,270	$180,521
Graduate Student 4 (IIT)	$34,002	$35,022	$36,073	$37,155	$38,270	$180,521
Graduate Student 5 (IIT)	$34,002	$35,022	$36,073	$37,155	$38,270	$180,521
Graduate Student 6 (IIT)	$34,002	$35,022	$36,073	$37,155	$38,270	$180,521
Graduate Student 7 (IIT)	$34,002	$35,022	$36,073	$37,155	$38,270	$180,521
Graduate Student 8 (IIT)	$34,002	$35,022	$36,073	$37,155	$38,270	$180,521
Travel-related costs (IIT)	$9,563	$9,849	$10,145	$10,449	$10,763	$50,769
Mr. John Kelly (Endurant)	$14,983	$15,433	$11,922	$4,093	$0	$46,431
Mr. Greg Rouse (Endurant)	$70,973	$89,348	$58,563	$17,234	$0	$236,119
Programmer (Endurant)	$38,444	$46,198	$30,589	$10,502	$0	$125,732
Consultant (Endurant)	$30,220	$30,220	$17,628	$7,555	$0	$85,623
Travel-related costs (Endurant)	$1,479	$1,479	$1,479	$1,479	$0	$5,916
Equipment (Endurant)	$41,972	$50,366	$57,082	$4,197	$0	$153,618
Subcontract Indirect Cost (IIT)	$25,000	$0	$0	$0	$0	$25,000
TOTAL	**$596,155**	**$617,320**	**$573,068**	**$452,739**	**$419,909**	**$2,659,191**

9 Success Criteria at Decision Points

The success criteria for each decision point in the proposed project are listed as follows.

Phase I – Perfect Power Foundation

- Demand Response – By the second quarter 2009 the team will be participating in the PJM demand response program leveraging the existing turbine generators.
- Perfect Power Design – By the end of the third quarter 2009 the team will complete the Perfect Power design and initiate all long lead-time procurement.

Phase II – Multi-year Research Phase

Task 1.0 –Advanced Distribution Automation and Recovery System

- dNetSim Communication Model – By the end of the third quarter 2009, a communication model for each receiving and transmitting device should enable the team to test and redesign strategies for fault-tolerant communication
- dNetSim Visualization Platform – By the end of the third quarter 2010, a visualization platform should be developed for displaying the dynamic network configuration
- Autonomous Agent Infrastructure Development – By the end of the third quarter 2012, the autonomous agent-based control system should have the following features: Fault detection, location and isolation; Feeder reconfiguration; Volt/VAR management; Service restoration; Emergency response; and Integration of distributed resources
- Autonomous Agent Infrastructure Demonstration – By the end of the third quarter 2013, the integrated monitoring system will have the following measurement parameters and data requirements:
    - Voltage, three-phase to ground – sampled as a minimum every cycle of the power frequency with an accuracy of 2% or better
    - Current, three-phase – sampled as a minimum every cycle of the power frequency with an accuracy of 5%
    - Control equipment status – sampled as a minimum once per second
    - Power consumption – average watts consumed by the controller will be less than 15 watts.
    - Communication topology: a meshed radio communication system with peer-to-peer communication capability to provide a system tolerant of one or more communication modules being out of service.
    - Power consumption: less than 15 Watts average power draw with less than 25 Watts peak during radio transmission.
    - Transmission technology: spread spectrum frequency hopping in the 900 MHz unlicensed radio band
    - Transmission latency: to be less than 0.1 seconds between units including 1 repeater.

Task 2.0 – Buried Cable Fault Detection and Mitigation

- Distribution Network Simulation – By the end of the first quarter 2010, a complete report on the simulation of IIT's distribution network including the following items:
    - Data: detailed information on IIT's distribution network, including configurations, cable types, cable parameters, feeder loads.
    - Fault impacts: ranking of faults at different locations in terms of overloading, over/under voltages
- Best FDM Identification – By the end of the third quarter 2011, the chosen FDM out of the two proposed approaches should satisfy the following criteria:
    - Sensitivity: FDM will detect different kinds of faults in distribution networks.

    - Reliability: FDM will detect faulty cables and have a robust mechanism against other cable functions such as circuit breaker switching, load shedding, and external faults.
    - Selectivity: FDM will be able to detect the faulty cable and the location of fault.
    - Speed: FDM will detect and separate the faulty segment quickly.
- FDM Pilot Demonstration – By the end of the third quarter 2013, The FDM demonstration should lead to the following improvements:
    - Fault impact reduction: FDM can detect cable faults quickly and discriminate the faulty cable fast for reducing the fault effect on the IIT's distribution network.
    - Increased reliability: FDM can perform accurately in different conditions to prevent unnecessary circuit breaker trips.
    - Downtime reduction: FDM can decrease the time spent by maintenance crews to locate faults.
    - Operational cost reduction: The FDM's fast and accurate estimates of fault locations will speed up the maintenance

Task 3.0 – Intelligent Perfect Power System Controller

- IPPSC – By the end of the first quarter 2010, software specifications are written and software passes software quality assurance tests.

Task 4.0 – Advanced ZigBee Wireless

- Interference Avoidance Techniques – By the end of the third quarter 2009, ZigBee can coexist with WLAN using the interference avoidance techniques should let.
- Self-forming and self-healing cluster-tree ZigBee systems – By the end of the third quarter 2010, the cluster-tree ZigBee systems should be self-forming for automatic setup and self-healing when some ZigBee nodes are dead or removed from the systems.
- MAC Layer Protocol – By the end of the third quarter 2011, the Scheduled contention-free channel access can avoid collision among cluster members in the cluster-tree ZigBee systems
- ZigBee Installation Plan – By the end of the third quarter 2012, a ZigBee router installation plan that can extend the network range efficiently with low costs and an energy-efficient routing algorithm for communications among cluster heads and routers should be completed.
- ZigBee Pilot Demonstration – By the end of the third quarter 2013, a robust wireless communication network can be used for controlling loads for participating in load reduction and energy savings programs.

Phase III – Ancillary Service Demonstration

By the end of 2010 the team will be capable of operating in the real time markets and providing ancillary service to PJM. More specifically:

- Version 1 of the IPPSC is installed and able to start engines and turbines (or send commands to the operator) per IPPSC specifications.
- Fast start capability will be added to turbines so that the turbines can transition from start to full load within ten minutes.
- 50% daily firm peak demand reduction capability achieved

Phase IV – Distribution System Automation Demonstration

By the end of 2011 the distribution system will be fully automated and operating in the High Reliability Distribution System (HRDS) mode. This will ensure power to all buildings in the event of a single failure on the IIT distribution system. Specifically:

- IIT will be able to demonstrate self-healing capabilities on IIT distribution system.
- The IPPSC will be able to switch off loads via HRDS controller.

Phase V – Distribution Level Peak Load Reduction Demonstration

By the end of 2012 the IIT campus will be operating in full demand response capability mode. This will provide for the immediate removal of 10MW of load from the ComEd distribution system in response to ComEd/PJM requests or high price signals. Phase V success will include:

- Load reduction controllers installed.
- IPPSC will be able to switch off loads per demand response signals.
- 20% permanent peak demand reduction achieved

10 Health and Safety

IIT has developed a comprehensive Health and Safety program to ensure the safety of faculty, students, contractors, and tenants. This includes the following safety procedures:

- Asbestos Operations & Maintenance Program
- Bloodborne Pathogens Policy
- Chemical Hygiene Policy for Lab Safety Standards
- Contractor Safety Policy
- IIT Fire & Life Safety Manual
- Hazard Communication Program
- Instructional Laboratory & Workshop Safety Policy
- Incident Investigation Policy
- Laboratory Safety Inspection Policy
- Life Safety Inspection Policy
- Lockout/Tagout Program
- Occupational Health Program - Animal Laboratories

With respect to contractor safety, IIT safety procedures call for a pre-construction safety meeting designed to review known and recognized potentially hazardous conditions and to discuss and receive information regarding the contractors on-site safety program. This includes the completion of a pre-construction safety checklist.

IIT requires that contractors performing construction activities have an on-site safety program. For electrical systems including electronic circuits, all design, development, fabrication and construction, modification, installation, inspection, testing, operation, maintenance, and decommissioning will conform to national standards and best practices including the Institute of Electrical and Electronics Engineers (IEEE), National Electric Safety Code (NESC), and other applicable regulations and standards, including the following;

1. OSHA's general industry electrical safety standards; Title 29 Code of Federal Regulations (CFR), Part 1910.302 through 1910.308 – Design Safety Standards for Electrical Systems, and 1910.331 through 1910.335 – Electrical Safety-Related Work Practices Standards.
2. National Fire Protection Association Standards; NFPA 70 – National Electric Code and NFPA 70E – Electrical Safety Requirements for Employee Workplaces
3. State and local requirements.

Details of the IIT's Heath and Safety program is also available at http://www.iit.edu/~ogc/policies/safety_committee_reports.html

Appendix 3


ILLINOIS INSTITUTE
OF TECHNOLOGY
GALVIN
ELECTRICITY
INITIATIVE
Sponsored by The Galvin Project, Inc.
perfect
power
at iit
PERFECTING POWER FOR A SECURE, SUSTAINABLE ENERGY FUTURE

THE **ISSUE**

Built largely in the 1960s or before, our electric power system cannot reliably run the kinds of digital devices on which today's economy depends. The effects of this inefficient, unreliable, and outdated electricity system are acutely felt each year at Illinois Institute of Technology (IIT). Like many other universities and municipalities, IIT is on the brink of outgrowing its current electricity distribution system.

A number of converging factors have brought the system to a tipping point:

- IIT is experiencing three or more power outages each year, at a cost of up to $500,000 annually in restoration expenses, lost productivity, and ruined experiments that often cannot be recovered.
- Its energy infrastructure is getting old and critical components are facing the end of their useful life.
- Demand for electricity to power the technology and research needs of its students, faculty, and staff is growing steadily.
- IIT will soon be renegotiating its wholesale contract with Constellation NewEnergy, as it expires in 2010.

THE **SOLUTION**

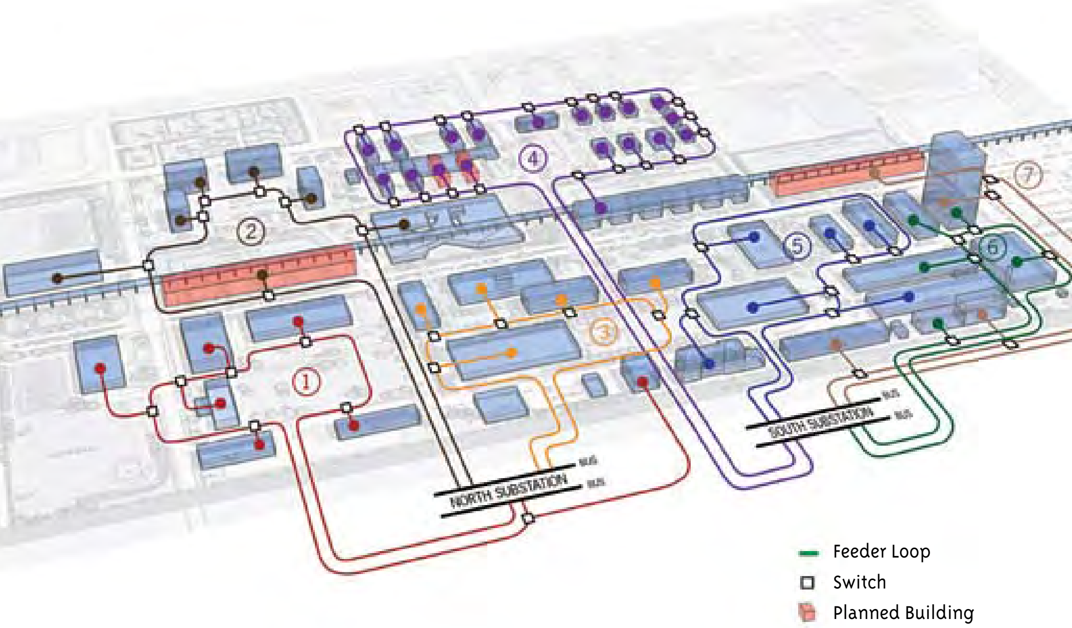
The Perfect Power System at IIT will be the first energy distribution system of its kind in the United States.

IIT has partnered with the Galvin Electricity Initiative and the United States Department of Energy (DOE) to develop a comprehensive solution to this urgent situation—one that will reduce the time and money lost to power outages and meet IIT's growing, specialized energy needs. This partnership, in collaboration with S&C Electric, Endurant Energy, and ComEd, has developed a Perfect Power System design for IIT's Main Campus. This flagship system will confront and model—for other universities, municipalities, developments, and more—a solution to the nation's energy crisis.

The Perfect Power System at IIT will position the university as a pioneer in electricity delivery and infrastructure. As an innovator of this approach, IIT will attract the attention of prospective students, alumni, the research community, the power industry, potential donors, federal and state agencies, and other important stakeholders.

The Perfect Power System design at IIT will result in a power system that will not fail the end user. The system consists of smart microgrids featuring a loop system and redundant electricity. It will offer IIT the opportunity to eliminate costly outages, minimize power disturbances, moderate an ever-growing demand, and curb greenhouse gas emissions.

HIGH RELIABILITY DISTRIBUTION SYSTEM
(DRAWING NOT TO SCALE)



IIT's Perfect Power System will include the following elements:

Self-sustaining electricity infrastructure

An intelligent distribution system and system controllers

Onsite electricity production

Demand-response capability

Sustainable energy systems and green buildings/complexes

Technology-ready infrastructure

INVESTING IN PERFECT POWER

The Perfect Power System will allow IIT to avoid costly system upgrades and realize efficiency savings well into the future. It is estimated that the system will pay for itself as it's built, over the next five years. The project is funded by IIT and the DOE.

ESTIMATED PERFECT POWER COSTS AND SAVINGS

System cost	$12M
One time savings	$5M
Annual savings	$1.3M
Simple payback period	5 years

$3.5 million of the total project funding will include research in advanced distribution automation and recovery systems, buried cable fault detection and mitigation, intelligent system controllers, and advanced ZigBee wireless.

THE **BENEFITS** OF PERFECT POWER

Perfect Power means not only a cheaper energy bill for IIT, but also a safer, more productive campus and the opportunity for IIT to set the standard for electric power delivery.

BENEFITS INCLUDE:

Reduced need for scheduled upgrades — In addition to the savings listed above, Perfect Power will mean savings for ComEd and Illinois consumers, as it allows the utility to defer a planned $2 million upgrade to the Fisk substation. As noted, it will also eliminate the need for a new east campus substation that would otherwise cost IIT $5 million, for a total of $7 million in savings from avoided infrastructure upgrades.

Reduced energy costs — IIT is projected to save approximately $500,000 to $1.5 million per year by reducing electricity peak demand, electricity usage, and providing ancillary services to the grid. IIT can also reduce costs by purchasing a portion of its electricity in real time. In addition, IIT will save transmission and distribution charges and taxes.

Improved power reliability and quality — With the Perfect Power System, cable failures will be automatically isolated and power rerouted to prevent local building outages. Onsite generation combined with demand response will allow the campus to continue to operate in the case of an interruption in ComEd supply.

Create a greener campus — The Perfect Power System will help IIT achieve its Energy Action Plan objectives—including significantly reducing CO_2 emissions and improving efficiency in electricity use by 20 percent—by reducing peak demand, distributing energy more efficiently, and leveraging solar and other renewable resources.

IIT is positioned as an electrical engineering innovator — Perfect Power will position IIT as a living laboratory for the most advanced distribution system concepts and control technologies, providing a powerful resource for attracting students and government/ industry funding.

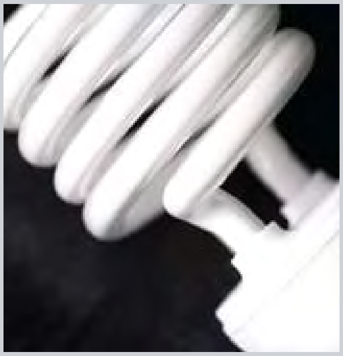
Expanded research and education grant opportunities — IIT's Department of Electrical and Computer Engineering plans to attract additional grants and philanthropic support, in excess of $1 million per year, due to the added campus features and functions of the Perfect Power System. The societal benefits of the proposed $3.5 million research on Perfect Power is viewed to be substantially higher once the proposed research results are replicated throughout the U.S.

Improved campus safety and security — The Perfect Power System will provide IIT with a significantly more robust energy system that can respond to weather, aging, and other threats, ensuring power to students, teachers, and tenants during emergencies. The system will also enhance IIT personnel safety due to the automation of manual high voltage switches.

TIMELINE FOR **IMPLEMENTATION**

Implementing Perfect Power at IIT will occur in four phases over five years. This timeline began in December 2008 and will continue through 2013.

A description of each phase is as follows:



PHASE I

Improve overall energy efficiency of the IIT campus and the reliability of the ComEd supply system.

PHASE II

Modify existing IIT turbines for fast start capability; add additional generation capability and install advanced building meters; to allow IIT to earn revenue for demand response and ancillary services.

PHASE III

Create a redundant and intelligent distribution system that interfaces with a dynamic campus-wide energy system controller to ensure continuous service to IIT buildings.

PHASE IV

Provide local uninterrupted power supplies, solar power, and the final version of the Intelligent Perfect Power Controller that will optimize building operating efficiency and reliability, demand response revenues, and ancillary services.

ILLINOIS INSTITUTE OF TECHNOLOGY

Transforming Lives. Inventing the Future. ***www.iit.edu***

Founded in 1890, Illinois Institute of Technology is a private, Ph.D.-granting research university that awards degrees in engineering, the sciences, architecture, law, design, psychology, humanities, and business.

IIT MISSION STATEMENT

To advance knowledge through research and scholarship, to cultivate invention improving the human condition, and to educate students from throughout the world for a life of professional achievement, service to society, and individual fulfillment.

GALVIN ELECTRICITY INITIATIVE

Sponsored by The Galvin Project, Inc.

The Galvin Electricity Initiative, launched by former Motorola chief Robert W. Galvin, is leading a campaign to transform the nation's obsolete electric power system into one that can truly meet consumers' needs in this new century. Galvin's vision—a Perfect Power System that cannot fail the end user—includes a major technological update as well as the development of smart microgrids that benefit consumers and suppliers alike. Learn more at www.galvinpower.org.

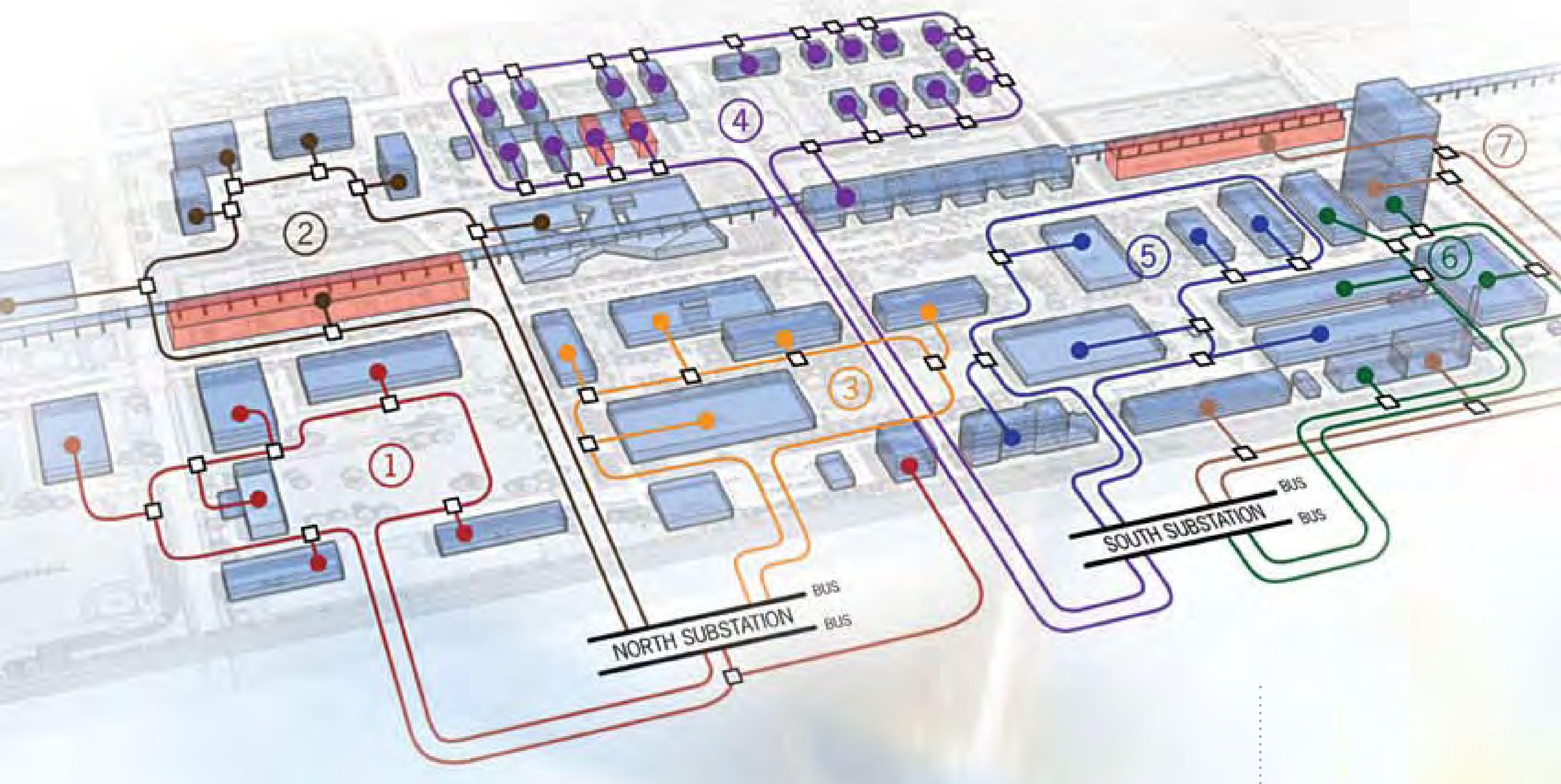
For more information about Perfect Power at IIT, contact Jeffrey D. Bierig at 312.567.5057 or bierig@iit.edu.

Appendix 4

ILLINOIS INSTITUTE OF TECHNOLOGY

iitmagazine

Spring 2009



New Grid in Town

PERFECT POWER SYSTEM RAMPS UP IIT

WALTER NATHAN Preserving the Past **ART PAUL** The Art of Designing *Playboy*

IIT RESEARCH Counteracting Societal Stigma, Condensed Soft Matter

New Grid in Town

MAIN CAMPUS TO BECOME A PERFECT POWER SHOWPIECE

BY MARCIA FAYE

THE GREEK PHILOSOPHER ARISTOTLE IS CREDITED WITH AUTHORING THE EARLIEST DEFINITION OF THE WORD PERFECTION, WHICH HE SAW AS BEING COMPOSED OF THREE CONCEPTS: "THAT IS PERFECT—WHICH IS COMPLETE, WHICH CONTAINS ALL THE REQUISITE PARTS; WHICH IS SO GOOD THAT NOTHING OF THE KIND COULD BE BETTER; AND WHICH HAS ATTAINED ITS PURPOSE." IN DISCIPLINES FROM AESTHETICS TO ETHICS, HOW INDIVIDUALS DEFINE PERFECTION RANGES FROM BEING AN APPROXIMATE IDEAL TO SOMETHING SO AMBITIOUS AS TO BE UNATTAINABLE.

A group of energy visionaries comprising the Galvin Electricity Initiative (GEI) subscribe to Aristotle's bold and decisive definition in regard to perfect power and their innovative plan to reinvent the nation's electricity transmission, generation, and delivery network. Three years ago, GEI members and IIT faculty developed their idea to create a Perfect Power System on the university's Main Campus. The group then elicited help from the United States Department of Energy (DOE), creating a three-faceted partnership between government, education, and industry to make the Perfect Power energy-distribution system the first of its kind in the country.

"We own our own power plant, distribution systems, and wires throughout the campus," says Mohammad Shahidehpour, professor and chair of the Department of Electrical and Computer Engineering (ECE), and Perfect Power principal investigator, of IIT's 120-acre Main Campus. "The university is like a city. So whatever we can do here can be replicated in cities and other large entities across the country."

The Perfect Power transformation will be completed in four phases over the next five years. Central to this conversion is a technology touchstone—a smart microgrid—that ultimately will be a model for revamping our nation's antiquated and outage-ridden power grid.

SIX-SIGMA PERFECTION

"Perfection—and let me define that as we have defined it for GEI—is that every consumer of electricity, large or small, can be absolutely assured of getting the quantity and quality of electricity that they need at the fairest price without any concern about it ever failing. That is, in our judgment, a very achievable goal," said Kurt Yeager, GEI executive director, at a press conference announcing the launch of Perfect Power at IIT. The conference was held November 19, 2008, in Siegel Hall, the first building that will be reconfigured in the Perfect Power plan.

At the conference, Yeager was joined by IIT President John Anderson; GEI founder and IIT University Regent Robert W. Galvin, former chair and CEO of Motorola, Inc.; representatives from project partners Commonwealth Edison (ComEd), Endurant Energy, and S&C Electric Company; and Shahidehpour. Perfect Power at IIT is one of nine projects that received DOE funding for smart grid research. In addition to the $7 million DOE grant, Perfect Power received $5 million in funding from the university.

Galvin told conference attendees that he was inspired to form GEI after his wife, Mary, became one of the estimated 40 million Americans affected by a blackout that shut down cities in eight Northeastern states in the summer of 2003. During his tenure at Motorola, Galvin was instrumental in significantly improving quality standards through implementation of Six Sigma, a business philosophy that values defect prevention over defect detection. According to the GEI, the nation's current electricity system accounts for at least $150 billion lost each year on power outages and interruptions. Smart grid technology could ramp up system reliability to 99.99 percent.

The application of Six Sigma quality principles, coupled with the support of IIT's electricity supplier, ComEd, in the goal of achieving a perfect system sets the university's smart microgrid project apart from power conversions taking place at two other schools. After attending Six Sigma training courses, IIT team members established a basis for the microgrid by developing electricity system performance metrics based on consumers' needs, applying error proofing to the IIT electricity system design, and developing cost-effective means to lessen failures and system shortcomings.

SOME POWERFUL STATISTICS

- 41 percent more outages affected 50,000 or more consumers in the second half of the 1990s than in the first half of the decade.
- If the grid were just 5 percent more efficient, the energy savings would equate to permanently eliminating the fuel and greenhouse gas emissions from 53 million cars.
- In 2000, the one-hour outage that affected the Chicago Board of Trade resulted in $20 trillion in delayed trades.

SOURCE: U.S. DEPARTMENT OF ENERGY

WANTED: A SYSTEM FOR TWENTY-FIRST CENTURY NEEDS

IIT's Main Campus averages three power failures each year at a cost of $500,000 annually in restoration expense, lost productivity, and ruined experiments. IIT is currently operating at capacity and in order to accommodate the increasing power requirements and digital demands, a new $5 million substation has been considered for the east side of campus to supplement two existing substations. Although Main Campus has the capability to generate essential power if there is a ComEd failure, its cogeneration plant is only cost effective at producing hot water, not the hot water, steam, and electricity it was originally meant to generate.

"Perfect Power consists of more than just the infrastructure upgrades that we are currently implementing on campus; however, the infrastructure improvements provide the foundation for every other electrical energy project that we will pursue over the next decades," says Joseph Clair (M.S. MAE '95), director of campus energy and sustainability.

The nation's century-old electric grid, hailed by the National Academy of Engineering as "the most significant engineering achievement of the twentieth century," is dominated by central generation through largely fossil fuel-driven power plants, which deliver electricity via a system of regional grids that are owned or run by utility companies. Its 300,000-mile network of transmission lines, subject to weather conditions and physically sagging under the burden of increased usage demands, crisscross the country on their way to delivering electricity to homes and businesses.

According to the DOE, since 1982, growth in peak demand for electricity needs has exceeded the construction of new transmission lines by 25 percent. When an outage occurs, large populations of grid users can be left without power, sometimes for days at a time. Additionally, the centrally located design of the grid leaves it more vulnerable to terrorist attack. More numerous microgrids supplying power to cities and essential buildings would make such an attack far less widespread.

[Left to right] John Kelly, Mohammad Shahidehpour, Bob Galvin, John Anderson, Rita Stols, Tom Tobin, and Kurt Yeager at the conference launching the Perfect Power System

PERFECT POWER TRIO

While the IIT community can expect to see some physical changes in the campus landscape as Perfect Power unfolds, other modifications will occur at the cyber-level as the microgrid works to advance and integrate a powerhouse composed of three technologies: a high reliability distribution system (HRDS), smart metering, and renewable energy sourcing.

Serving as the core of the smart microgrid, the fully automated HRDS will operate as an electrical feeder loop system that sequesters power faults and reroutes power flows, essentially functioning as a self-healing circuit. Vista® Underground Distribution Switchgear developed by S&C Electric will replace outdated manual switches and breakers, sensing electrical changes and shifting power without interrupting usage in IIT's buildings.

Distribution lines, visible above many neighborhoods in the Chicago area, are located underground on Main Campus. Each building and the cogeneration plant will be outfitted with an external, above-ground switch, protected from the elements in a watertight metal box, which will manage power throughout the underground lines. Another external unit—a master controller—will send information to the switches to ensure that the grid remains in an ideal mode of operation and also provide information to ComEd to help manage power during periods of peak usage or emergency situations, such as threatening weather. If a power outage occurs, a signal will be sent via a wireless connection from the controller to ComEd, making it easier for the utility to pinpoint the damaged circuitry. Research to enhance this automated distribution system is being led by Alex Flueck, ECE associate professor, coupled with research on fault detection in the buried distribution lines being led by Zuyi Li (Ph.D. EE '02), ECE assistant professor.

A second controller will work to increase energy efficiency by communicating with intelligent sensors attached to equipment such as water heaters; heating, ventilation, and air conditioning equipment; and lighting devices. On-off power switches will become a thing of the past, as the sensors will even determine whether a room is occupied and adjust the lights accordingly. Chi Zhou, ECE assistant professor, is working on these and other sensors that can be programmed to complete a task—be it washing laboratory glassware or completing an experiment—by a certain time, with the controller-sensor unit deciding the most efficient time to run.

Siegel Hall will also be fitted with a smart meter that, like a standard electric meter, will indicate power is being used, but unlike a standard meter, will record usage in real time. This additional feature will enable IIT to determine the most cost-effective schedule for using power. Though the cost of electricity is currently fixed, using the new system, the university will have the choice to buy or generate and sell back power depending on the real-time price.

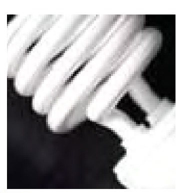
"The Siegel Hall component of the current phase will give us in campus operations a view into what is possible as we look to make IIT the most sustainable, urban university campus in the country," says Clair.

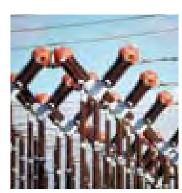
At current power costs, avoiding peak-period usage will save the university at least 15 cents on each kilowatt-hour. Projections indicate that Perfect Power at IIT will effect a 15 percent reduction in overall demand and a 50 percent reduction in peak demand from ComEd. The smart meters will also measure the power generated by renewable energy sources, such as the solar panels being planned for the roof of Siegel Hall, which will be used to fuel a plug-in hybrid vehicle charging port set up next to the building.

"Smart grid technology is based on making the electric grid safer, more reliable, more efficient, and more secure," says Brianna Swenson (EE '04, M.S. '05), who served as an electrical/design engineer on Perfect Power at IIT during her employment with S&C Electric. "Any one of these improvements is beneficial to the average person all on its own, but tying all four together is what the smart grid movement is all about."

Hamid Arastoopour (M.S. GE '75, Ph.D. '78), Henry R. Linden Professor of Energy and director of the Wanger Institute for Sustainable Energy Research (WISER) at IIT, notes that the project is in line with WISER's mission to advance the quality of life for all citizens.

"As a WISER initiative, the Perfect Power system demonstrates the institute's commitment to improving the energy efficiency and security of our nation," he says.






PERFECT POWER TIMELINE (2008–2013)

PHASE I—Improve overall efficiency of Main Campus and the reliability of the ComEd system

PHASE II—Modify existing IIT turbines for fast-start ability and add additional substation generation capabilities to carry campus demand

PHASE III—Create the HRDS to interface with the dynamic campuswide energy system controller

PHASE IV—Provide local uninterrupted power supplies, solar power, and demand response capability to complete the project

GLOBAL GRID LEADERSHIP

While eliminating costly power outages and reducing dependence on traditional energy sources are good enough reasons for the United States to take steps toward perfecting its present power system, there is another compelling reason: global leadership.

"Electricity infrastructure is a way of measuring the progress of any country in the world," says Shahidehpour. "The power systems of India and China are by far more advanced than what we have in the United States because these countries have spent more money and have revamped their systems in recent years."

Power Grid Corporation of India Limited, a state-run company established by the government in 1989 to create a unified power grid, has already maintained network availability for power transfer at 99.65 percent, which places it among the most efficient transmission utilities in the world. China's target year for the unification of the country's regional and provincial grid system is 2020. Plans include a possible link to Thailand's power grid network, as well as to Russia's grid.

In the United States, President Barack Obama signed into effect the American Recovery and Reinvestment Act of 2009 on February 17 that includes $11 billion in credits and incentives for smart grids. In his "New Energy for America" plan, the president specifies investing in advanced smart grid technologies such as smart metering and distributed storage to help ensure that both energy use and costs will be significantly lower than they are now. That smart grid technology encourages user participation increases opportunities for consumers to actively partner with the government in the effort to increase the country's energy efficiency.

And on the South Side of Chicago, one town-like university campus will be leading the way for all Americans to count on having power that is, in essence, perfect.

"The Perfect Power development and demonstration project provides a unique opportunity for DOE, Exelon, IIT, and the Galvin Electricity Initiative to work together to develop and demonstrate the distribution system of the future," says Terence Donnelly, ComEd senior vice president of transmission and distribution operations. "IIT is ideally suited to serve as a test bed for joint research and demonstration activities, and we see significant potential for the collaboration to produce advanced distribution system technologies that can be applied to the ComEd system to improve reliability and reduce operating costs." ■

MORE ONLINE

United States Department of Energy: **www.oe.energy.gov/smartgrid.htm**
Galvin Electricity Initiative: **www.galvinpower.org**
Gridwise® Architecture Council: **www.gridwiseac.org**
IIT Perfect Power System: **www.iit.edu/perfect_power**

CURRENT AND SMART GRIDS: A COMPARISON

CONSUMER PARTICIPATION

- C Passive plug-in consumers
- S Participatory, informed consumers

GENERATION OPTIONS

- C Restrictive, central generation
- S Multiple distributed-energy stations for plug-in technologies

COST CHOICES

- C Limited wholesale pricing
- S Developed wholesale pricing, with new real-time market options

POWER QUALITY

- C Emphasis on preventing outages
- S Emphasis on powering digital economy

RESPONSE TO SYSTEM DISTURBANCES

- C Focus on preventing further damage post-problem
- S Focus on automatically detecting potential failures

SECURE OPERATIONS

- C Central design susceptible to attack
- S Multiple-unit design more resilient to attack

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Appendix 5

Perfect Power Control Working Document

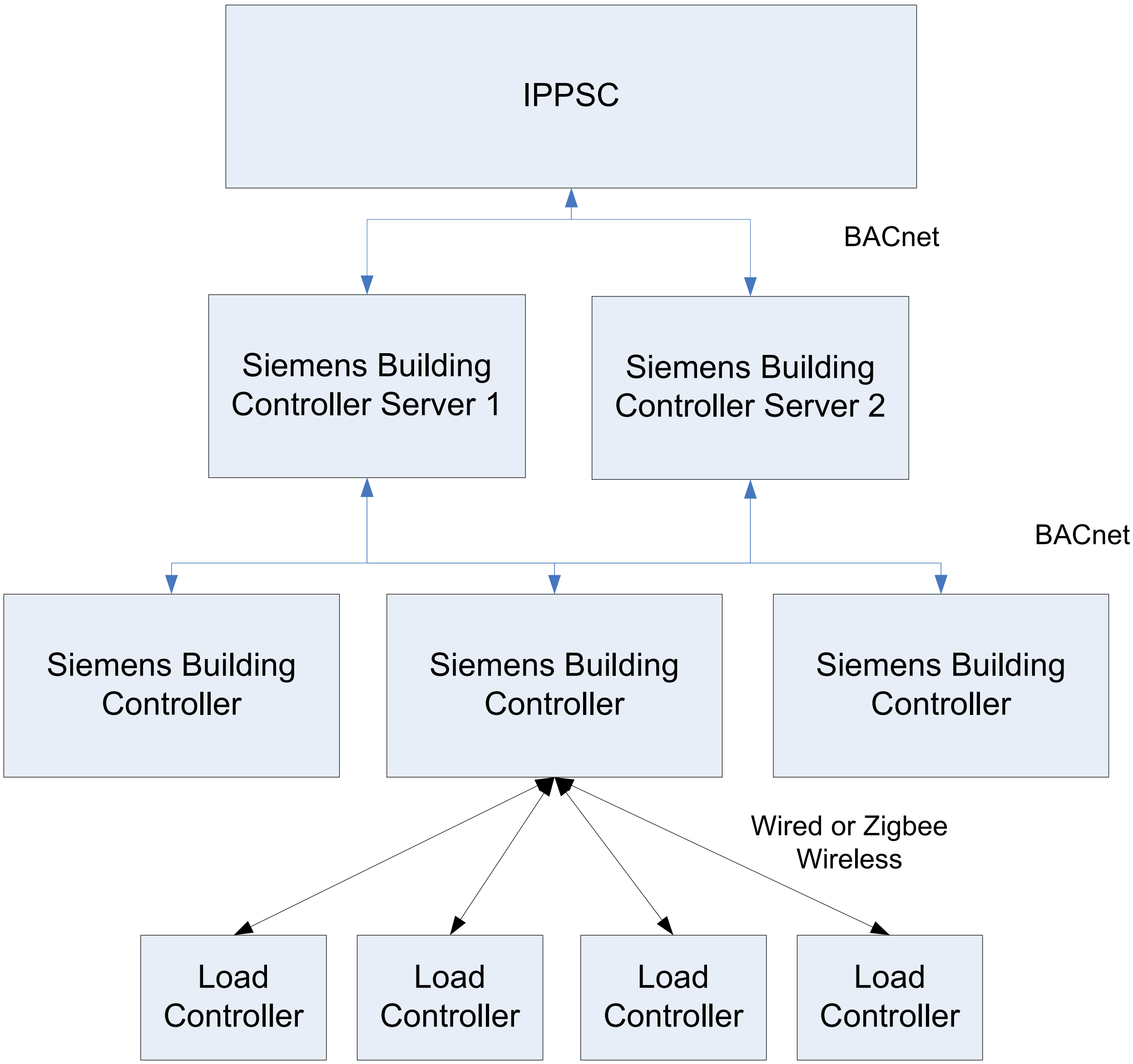
Revision History

- The first draft document of the Perfect Power control is based on a meeting held on June 16, 2009 at the ECE Department, IIT. Participants: Mohammad Shahidehpour, Alex Flueck, Chi Zhou, Zuyi Li, John Kelly
- Rev. A: Based on a meeting held June 23, 2009 at the ECE Department, IIT. Participants: Participants: Mohammad Shahidehpour, Alex Flueck, Chi Zhou, Zuyi Li, Greg Rouse, Joseph Clair

1. Controls That Are Related to Siegel Hall

Intelligent Perfect Power System Controller (IPPSC)
Siemens Building Controller
Zigbee Controllers
Individual Load Controllers
Agentis Monitoring

2. Hierarchy of Perfect Power Control



Control Hierarchy:

- IPPSC communicates directly with the Siemens Building Controller Servers (SBCS) through BACnet*. There are two SBCS located in Stuart Building. One SBCS works as the main and the other works as the backup. It is suggested that IPPSC be located in Stuart Building as well. There will be remote interfaces that can monitor and issue

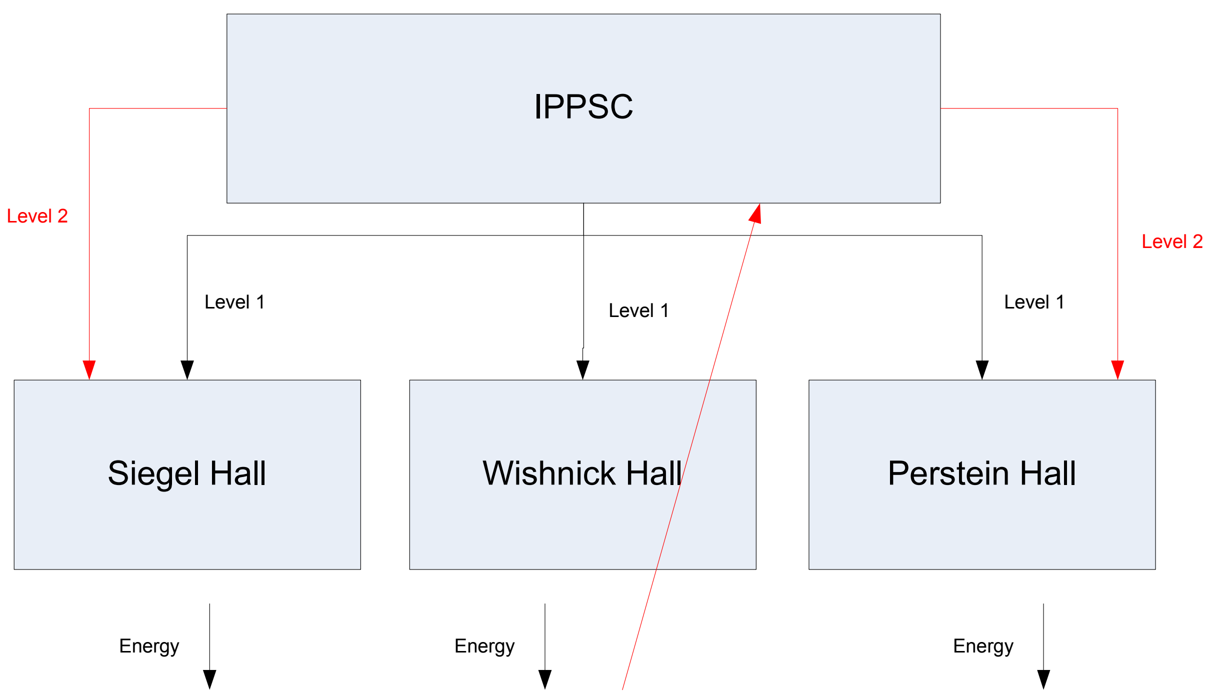
* BACnet is "a data communication protocol for **b**uilding **a**utomation and **c**ontrol **net**works." For more information, see http://www.bacnet.org/.

control commands to the IPPSC and the SBCS[†]. It is suggested that one remote interface be located in Siegel Hall so that visitors can see the entire control process without traveling to the Stuart Building. The communication between the remote interfaces and the IPPSC and the SBCS will be through campus network (Internet?).

- As is the case now, the SBCS communicate with the Siemens Building Controllers (SBC) in individual buildings through BACnet.
- SBC then communicates with load controllers inside the building through either wired connection or Zigbee wireless connection.

It is suggested that IPPSC should have feedback control functionality. One such scenario is as follows.

- IPPSC issues level 1 demand reduction commands to Siegel Hall (SH), Wishnick Hall (WH), and Perstein Hall (PH).
- SH and PH respond as required.
- WH initially responds as required (e.g., turn off AC), which, however, causes temperature to exceed tolerable range. Thus, energy usage in WH goes up again (e.g., AC has to be turned on again).
- To meet the demand reduction requirement, IPPSC has to issue level 2 demand reduction commands to SH and PH.



[†] There is remote interface in the Facilities Department than can monitor and issue control commands to the SBCS.

Related to the architecture and infrastructure of the building control system, although some of the improvements to the buildings will take place as part of the implementation of the Energy Management Plan, the following are important elements to consider:

- The programming of demand reduction strategies will require significant input from the occupants as there will definitely be a reduction in services provided in order to achieve the desired reduction goals.
- The programming of efficiency strategies will be more driven by the amount of energy reduction as the intent is to maintain services but deliver them more efficiently, and as such will involve the occupants only when significant changes in the type (but not quality) of services will be changed.
- Clearly defining the sequences of operation for these two modes will be critical to the success of both strategies, and requires the owner to define appropriately all desired outcomes.

3. IPPSC Modes

There are six IPPSC modes currently defined. More details need to be specified.

- Demand Response 0 (normal operation and energy efficiency)
- Demand Response 1 (contracts, external call response (ComEd or other energy provider))
- Demand Response 2 (max response, real time price response)
- Island Mode Startup (all major loads off)
- Island Mode Critical (critical loads on)
- Island Mode Preferred (critical loads plus preferred loads on)

The first three modes are for demand response.

- IPPSC does not play an active role in Demand Response 0, in which the switch-off of unnecessary loads for energy efficiency is autonomously controlled by local controllers such as occupancy sensors. For instance, if the occupancy sensor in a classroom detects that the room is vacant, the lights in the room can be turned off. It is emphasized that occupancy sensors should be deployed for Demand Response 0. Details on Demand Response 0 have to be worked out. It is mentioned that by September 2010, energy performance contractors will be able to provide information on how to reduce energy usage by 20%. This information is not available now. In addition, the base point for the 20% energy usage reduction is undecided yet.
- Demand Response 1 operates based on contracts IIT signs with ComEd or other energy provider such as Constellation Energy. Under certain circumstances, ComEd or other energy provider may ask IIT to cut its load to relieve congestion. IPPSC will be the starting point to send load shedding commands to individual building controllers.
- Demand Response 2 operates based on real-time market prices. Whenever market prices are over a pre-specified threshold, IPPSC will direct the shedding of loads, again by sending commands to individual building controllers.

The last three island modes are for restoration in case IIT loses power from ComEd.

- In the initial stage (Island Mode Startup), IPPSC has to make sure that all major loads are off to avoid the trip of power plants due to excessive rush currents.
- Then (Island Mode Critical), IPPSC can send signals to switch on critical loads[‡].
- After that (Island Mode Preferred), IPPSC can send signals to switch on additional preferred loads[§].

To work effectively during the island modes, IPPSC will be able to communicate with power plants, backup generators, and SCADA systems in the substation, in addition to building controllers.

[‡] Which loads constitute critical loads need to be defined further.
[§] Which loads constitute preferred loads need to be defined further.

If the IIT campus loses power from ComEd, the IPPSC should

- send signals to substations to open circuit breakers, and
- send signals to building controllers to switch off loads within the buildings.

It is agreed that a questionnaire should be prepared in order to implement various IPPSC modes. The questionnaire can be initiated for Siegel Hall and improved for other buildings afterwards. One example is as follows.

IPPSC Mode	DR1	DR2	IM1	IM2	IM3
Load1	On/Off	On/Off	On/Off	On/Off	On/Off
Load2	On/Coast	On/Coast	On/Coast	On/Coast	On/Coast
Load3	Setting Point	Setting Point	Setting Point	Setting Point	Setting Point
Summary	X1	X2	Y1	Y2	Y3

By choosing the control for each load, a user can have the knowledge of how much load can be reduced (X1 for DR1, Y1 for IM1, etc.).

The ultimate goal is to determine which loads to control under a specific IPPSC mode.

To complete the above table, we also need to know how many watts each load is. The students supervised by Joseph Clair are counting the loads in Siegel Hall. This information will be merged with the inventory list prepared by John Kelly so that the list of loads and corresponding wattages can be obtained. Additional students should be recruited to finish the load counting for other buildings than Siegel Hall.

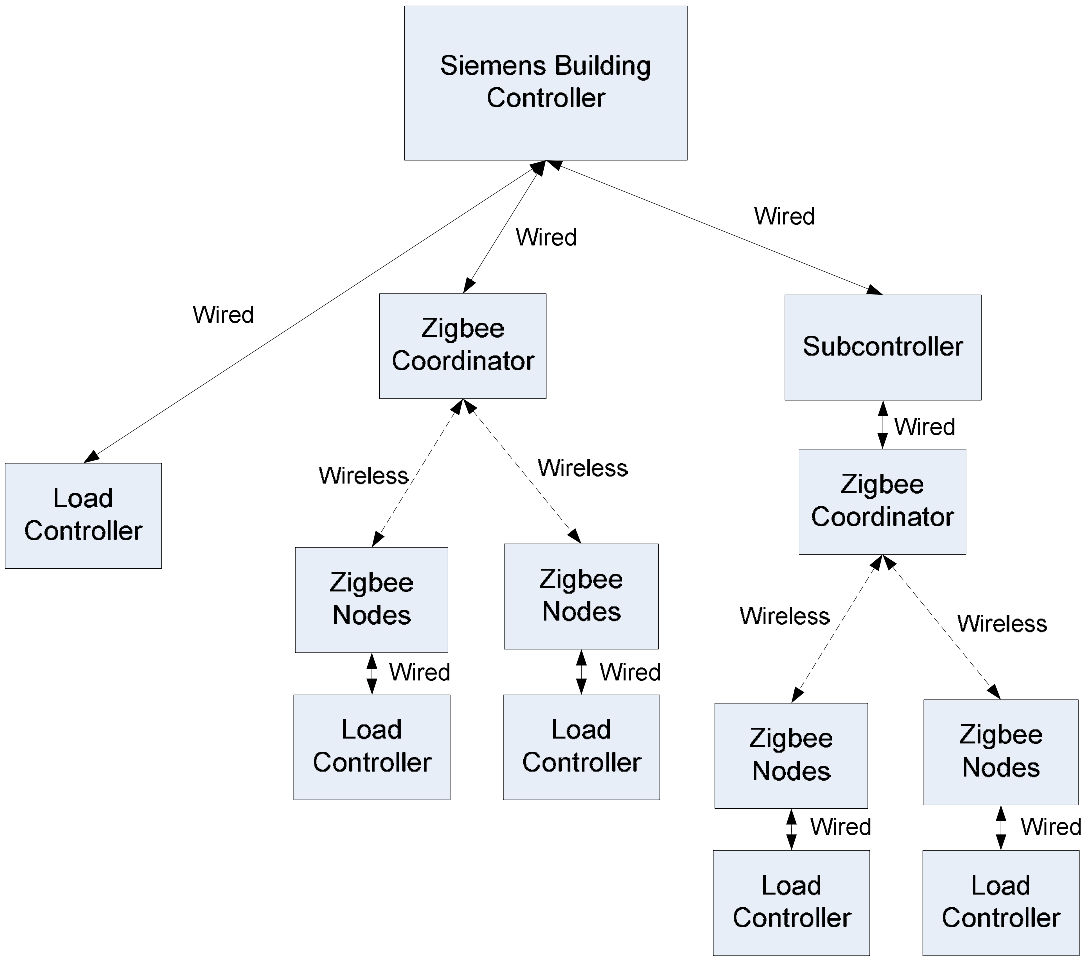
Coast: is a way of controlling load. Consider the following scenario. The AC for a room is running to maintain the room temperature at 72 degree. When ordered for demand reduction, the AC is turned off and the room temperature starts to rise. When the room temperature reaches an unbearable 90 degree (this value can be set), the AC will be turned on automatically.

More details on energy efficiency program:

- The important fact to consider when discussing building automation system controls within the scope of the implementation of Perfect Power at IIT is that there are two separate aspects of energy optimization that the building controls will affect: permanent efficiency and demand reduction. The communication process outlined in Section 2 shows the hierarchy of the system for demand reduction: the IPPSC will decide the level and duration, then signal the individual buildings as to the decision; the building controllers will then, to whatever extent they have infrastructure and capacity, execute a pre-determined demand reduction strategy. For permanent efficiency, the control systems will be programmed individually to make the most effective use of energy in delivering a service to the building. For example, occupancy sensors, photocells and software "timeclocks" will regulate everyday lighting usage to make sure that the right amount of light is provided where it is needed....and that the least amount of energy necessary is transferred to provide that light.

- The documents provided to DOE for the project currently note the demand reduction goal, over which the implementation of the DOE project has complete control, as well as a consumption reduction goal (stated as 20%) for which no funding or scope is provided in the DOE grant.
- IIT plans to develop and release in December, 2009 an Energy Policy and Energy Management Plan tailored to describe the commitment IIT will make to energy reduction, with a plan for how to reach that commitment. These reductions will come in one of 3 basic forms: infrastructure improvements, energy efficiency improvements, behavioral changes. The Plan will describe how each one fits into the overall commitment, and what the IIT community needs to invest (in human and financial capital) to realize the goals. After this plan is released, IIT's Office of Campus Energy and Sustainability (OCES) will work with Energy Service Companies (ESCO) to identify projects and improvements that can be made to accelerate the efficiency and infrastructure components necessary to reach the commitments and targets.

4. Controls Inside Building



Inside a building, the Siemens Building Controller (SBC) is the focal point.

- For big loads such as rooftop fans, SBC will communicate with the load controller through wired connection.
- There could be two options for the SBC to communicate with load controllers wirelessly.
    - Directly through the Zigbee coordinator, which is hardwired to SBC.
    - Indirectly through a sub-controller (e.g., a PC)

Potential Zigbee Control Points

- Exterior office room lights
- Window units
- Elevators (?)

5. Others

Replace current manual switches with smart switches

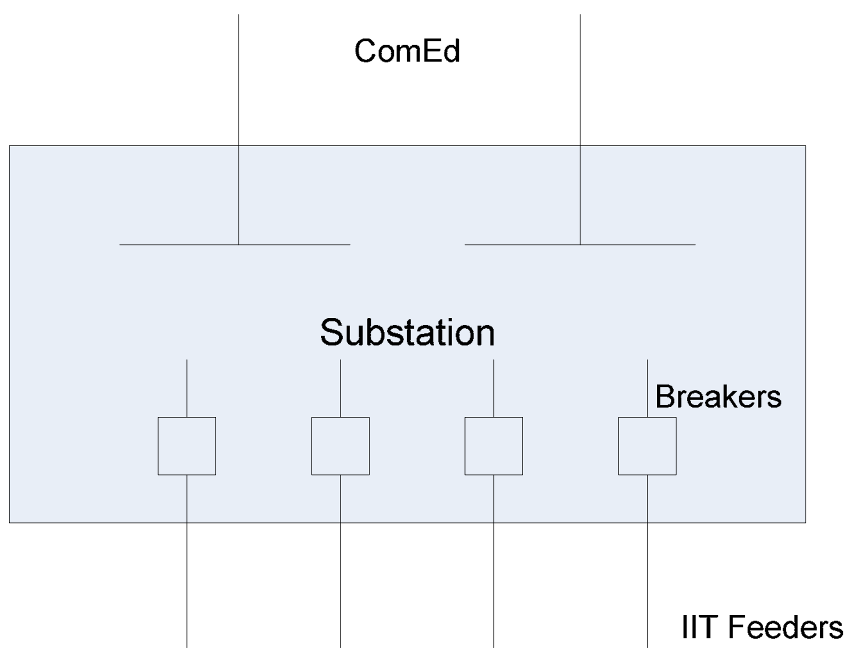
Be able to switch off partial loads (may need to replace one manual switch with two or more smart switches)

Be able to override the smart switch

Embed some intelligence in local switches

Agentis sensors will be installed to monitor key loads. The information would be available through web access. Agentis sensors are not able to monitor the power at the transformer level. Its maximum is about 15 kVA (240V * 100A and consider some margin).

Should be able to get data from Agentis so that further analysis could be done. Agenetis does not provide this function at this time.



Conceptual Configuration of IIT Substations

Inside the substation, the SCADA gets information from Schweitzer relays as well as S&C vista switches.

Appendix 6

POWER SHIFT

SCI-TECH SCENE | Old name behind new design for IIT electricity delivery

SANDRA GUY
sguy@suntimes.com

Robert Galvin, the son of Motorola's founder who ran the company for 30 years, has started a not-for-profit venture making Chicago "ground zero" for a new U.S. electrical system run by entrepreneurs.

Galvin, 86, was jolted by the reality of this country's outmoded electrical grid six years ago when his wife got stranded in New York during a blackout that left 40 million people in eight Northeastern states in the dark.

Robert Galvin

"I said, 'Someone needs to do something about this,' " said Galvin, who has poured his own millions into developing a business plan and technologies in the last five years.

The latest move is a partnership between the not-for-profit Galvin Electricity Initiative and the Illinois Institute of Technology.

IIT is converting its South Side campus into a "Perfect Power" system, making it the model for Galvin's vision of small electrical grids that would serve local communities.

The four-year project at IIT requires the university to upgrade its two ComEd electric substations and to upgrade and attach smart switches to the seven electrical-service loops that feed electricity to campus buildings, said Joseph Clair, director of campus energy and sustainability at IIT. The system is expected to decrease power demand by 20 percent, Clair said.

The smart switches will also instantaneously relay to humans what's going on in the electrical grid, allowing power to be automatically redirected in case of an emergency.

The $12 million project is being funded with a $7 million construction and research-and-development grant from the U.S. Energy Department and the remainder from IIT. The energy savings are estimated at $1.3 million a year.

Galvin realizes the existing electrical grid and overhead power lines won't go away instantly, but he looks forward to entrepreneurs being motivated to build power systems underground, losing less energy into the air and boosting reliability.

Kurt Yeager, executive director of the Galvin Electricity Initiative and the retired president of the Electric Power Research Institute, said the smart switches are a necessary first step because today's power grid is as outdated as a rotary dial telephone.

"We're trying to set up the Internet of the electric industry," said Yeager, who argues that today's regulations give utility companies no incentive to upgrade.

Ultimately, an upgraded electricity system could even do away with the meter and rely on local power sources such as solar power, local gas turbines and other complementary sources.

The goal is to make America more competitive, Galvin said.

His next priority is to change state regulations that favor electrical power monopolies.

In January, he convened a meeting of what he called "public spirited and active influentials" to endorse principles and policy objectives to guide the new electric environment.

Indeed, the Illinois Commerce Commission has launched a smart-grid initiative. The federal government has started its own initiative, in which Galvin hopes to participate.

Entrepreneurs and major corporations are racing to join what Barron's magazine calls a "Grid Rush" to pan for some of the $11 billion the Obama administration intends to spend to upgrade the electrical grid. Some experts say it will take $10 billion each year for five years to install the latest smart meters and billing systems into the grid.

"The $11 billion that the Obama administration plans to use to upgrade the grid is an excellent start, but support cannot stop there," said Mohammad Shahidehpour, chairman of electrical and computer engineering at IIT and principal investigator on the Perfect Power project. "The key is to spend wisely on technology that will provide results. Moving into the digital era of energy infrastructure, we must teach people to use energy efficiently. Smart grid technology is the most straightforward way to do that."

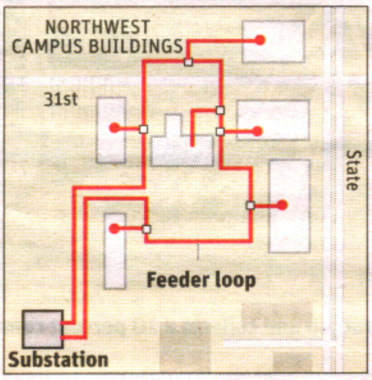
Comment at suntimes.com.

Alexander Flueck (left) and Mohammad Shahidehpour discuss their design for a new electrical distribution grid for the IIT campus. | KEITH HALE~SUN-TIMES

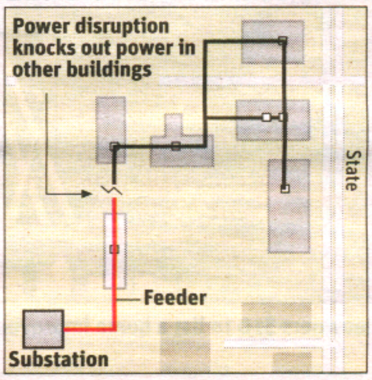
IIT'S NEW ELECTRICAL SYSTEM

Below is one of the seven planned redundant electricity loops at IIT's Main Campus. The loop structure sends electricity from one building to the next and allows the flow to automatically switch directions if a fault causes one of the buildings to lose power. This concept keeps electricity flowing to the rest of the block of buildings.

NEW DISTRIBUTION SYSTEM



EXISTING DISTRIBUTION SYSTEM



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SEE THE VIDEO

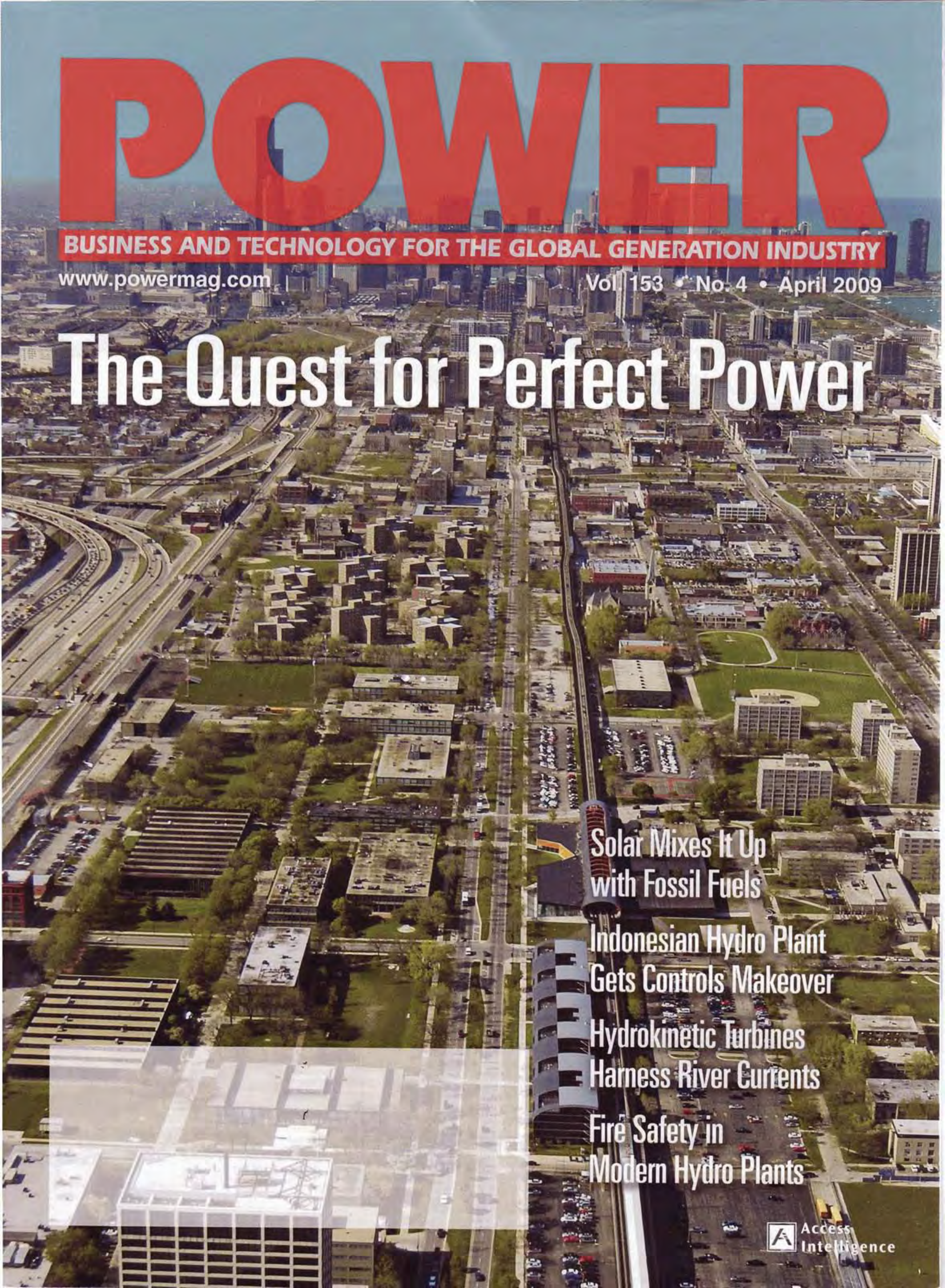
Want a look at the revolutionary process? Go to: suntimes.com/business

Appendix 7

POWER

BUSINESS AND TECHNOLOGY FOR THE GLOBAL GENERATION INDUSTRY

www.powermag.com Vol. 153 • No. 4 • April 2009



The Quest for Perfect Power

Solar Mixes It Up with Fossil Fuels

Indonesian Hydro Plant Gets Controls Makeover

Hydrokinetic Turbines Harness River Currents

Fire Safety in Modern Hydro Plants

Access Intelligence

In Search of Perfect Power

What do you do when your research institution is losing roughly half a million dollars annually as a result of multiple electricity outages — and electricity demand keeps rising? If you're the Illinois Institute of Technology, you turn the challenge into a campuswide learning experience by teaming with the Galvin Electricity Initiative and other experts to design and construct a prototype Perfect Power System (PPS). Even during its implementation, the PPS promises to provide more reliable and sustainable electricity to the university at a lower cost than it had been paying.

Between 2004 and 2006, the 120-acre campus of the Illinois Institute of Technology (IIT) in Chicago (see cover photo and Figure 1) experienced an average of three unplanned electricity outages per year. Those outages ranged from partial to complete loss of load on the main campus and cost the university an estimated $500,000 annually in destroyed experiments, damaged equipment, lost productivity, cancelled classes, and other consequential damages.

1. Windy City campus. This shot looks northeast across the IIT campus. Main is the red brick building to the left, and the Galvin Library is the one-story building to the right of Main. The three-story Siegel Hall, which houses the Department of Electrical and Computer Engineering, is directly up from the Galvin Library. Courtesy: IIT

IIT offers degrees in engineering, science, psychology, architecture, business, and law. Together with the IIT Research Institute (IITRI), its contract research affiliate, the institution specializes in areas such as aerospace, synchrotron radiation science, environmental engineering and regulatory policy, polymer science and recycling, food safety and technology, and transportation and infrastructure. A common concern among researchers working on such projects is insulating their long-term and critical experiments from the university's notoriously unreliable electricity supply (see "The Cost of an Unreliable Electricity Supply"). Each of the research laboratories is much like a small business that is open 24/7 — but with student employees who can't take a weekend off or head to Daytona for spring break when an experiment is in process.

Together, IIT and IITRI enjoy annual research revenues of $130 million. Protecting that revenue means ensuring a reliable power supply.

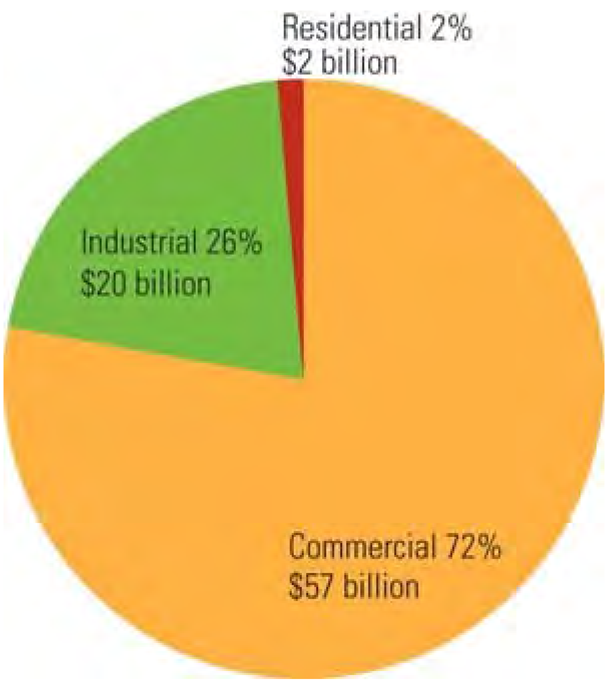
In response to the too-frequent outages, some laboratories shifted key experiments to evening and/or weekend hours, when the risk of an outage was less than during the day. By the summer of 2006, the mounting costs and complaints captured the attention of senior university administrators and even the IIT Board of Trustees.

Robert W. Galvin, former chairman of the IIT Board of Trustees, extended an invitation to the IIT power engineering faculty to join the Galvin Electricity Initiative (GEI) and proposed using IIT's main campus as a possible site for what Galvin calls the "Perfect Power System" or smart microgrid. IIT soon signed on with the GEI (see sidebar) and began work on GEI's first Perfect Power System (PPS) installation with the goal of improving electricity reliability and reducing costs on the IIT campus.

Energy efficiency projects were soon under way at IIT after its 2006 Energy Master Plan to maximize energy efficiency technologies and introduce renewable energy options was adopted. That plan requires energy efficiency improvements to reduce electricity consumption by up to 11 million kWh (20% reduction) and reduce natural gas consumption by nearly 1 million therms (10% reduction) per year. IIT was soon to find that a PPS could produce this level of energy savings while significantly improving overall system reliability.

The Cost of an Unreliable Electricity Supply

The Lawrence Berkeley National Laboratory (LBNL) attempted to capture the costs incurred by consumers because of unreliable electricity supplies in a September 2004 study titled, "Understanding the Cost of Power Interruptions to U.S. Electricity Consumers." This report, prepared after the August 2003 Northeast Blackout, revealed that the cost of power interruptions approaches $80 billion annually and that the bulk of that cost is being born by commercial users (Figure 2). One of the report’s authors estimated that the level of investment in the grid needed to improve reliability was in the range of $50 billion to $100 billion.



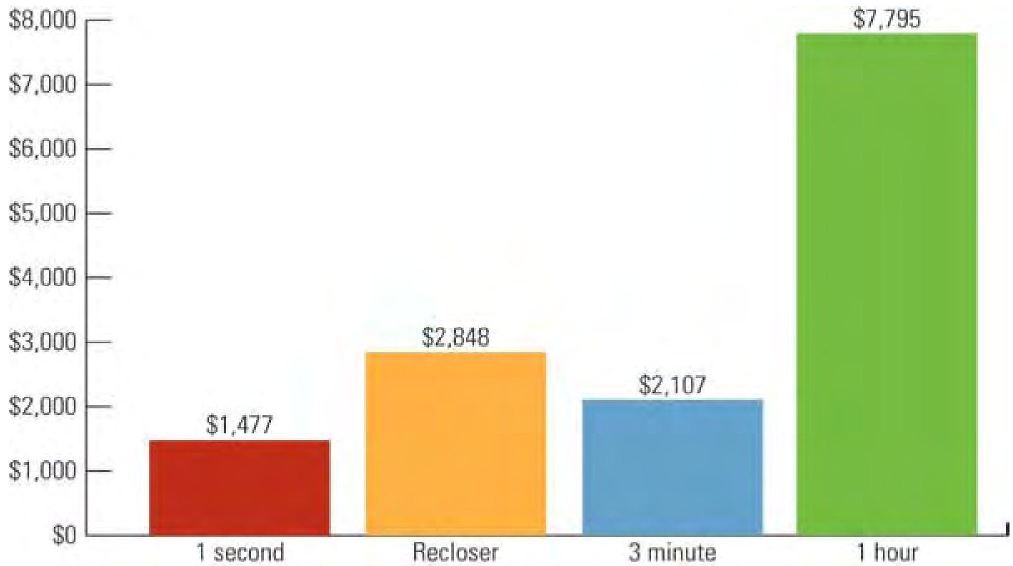
2. The average cost of a power interruption. Lawrence Berkeley National Laboratory (LBNL) estimated that the total losses due to U.S. power outages are approximately $80 billion per year. *Source: LBNL*

The LBLN researchers found that the industry knowledge base available to analyze power outages had many data gaps. Lab researchers aggregated data from three key sources: surveys on the value electricity customers place on uninterrupted service, information recorded by electric utilities on power interruptions, and information from the U.S. Energy Information Administration on the number, location, and type of U.S. electricity customers.

One of the key conclusions of the study was that mere momentary outages, which tend to be more frequent, have a bigger impact on the total cost of interruptions than major outages. Intermittent outages were estimated as accounting for two-thirds of the $80 billion annual loss.

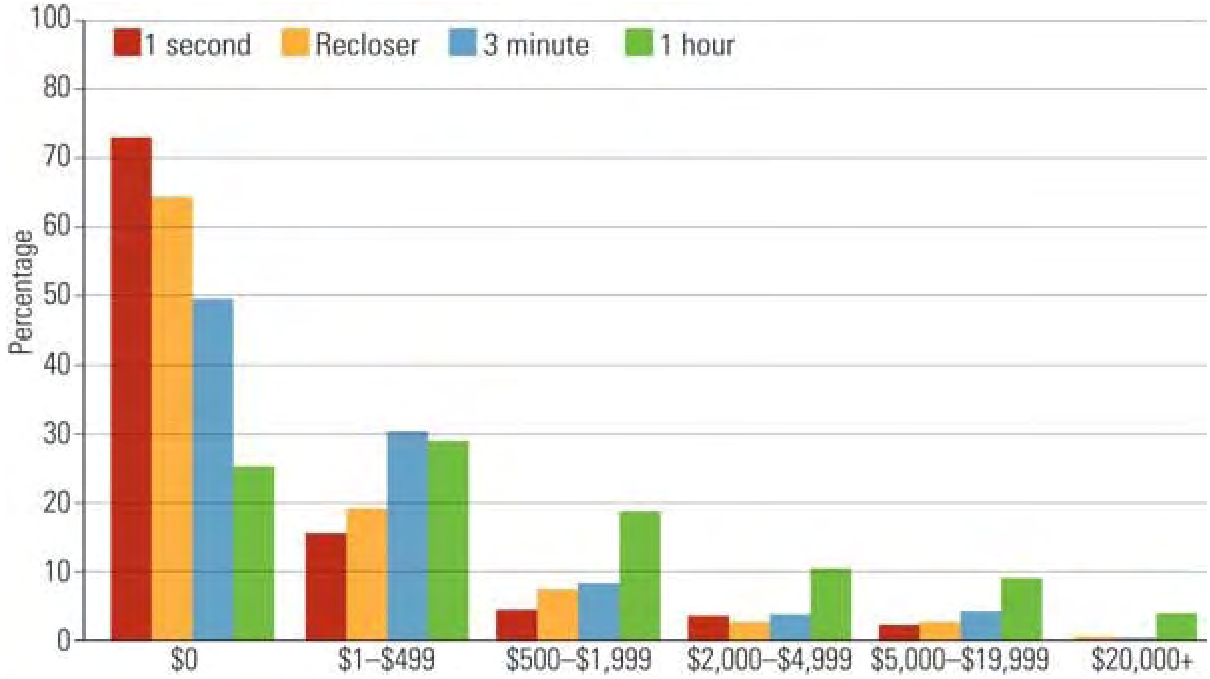
The Electric Power Research Institute (EPRI) estimated the annual cost of interruptions and power quality events at $104 billion to $164 billion annually in another study of the impact of power outages on the digital economy. That study also found that between $15 billion and $24 billion in losses were attributable to power quality problems.

The EPRI study concluded that the cost of an outage increased with the length of the outage, although even very short outages were expensive (Figure 3). In addition, the average cost of even a recloser event is more than that incurred by a 1-second outage. Perhaps some utilities are operating their equipment in ways that are detrimental to their customers.



3. The average cost per outage by duration. *Source: EPRI*

The EPRI study also concluded that the distribution of costs related to outages is uneven (Figure 4). For example, almost three-quarters of the businesses surveyed reported virtually no cost to their business for a 1-second outage or a recloser event. In sum, the majority of businesses incur little or no costs from an outage, but a few have very large costs. Five percent of businesses studied incurred costs in excess of $20,000 or more for a 1-hour outage, and a select few reported losses as high as $1.5 million or more.



4. Distribution of costs per outage by duration. Fewer companies experience large losses than smaller losses as a result of a power outage, but a small portion of companies experience losses as large as $1.5 million or more. *Source: EPRI*

Assembling the Team

During the summer of 2007, IIT joined forces with several key organizations in the electric power industry to assemble a team of experts capable of designing and implementing Galvin's first PPS at IIT. A proposal submitted to the Department of Energy's (DOE's) Renewable and Distributed Systems Integration Funding Opportunity within the R&D Division of the Office of Electricity Delivery and Energy Reliability "[to] demonstrate peak load reduction on distribution feeders with the implementation of distributed energy and energy management systems at a cost competitive with system/capacity upgrades" was successful. After that funding was secured, the project team was assembled.

In addition to IIT and GEI, the expert team included Exelon/Commonwealth Edison Co. (ComEd), S&C Electric Co., Endurant Energy, and Integrys. The five-year PPS project began construction in early 2009.

The project consists of six distinct steps inspired by Six Sigma quality methods developed by Motorola.

Step 1: Adopt Quality Methods

The first step in developing any quality program is to develop a methodology to collect discrete statistics from which to measure progress and determine a set of desired end-state metrics (Table 1). The IIT team participated in two training courses on Six Sigma quality methods and principals at the Joseph M. Juran Center for Leadership in Quality at the University of Minnesota, Carlson School of Management. The purpose of this training was to develop a replicable methodology for creating PPS. The team subsequently adopted the following standard quality methods for the project:

- Determine what is critical to quality (CTQ) from the customer's perspective.
- Process map CTQ elements and develop measures that quantify performance or the cost of poor quality.
- Perform a Failure Modes and Effects Analysis (FMEA) for each process step.

- Engage in error proofing, innovative problem solving, and solution set generation.
- Prioritize the implementation steps.

Metric	Description
Interruptions as defined by the customer. This could include a loss of power, loss of a phase, or power quality fluctuation.	Measure interruptions/customer/year. Prioritize customer's life safety, economic loss, damage. Use these criteria to focus limited resources.
Economic impact of outages	A measure of the real impact of each outage in terms of the impact on customers. Lost productivity, lost product, damaged goods, etc.
Asset utilization	The ratio of actual kWh delivered divided by the theoretical capability of the asset.
Aesthetics	Cities, developers, and customers are seeking to eliminate the blight caused by overhead distribution systems.
Carbon emissions	Reducing carbon footprint.
Energy costs	Energy costs compared with a baseline (in this case, ComEd rates).

Table 1. Energy system quality metrics. The Perfect Power System team began by defining IIT's power quality needs and a set of desired end-state metrics. *Source: IIT*

Step 2: Do Process Mapping

Once the key project metrics were established, the process mapping quality method divided the IIT utility system into the following major processes:

- Supply or transmission systems, larger area switch stations, area substations, and step-down transformers.
- Campus distribution or substations, substation breakers, building feeders, building isolation, and communications.
- Building distribution or switches, transformers, and circuits within the building.
- Backup power or standby generation to protect critical loads.
- Procurement and sustainable energy systems to minimize the energy and environmental impacts of the campus loads.

Step 3: Assess Major Subsystems

The team then performed an assessment of the existing campus infrastructure and power supply system processes from Step 2. They confirmed that a number of significant infrastructure upgrades were required before they could apply the PPS principles.

The team found three separate underground circuits, fed from a single substation, that supply three 7-MW ComEd transformers. ComEd designed the electricity system to accommodate a single circuit failure, so the effective demand at the substation was 14 MW. Campus records show IIT's highest peak load through 2006 was approximately 10 MW. ComEd tested all the substation components and subsequently upgraded the supply circuits to improve short-term reliability.

IIT also installed over 2 MW worth of natural gas – fired engine generators for standby generation to protect critical loads as part of the PPS project. Distributed resources can reduce peak demand and can eliminate or defer new transmission and distribution capacity and decrease electricity wholesale or market prices. Enhanced on-site peaking generation resources can also improve reliability and security.

In addition, IIT is in the middle of a major upgrade to its steam heating system that entails adding new natural gas –fired boilers.

IIT is also working to slow the growth of its electricity demand by installing advanced lighting, windows, and other energy-reducing technologies that will help it avoid rising electricity costs as it continues to expand the campus.

On-site generation, when combined with a new automatic demand response capability, will be capable of sustaining campus operations in the event of a loss in ComEd electricity supply. The completed PPS will be able to remove 10 MW of demand from the grid when called upon by ComEd or the PJM independent system operator to do so. On-site generation sources will also support distribution- and transmission-level load control programs.

Step 4: Identify the Weakest Links

Many organizations fix problems after the fact and thereby incur the cost of failure in their product cost, according to the Juran Center for Quality. Others avoid fixing problems by adding unnecessary costs at the end of a process by, for example, increasing the number of inspectors and production redundancy. In contrast, the IIT PPS team applied Six Sigma quality principles, including failure modes and effects analysis and error proofing quality tools, to identify and define the types of failures that were possible and determine how to minimize or prevent those failures before they occur.

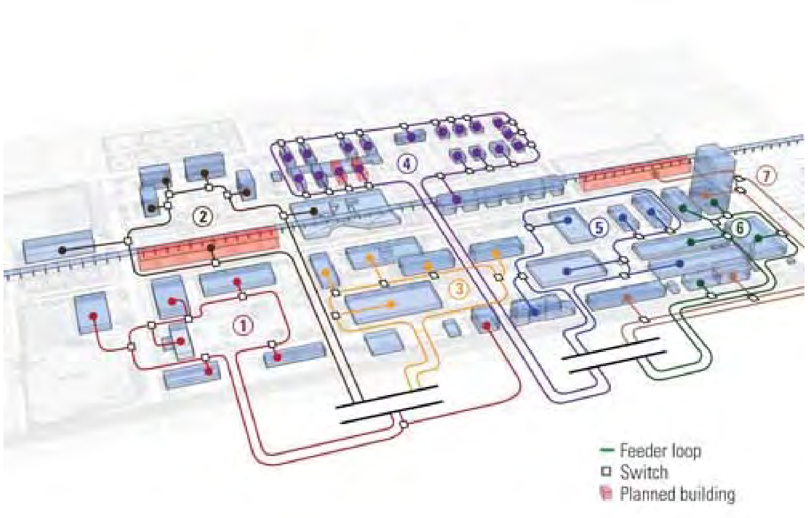
The team determined the severity (major, moderate, and minor), probability (frequent, occasional, uncommon, and remote), and severity factors (severe weather, aging, usage, and human error) for each failure mode. The severity of the impact of a power failure depends upon the severity of the impact of the loss of power on the customer and may vary from customer to customer.

This process identified several weak links in the system that are now part of the planned PPS upgrades:

- *ComEd electricity supply.* IIT is located in an area subject to severe weather, but it has only one transmission feed, which makes it more vulnerable to outages. In addition, the campus electricity supply is via older direct buried cables that have been experiencing failures. Furthermore, some of the ComEd supply system is still above ground and subject to weather damage. These conditions resulted in an offsite power supply rating of "frequent." In addition, the severity of the impact was rated as "moderate" due to the economic impacts from the loss of productivity. The analysis concluded with the imperative that IIT will need to ensure that the campus can be supplied by a local alternative power source.
- *Site distribution cables.* IIT supplies a number of the campus buildings via direct buried cables. The buildings are supplied by two feeder cables that must be manually selected. The PPS design requires that these failure modes be eliminated.
- *South Substation.* The IIT South Substation is more than 30 years old and nearing its supply capacity. The substation should be upgraded and the power feeds reconfigured to move some of the loads to the newer North Substation.

Step 5: Design the Perfect Power System

IIT's PPS is modeled after the "High Reliability Distribution System" (HRDS) developed and implemented by S&C Electric for the University of California at Santa Barbara. The team divided the IIT campus into logical groups of buildings that will form electricity and thermal loops to maximize reliability and efficiency. The HRDS leverages a continuously energized loop feeder concept, which provides a redundant supply of electricity to designated campus buildings (Figure 5). Both feeds will be energized and will supply electricity to designated buildings. They will also be capable of carrying the entire building load. In addition, feeder redundancy will allow the rerouting of power to buildings in the event of a distribution feed fault.



5. The perfect number. The IIT High Reliability Distribution System divides the campus into seven independently controlled and redundantly supplied management zones. Siegel Hall is the far right building in zone 3. Source: Michael Meiners, Galvin Electricity Initiative

This approach was based on the team modeling projected loads on campus based on expected increases in enrollment and planned construction of new and recommissioned campus buildings. Transformers will be upgraded where necessary, and new 15-kV cables will be installed to provide additional flexibility. The result will be a robust feeder network that will give IIT the option of eliminating the existing above-ground ComEd transformers that step down ComEd distribution voltage of 12.46 kV to the switchgear rating of 4,160 V.

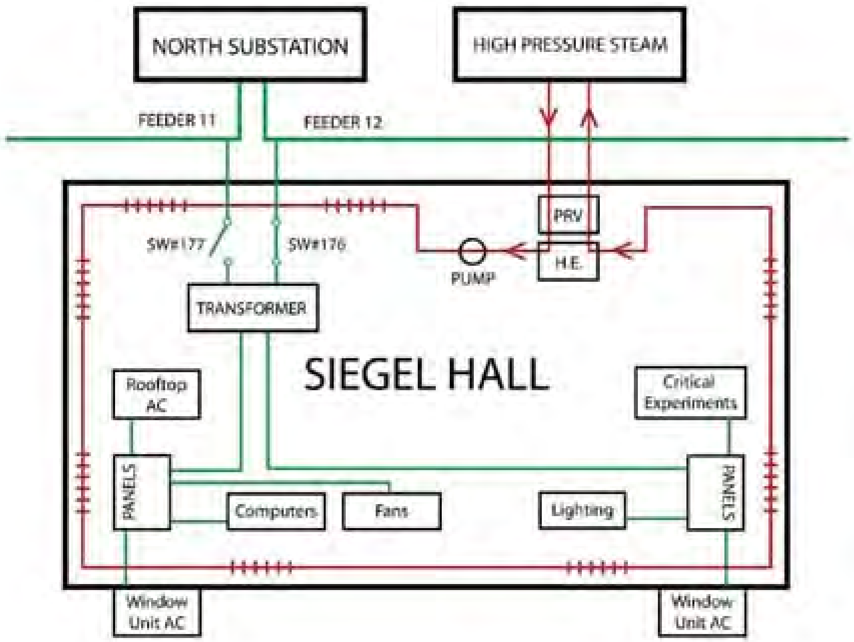
The backbone of the PPS is an intelligent trending, detection, and mitigation system that collects thousands of inputs, trends their parameters, determines their potential impact, and changes the system operation to mitigate the consequences of adverse trends. An Intelligent PPS Controller (IPPSC) that monitors and trends critical parameters to determine the system state manages the PPS. The IPPSC then changes system operating conditions to maintain the system within the specified limits of operation. The monitoring and communications system includes the robust deployment of lower-cost mesh sensors and modules that communicate via either a wireless or a wired IP-standardized communications network, including:

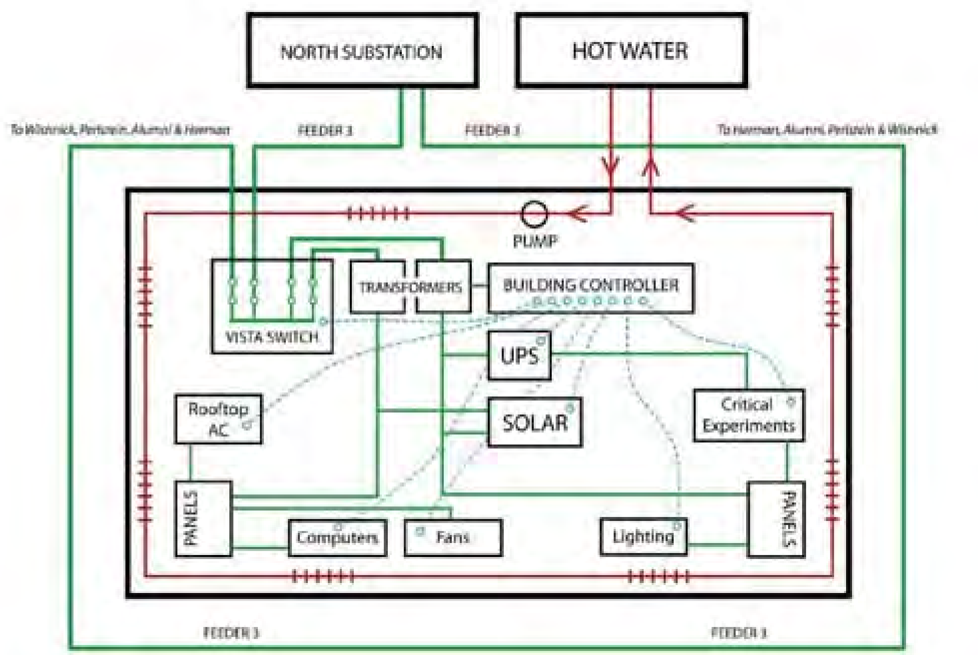
- Advanced meters for each building that measure voltage, frequency, current, reactive power, power consumption, and harmonics as well as individual building loads.
- Signals from the IPPSC to dispatch generation based on PJM real-time electricity and natural gas prices.
- Local generation and storage output levels, storage capacity, and fuel supply status.

For example, in the event of a loss of one section of cable or a switch, the design concept provides for the rapid assessment of fault conditions and opens within 1/4 cycle, simultaneously isolating the fault and allowing power to flow along a secondary feeder route without interrupting power to any loads. This approach uses S&C Vista fault-clearing switchgear in a closed-loop system with directional overcurrent protection relays. This combination of high-speed automated breakers, switches, and redundant feeders allows for the instant reconfiguration of the system to keep power flowing to all buildings.

Siegel Hall, a research lab, is a good example of specific infrastructure upgrades that will mesh with the PPS technology. Siegel Hall's distribution system consisted of two 4,160-V feeds from the North Substation (Figure 6). Feeders 12 (primary) and 11 (secondary) provided feeder redundancy through manual switches 176 and 177, respectively, which fed into a 500-kVA transformer where power was stepped down to 240 V. Typically, two panels on each of the three floors distributed electricity to lights, fans, and computers. A high-pressure campus steam system supplies heating to the building.

Figure 6 also provides an overview of Siegel Hall's future Building Integrated Energy System. The PPS upgrades include a redundant electricity supply, efficient hot and chilled water supply, uninterruptible power source and/or generation, renewable energy sources, and an advanced building control system.





6. A world of difference. Each building will have a number of energy system retrofits completed. For example, these diagrams show Siegel Hall's distribution system before (top) and after (bottom) the planned Perfect Power System upgrades. *Source: Michael Meiners, Galvin Electricity Initiative*

Step 6: Implement the Plan and Achieve Cost Savings

IIT's PPS is being implemented in the following four phases, determined mainly by the prerequisite infrastructure upgrades described previously.

Phase 1: Perfect Power Foundation. The first phase, started by IIT several years ago and currently near completion, built the foundation for this project by improving the overall efficiency of the campus and the reliability of the ComEd supply system. During this phase, the existing IIT gas turbines were modified for fast-start capability and to meet expanding building demand response capability, thus providing for continued operation of the IIT campus in the case of a loss of offsite power.

Phase 2: Real-Time Pricing and Ancillary Services. IIT and ComEd are located in the PJM Independent System Operator territory, which will provide IIT the opportunity to purchase lower-cost electricity in real time from the retail electricity market. With every opportunity, however, comes risk.

Entering the real-time markets without a means of hedging hourly price spikes could result in a sizable increase in electrical costs of $1 or more per kWh during peak periods. This volatility is the reason most facilities such as IIT do not accept real-time market risk. However, IIT's on-site generation, coupled with expanded building demand response capability, can be operated to mitigate peak demand prices and provide demand response. Fast-starting gas turbines also can provide new spinning reserve services to ComEd and PJM, effectively capping prices at the operating costs of the on-site generation. This arrangement will give IIT the flexibility in the future to purchase electricity when real-time markets' costs are lower than the cost of generating power on site and to deploy its backup generation when the price of electricity exceeds seven to eight cents per kWh.

If IIT had procured electricity in the real-time market in 2008 by leveraging the PPS to hedge peak prices, the campus would have reduced its annual electricity bill by about $800,000. IIT today can also generate revenue by participating in system operator load or demand response programs and purchase power contracts. A purchase power contract with Constellation Energy for 2009 is expected to reduce IIT's electricity bill by 25% this year.

Phase 3: Perfect Power, Distribution System Reliability, and Automation. Next, a redundant and intelligent distribution system that interfaces with a dynamic campuswide energy system controller will be implemented. This upgrade will ensure continuous service to IIT buildings in the event of a site cable or switch failure. The S&C Vista switches automatically and instantaneously reconfigures when a fault is detected, with no loss of service.

Phase 4. Distribution-Level Peak Demand Reduction. A local uninterruptible power supply, solar energy, and demand response capability will complete the PPS. This system will optimize building operating efficiency and reliability, demand response revenues, and ancillary services.

The Galvin Electricity Initiative

Former Motorola Chairman Robert W. Galvin formed the Galvin Electricity Initiative (www.galvinpower.org) in 2005, not long after the northeast U.S. blackout in August 2003 that left nearly 50 million people without power for days. Galvin was inspired by the event to design and promote a "Perfect Power System" that cannot fail the end user, primarily by eliminating outages at the consumer level. In addition, he claims the system is environmentally sound and fuel-efficient, robust and resilient, able to withstand natural and weather-related disasters, and mitigate the potential damage caused by terrorist attack. (Galvin's policy principles can be found at www.galvinpower.org/files/PolicyPrinciples_1008.pdf.)

Galvin, known throughout the business and technology communities for his dedication and leadership in quality improvement, asserts that the pursuit of perfection allowed Motorola to thrive in the face of fierce international competition. Galvin now sees an opportunity for utilities to leverage quality methods to achieve perfection — not in a few years, but over the next four decades. The Galvin Electricity Initiative believes that continuous improvement methods, which have been developed and refined over the past century, provide utility executives and entrepreneurs with a lever for improving quality and spurring innovation in the electricity sector.

Galvin has often been quoted as saying that "quality is a journey, not an end state." By applying Six Sigma quality principles and available technology to enhance the efficiency, reliability, and security of the dynamic U.S. power system, his Initiative intends to demonstrate that it is both economically plausible and practical to deliver what he calls "Perfect Power" to the consumer.

What's the Price?

The PPS, funded by IIT and the DOE, will allow IIT to avoid costly system upgrades and realize efficiency savings well into the future. The team estimates that the PPS will pay for itself even as it is being built over the next five years (Table 2).

System cost	$12 million
One-time savings	$5 million
Annual savings	$1.3 million
Simple payback period	5 years

Table 2. Estimated Perfect Power System costs and savings. *Source: IIT/Endurant Energy*

Coincidentally, IIT's investment will save all Illinois customers money by eliminating $2,000,000 in upgrades to the ComEd area substation that would have been needed to meet the rise in IIT's expected demand had the PPS upgrades not been proposed.

Implementation of a PPS at IIT will provide a powerful resource for attracting students and government/industry funding. For example, the electrical engineering program expects to raise an additional $1,000,000 per year in research funding due to the added campus features and functions.

In fact, the DOE recently awarded IIT a $6.7 million research grant to develop and demonstrate more advanced PPS technologies.

IIT plans to have construction photos and project status updates on its web site (www.iit.edu).

--James M. Hylko is a *POWER* contributing editor.

Close Window

Appendix 8

WORLD
UNITED STATES

Electricity

Smart move

Mar 19th 2009 | CHICAGO
From The Economist print edition

The push for a more intelligent grid

THE Illinois Institute of Technology (IIT) has always exemplified efficient design. Ludwig Mies van der Rohe, a master modernist, filled its Chicago campus with simple rectangular buildings. Critics quipped that IIT's only church spire was the chimney of its power plant. It is fitting, then, that IIT should herald a new era of efficiency. With the help of the Galvin Electricity Initiative, it is adopting the electric grid of the future. The hope is that the rest of the country will soon have one, too.

Electrocrats have been plugging the "smart grid" for years. Now others have joined them. Barack Obama's stimulus package contains about $4.5 billion in grants for smart-grid investments and regional demonstrations. GE is promoting the smart grid with ads that show a scarecrow singing "If I only had a brain" from "The Wizard of Oz" while bouncing along an old power line. In January Mr Obama declared that a smart grid could "save us money, protect our power sources from blackout or attack, and deliver clean, alternative forms of energy to every corner of our nation"—grand goals indeed.

America's power system has changed remarkably little over the past century, with centralised utilities delivering electricity to passive consumers. A smart grid would use digital technology to collect, communicate and react to data, making the system more efficient and reliable. For example, sensors would help utilities locate problems and fix them quickly—power cuts now cost businesses more than $100 billion each year. A nimble grid would integrate electricity from both predictable sources, such as coal, and fickle ones, such as the sun and wind.

Meters, to monitor both use and prices, would give consumers more control over their electricity bill. Advocates predict that some consumption would move to cheaper, off-peak hours, easing congestion and reducing the need for new infrastructure. Consumers would save money and emissions would fall. Installing smart meters in 25% of American homes, GE estimates, would be equivalent to removing 1.7m cars from the roads. Plug-in hybrids, meanwhile, could charge at night, when demand is low, and even pump power back to the grid while parked during the day.

The pilot at IIT is one of many. Xcel Energy, a utility, is transforming Boulder, Colorado, into what it calls the world's first "smart grid" city. The smart grid, however, should not be confined to pilots. But the problem is figuring out how to scale up.

Advocates have many tasks, not least of which is convincing consumers that a smart grid will lower their costs, not raise them. Changing regulations, meanwhile, is even thornier. For utilities, reducing consumption means reducing revenues, hardly an appealing prospect. The stimulus encourages rewarding utilities for efficiency, but it is local commissions that must change the rules, and they may be wary of what is still seen as a risky investment. Illinois's regulatory commission approved the installation of up to 200,000 smart meters in 2009. Wider investments, however, await a two-year cost-benefit study.

At the national level, standards are needed so that innovations can interact seamlessly. The National Institute of Standards and Technology, part of the Commerce Department, is expected to present only a rough framework by the summer. The momentum for a smart grid continues to build. But God, as Mies liked to say, is in the details.

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Sponsored by The Galvin Project, Inc.

Appendix 9

http://www.renewableenergyworld.com/rea/news/article/2009/08/us-government-continues-to-fund-renewable-energy-r-d

August 12, 2009

US Government Continues To Fund Renewable Energy R&D

by Ernie Tucker, NREL

Washington, DC, United States [RenewableEnergyWorld.com]

Last month, the U.S. Department of Energy (DOE) made yet another round of funding announcements for renewable energy projects and initiatives again showing its ongoing commitment to the greening of the American economy. The following announcements were reported in the EERE Network News.

$52.5 Million for Concentrating Solar Power Research

DOE offered $52.5 million for research, development and demonstration of concentrating solar power (CSP) systems that provide low-cost electrical power both day and night. The new funding will seek to improve energy storage technology and develop novel system designs that will extend operations to a level of production that would make it possible for a CSP plant to displace a traditional coal power plant.

The competitive funding opportunity for up to 13 awards focuses on developing a CSP system capable of operating at least 18 hours per day. It involves two areas: Research and development of concepts and components for such a CSP system; and development of a complete CSP system that can operate into the night, including an evaluation of the system and testing of the components for a future prototype. Applications are due by October 15. S

$13.8 Million to 28 New Wind Energy Projects

DOE selected 28 new wind energy projects to receive up to $13.8 million in funding, tapping $12.8 million in American Recovery and Reinvestment Act (ARRA) funds. The projects will help address market and deployment challenges, including wind turbine research and testing and efforts to better integrate wind power into the nation's electrical grid.

The 14 wind-turbine research and testing projects include work on improved wind turbine towers, blades, gearboxes, lubricants and generators; advanced manufacturing techniques and technologies for monitoring the performance of operating wind turbines.

The wind integration projects involve analyses of wind measurement and forecasting techniques, energy storage systems and means of integrating wind power into electrical grid operations, including operating techniques, software models, market simulation tools and other strategies and decision support tools. For a complete list of projects, click here.

$21.45 Million for Community Renewable Energy Projects

DOE offered $21.45 million in ARRA funds for up to four U.S. communities to use in planning and installing utility-scale renewable energy projects. The projects will demonstrate how multiple renewable energy technologies can be deployed at scale to supply clean energy to communities. The renewable energy systems may include solar, wind, biomass, landfill gas, geothermal and ocean energy systems, as well as upgrades to existing hydropower systems.

Applicants must provide matching funds and will ideally be ready to implement their projects with readily deployable renewable energy systems. Completed applications are due September 3, and DOE will select the projects by the end of November.

Smart Grids and Statewide Clean Energy Programs

DOE awarded $47 million in ARRA funds to eight ongoing smart grid demonstration projects. The $47 million investment will add to the $17 million in funds DOE had awarded these eight projects in 2008, thereby accelerating the timelines for the projects. Most of the projects relate to technologies to help transmission and distribution systems operate better, but a few are directly related to clean energy.

- Fort Collins, Colorado, will research, develop, and demonstrate a coordinated and integrated system of mixed clean energy technologies and distributed energy resources
- The Illinois Institute of Technology (IIT) in Chicago will focus on implementing distributed energy resources and creating demand-responsive microgrids, which are small power networks that can operate independently of the utility power grid.
- The University of Hawaii will explore the management of its electrical distribution system to better accommodate wind power.

DOE also announced that it has begun the development of a Smart Grid Information Clearinghouse, tapping Virginia Polytechnic Institute and State University for the $1.3 million initiative to develop and maintain the clearinghouse website, which will provide information to the public about smart grid initiatives happening nationwide. The Smart Grid Information Clearinghouse was mandated by the Recovery Act.

$212 Million for Clean Energy in Ten States and Puerto Rico

DOE awarded $212 million in ARRA funds to Colorado, Delaware, Indiana, Louisiana, Massachusetts, Nevada, Pennsylvania, Rhode Island, Vermont and Wisconsin and Puerto Rico to support energy efficiency and renewable energy projects. Under DOE's State Energy Program (SEP), states and territories have proposed statewide plans that prioritize energy savings, create or retain jobs, increase the use of renewable energy and reduce greenhouse gas emissions.

The funds will support loan, grant and rebate programs; capital financing programs; education and training efforts; energy audits; building retrofits; building energy code upgrades; coupons for purchases of Energy Star appliances; and partial funding for alternative-fueled vehicles and fueling stations.

The funds are part of the Obama Administration's national strategy to support job growth while making a historic down payment on clean energy. The Recovery Act appropriated $3.1 billion to the State Energy Program, giving priority to achieving national goals of energy independence while helping to stimulate local economies. For the 10 states and Puerto Rico, the new funds represent a portion of the State Energy Program funds available to them under the Recovery Act, following an initial 10% of the funds that were awarded to support planning activities.

The remainder of the funds will be released when they meet the reporting, oversight and accountability milestones required by the Recovery Act.

$6.3 million for Biofuels Research

DOE and the U.S. Department of Agriculture announced last month their joint selection of awards of up to $6.3 million over three years toward fundamental genomics research, which may lead to the improved use of plant feedstocks for biofuel production. DOE will provide $4 million for four projects, while USDA will award $2.3 million to three projects.

The projects will focus on developing enhanced versions of poplar trees, alfalfa, and grasses, including Miscanthus, switchgrass, Brachypodium distachyon (purple false brome), and sweet sorghum. Awardees are located in five states: California, Florida, Georgia, Michigan, and Nebraska. The grants will be awarded under a joint DOE-USDA program begun in 2006 that is committed to fundamental research in biomass genomics, providing the scientific foundation to facilitate use of lignocellulosic materials for bioenergy and biofuels.

Ernie Tucker is an NREL staff writer who has worked as a writer and editor in a variety of media, including newspapers, television and online content.

Appendix 10

THE **ISSUE**

Built largely in the 1960s or before, our electric power system cannot reliably run the kinds of digital devices on which today's economy depends. The effects of this inefficient, unreliable, and outdated electricity system are acutely felt each year at Illinois Institute of Technology (IIT).

THE **SOLUTION**

The Perfect Power System at IIT will be the first energy distribution system of its kind in the United States.

INVESTING IN PERFECT POWER

The Perfect Power System will allow IIT to avoid costly system upgrades and realize efficiency savings well into the future. It is estimated that the system will pay for itself as it's built, over the next five years. The project is funded by IIT and the DOE.

IIT to implement first-of-its-kind power grid. Watch the Channel 7 News Clip

Perfect Power News

Download a Perfect Power fact sheet containing much of the information displayed on this site.

IIT's Perfect Power project, which implements smart grid technology, was featured in "In Search of Perfect Power" the cover story of *Power Magazine's* April edition. Full Article

The Perfect Power project at IIT was featured in the May 19 Economist article, "Smart Move: The push for a more intelligent grid." Full Article

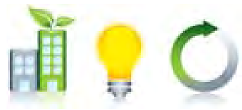
The IIT/Galvin Electricity Initiative project to bring Perfect Power smart microgrid technology to IIT's Main Campus was discussed in the February 14 Chicago Sun-Times article, "Power shift: Old name behind new design for IIT electricity delivery." Full Article

More Articles

Resources

Get educated on smart grid technology with this Institute of Electrical and Electronics Engineers (IEEE) online video.

More information can be found in The Smart Grid: An Introduction, a publication sponsored by DOE's Office of Electricity Delivery and Energy Reliability. It is the first publication of its kind to explore -- in layman's



THE **BENEFITS**

Perfect Power means not only a cheaper energy bill for iit, but also a safer, more productive campus and the opportunity for iit to set the standard for electricpower delivery.

terms -- the nature, challenges, opportunities and necessity of Smart Grid implementation. See mention of the Perfect Power project at IIT on page 37.

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Appendix 11

PowerTech 2009

28 June - 2 July 2009, Bucharest, Romania

- Innovative ideas toward the Electrical Grid of the Future -

PowerTech 2009 Main Menu
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University POLITEHNICA of Bucharest

National Power Grid Company TRANSELECTRICA S.A.

Program

Sunday, June 28

09h00 – 16h00	IEEE R8 Chapter Chairs Meeting**,** Senate Hall, UPB Campus
13h00 – 20h00	Registration and Welcome Reception at Romanian Athenaeum
17h00	Chamber Music by "George Enescu" Philharmonic at Romanian Athenaeum
18h15	Welcome Cocktail, Romanian Athenaeum

Monday, June 29

08h00 – 18h00	Conference Registration, Parliament Palace - C1 Entrance Hall
08h00 – 09h00	Welcome Coffee
09h00 – 12h30	Opening Ceremony, Parliament Palace, “Alexandru Ioan Cuza” Hall

Welcome Address

- *Mircea Eremia*, Conference Chair, University "Politehnica" of Bucharest
- *Wanda Reder*, IEEE-PES President
- *Ecaterina Andronescu*, Minister of Education, Research and Innovation
- *Costas Vournas*, Chair of the PowerTech Steering Committee, National Technical University of Athens
- *Iulian Iancu*, WEC - National Committee, President

Plenary Session

- *Andre Merlin*, CIGRE President and Honorary President of RTE:
  The Strategic Role and Challenges of EHV Power Grid in the New Context of the European Energy Policy
- *Mohammad Shahidehpour*, IEEE-PES Vice-President, Chairman of the Electrical and Computer Engineering Department, Illinois Institute of Technology:
  Smart Grid: A New Paradigm for Power Delivery
- *Peter Kirchesch*, AREVA Vice-President:
  Energy Efficiency in Electrical Networks

12h30 – 14h00	Lunch
14h00 – 15h45	Technical Sessions, Halls NI, NB, HR, CB, CR
15h45 – 16h15	Coffee Break
16h15 – 18h00	Technical Sessions, Halls NI, NB, HR, CB, CR
19h30 – 22h00	Student Meeting, Rectorate Hall of UPB Campus

Tuesday, June 30

08h00 – 18h00	Conference Registration, Parliament Palace - C1 Entrance Hall
08h30 – 10h30	Technical Sessions, Halls NI, NB, HR, CB, CR
10h30 – 11h00	Coffee Break
11h00 – 12h30	Technical Sessions, Halls NI, NB, HR, CB, CR
12h30 – 14h00	Lunch
14h00 – 15h45	Technical Sessions, Halls NI, NB, HR, CB, CR
15h45 – 16h15	Coffee Break
16h15 – 18h00	Technical Sessions, Halls NI, NB, HR, CB, CR
09h00 – 12h30	Poster Session I, Hall CB

Wednesday, July 1

08h00 – 18h00	Conference Registration, Parliament Palace - C1 Entrance Hall
08h30 – 10h30	Technical Sessions, Halls NI, NB, HR, CB, CR
10h30 – 11h00	Coffee Break
11h00 – 12h30	Technical Sessions, Halls NI, NB, HR, CB, CR
12h30 – 14h00	Lunch
14h00 – 15h45	Technical Sessions, Halls NI, NB, HR, CB, CR
15h45 – 16h15	Coffee Break
16h15 – 17h30	Technical Sessions, Halls NI, NB, HR, CB, CR
09h00 – 12h30	Poster Session II, Hall CB
19h00 – 20h00	Transport by bus to Snagov Palace
20h00 – 22h00	Gala Dinner at Snagov Palace
22h00 – 23h00	Return by bus to Bucharest

Thursday, July 2

08h00 – 18h00	Conference Registration, Parliament Palace - C1 Entrance Hall
08h30 – 10h30	Technical Sessions, Halls NI, NB, HR, CB, CR
10h30 – 11h00	Coffee Break
11h00 – 12h30	Technical Sessions, Halls NI, NB, HR, CB, CR
12h30 – 14h00	Lunch
14h00 – 15h45	Technical Sessions, Halls NI, NB, HR, CB, CR
15h45 – 16h15	Coffee Break
16h15 – 18h00	Basil Papadias Award & Closing Ceremony, “C.A. Rosetti” Hall
09h00 – 12h30	Poster Session III, Hall CB

Here is the detailed **Final Technical Program**

Authors of oral presentation papers are required to follow the **Oral Presentation Instructions** while authors of poster papers are required to prepare their poster sheets according to the **Poster Instructions**

If you have problems in displaying the PDF files, please update your **Acrobat Reader**

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Appendix 12

EIGHTH DRAFT - 17 JUNE 2009

San Diego 2009 Symposium on Microgrids

Faculty Club, University of California San Diego

Thursday & Friday, 17 & 18 September, 2009

DAY 1: Morning Sessions	
8:30 – 8:40	Chris Marnay (Berkeley Lab.) The Microgrid Symposium Tradition
8:40 – 8:45	?? (U.C.S.D.) Welcome to U.C. San Diego
Americas Session – chair: Reza Iravani (U. of Toronto)	
8:45 – 9:15	Merrill Smith (U.S. Dept. of Energy) - *no backup* Mike Gravely (California Energy Commission) - *no backup* Lisa Dignard-Bailey (Canada) - *no backup* Overview of Microgrid R&D in the Americas
9:15 – 9:35	Merissa Crow (U. of Missouri) - invited Title TBD – *no backup*
9:35 – 9:55	?? (Canadian SatCon speaker) Title TBD– *no backup*
9:55 – 10:15	Sunil Cherian (Spirae) - invited Title TBD – *no backup*
10:15 – 10:30	questions
Break (in the courtyard)	
Japan Session – chair: ?? (??)	
11:00 – 11:20	Akihiko Yokoyama (U. of Tokyo) Overview of Microgrid R&D in Japan
11:20 – 11:40	?? (Mitsubishi) Hachinohe Microgrid Demonstration – *no backup*
11:40 – 12:00	Hiroshi Asano (CRIEPI) TIPS, Next Generation Grid Technology – *no backup*
12:00 – 12:30	discussion of morning sessions
Lunch (in the courtyard)	

other logos: Solar Turbine, Chevron, Sempra, SCE, etc...

DAY 1: Afternoon Sessions

Singapore-Australia-Korea Session – chair: Hiang Kwee HO (SINERGY Centre)

14:00 – 14:30	Daniel Yap (SINERGY Centre, Singapore) - *no backup* Glenn Platt (CSIRO ICT Centre, Australia) - *no backup* Jaeho Choi (Korea Electrical Industry Tech. Res. Assoc.) - *no backup* Overview of Microgrid R&D in Singapore, Australia, and Korea
14:30 – 14:50	Jaeho Choi (Korea Electrical Industry Tech. Res. Assoc.) (Korea) – *no backup* Title TBD
14:50 – 15:10	Glenn Platt (CSIRO ICT Centre, Australia) – *no backup* Title TBD
15:10 – 15:30	Ashwin Khambadkone (Nat. U. of Singapore) – invited Title TBD – *no backup*
15:30 – 16:00	discussion

Break

Campus Tour and Solar Turbines Cruise

16:00 – 17:00	Tour of U.C.S.D. CHP plant and microgrid project ?? (U.C.S.D. & Solar Turbines)		
17:00 – 17:30	bus ride to Solar Turbine boat	or	reception at Sheraton Hotel
17:30 – 19:30	cruise of San Diego Harbor (limited to ~50 passengers)		
19:30 – 20:00	bus ride back to hotel		

dinner on your own

End of DAY 1

DAY 2: Morning Sessions	
Europe Session – chair: ?? (??)	
9:00 – 9:30	John Baker (IEA Microgrid Annexe) - *no backup* Overview of Microgrid R&D in Europe
9: 30 – 9:50	Phil Taylor (Durham University) - invited Title TBD – *no backup*
9:50 – 10:10	Thomas Ackerman (Energynautics GmbH) – invited Title TBD – *no backup*
10:10 – 10:30	discussion
Break (in the courtyard)	
Remote Applications and Emerging Nations – chair: Giri Venkataramanan (U. of Wisconsin, Madison)	
11:00 – 11:20	Patricio Mendoza-Araya or Rodrigo Palma-Behnke (University of Chile) invited Title TBD – *no backup*
11:20 – 11:40	Chengshan Wang (U. of Tianjin) Title TBD – *no backup*
11:40 – 12:00	discussion
Lunch (in the courtyard)	

DAY 2: U.S. Program Review	
chair : Merrill Smith (U.S. Department of Energy)	
13:00 – 13:15	Terry Mohn - SDG&E Utility Integration of Distributed Generation – *no backup*
13:15 – 13:30	Roger Weir - ATK Space Systems Integrated, Automated Distributed Generation Technologies– *no backup*
13:30 – 13:45	Yahia Baghzouy – University of Nevada, Las Vegas Dramatic Residential Demand Reduction in the Desert Southwest – *no backup*
13:45 – 14:00	Mohammad Shahidehpour – Illinois Institute of Technology Perfect Power Prototype – *no backup*
14:00 – 14:15	Howard Feibus – Consolidated Edison (Innoventive Power) Interoperability of Demand Response Resources – *no backup*
14:15 – 14:30	discussion
Break	
chair : Merrill Smith (U.S. Department of Energy)	
15:00 – 15:15	Hakan Inan – Allegheny Power (SAIC) West Virginia Supercircuit – *no backup*
15:15 – 15:30	Sunil Cherian – City of Fort Collins (Spirae Inc.) Fort Zed – *no backup*
15:30 – 15:45	Bruce Dickinson – Chevron Energy Solutions CERTS Microgrid Demonstration at the Santa Rita Jail – *no backup*
15:55 – 16:00	Terry Surles – University of Hawaii Managing Distribution System Resources – *no backup*
16:00 – 16:30	discussion
End of Special U.S. Session	
Dinner starting at ??:?? where? bar?	

Appendix 13

PROGRAMMA TECNICO

Domenica 27 Settembre 2009

16,00 - 18,00 *Registrazione Partecipanti* (presso sede Rettorato, Piazza Università, 2 Catania)

18,00 Sessione inaugurale - Indirizzi di saluto
Antonino Recca - *Magnifico Rettore Università degli Studi di Catania*, Claudio Scajola – *Ministro dello Sviluppo Economico*, Gianfranco Veglio - *Presidente AEIT,* Franco Bernabé – *Amministratore Delegato Telecom Italia*, Giuseppe Bono - *Amministratore Delegato Fincantieri,* Flavio Cattaneo -*Amministratore Delegato Terna*, Fulvio Conti - *Amministratore Delegato ENEL*, Bruno D'Onghia - *Presidente EDF Italia,* Alessandro Gandelli - *Presidente EUREL,* Alessandro Ortis – *Presidente Autorità per l'energia elettrica e il gas*, Nando Pasquali - *Ammistratore Delegato GSE*, Giorgio Scanavacca - *Presidente IMQ,* Ugo Tramutoli - *Presidente CEI,* Giuliano Zuccoli – *Amministratore Delegato A2A*
19,15 "Il futuro prossimo dell'energia"
Ugo Romano - *ENI Chief Scientific Advisor - Dipartimento Strategie e Sviluppo*
19,45 "Tecnologie di ultima generazione nel processo innovativo"
Aldo Romano - *Presidente e A.D. STMicroelectronics*
20,15 Saluto Autorità Locali

20,30 *Cocktail di benvenuto*

Lunedì 28 Settembre

Presso Facolta'di Ingegneria, Viale Andrea Doria 6, Edificio N° 14
Ore 8,00/13,00 - 15,00/18,00 *Registrazione Partecipanti*

8,30	Aula Magna: ***Apertura lavori*** Roberto Bacci - *Direttore Generale CEI,* Giuseppe Bertolini - *Amministratore Delegato Selta*, Matteo Codazzi - *Amministratore Delegato CESI*, Giuseppe Di Franco - *Amministratore Delegato E-Utile*, Stefano Dionigi - *Respondabile Formazione Gewiss*, Ugo Graziani – *Amministratore Delegato ERSE*, Giovanni Milani - *Amministratore Delegato Enipower*, Stefano Neri – *Presidente Terni Research*, Massimo Orlandi - *Amministratore Delegato Sorgenia*, Salvatore Pinto - *Amministratore Delegato EGL Italia*,Hannes Reuter - *Responsabile del settore Energy Siemens*, Fabio Romeo - *Amministratore Delegato Prysmian*
9,00	*Tavola Rotonda*: "***Electric Networks of the Future***", A cura di: *IEEE-PES* Chairman: C.A. Nucci *Panellists:* *Chen-Ching Liu - National University of Ireland, Dublin* *Mohammad Shahidehpour - Illinois Institute of Technology* *Hans B. (Teddy) Püttgen - Professeur de l'Ecole Polytechnique Fédérale de Lausanne* *Paola Petroni - Enel Infrastrutture e Reti*

10,30 Coffee Break

	Aula Magna	Aula D02	Aula D03
11,00	Sessione 1. *Scenari energetici e prospettive tecniche ed economiche nella produzione elettrica* *Chairman: A. Silvestri Politecnico MI*	Sessione 3.1.a *Criteri metodi e tecnologie per la sicurezza ed efficienza del sistema elettrico* *Chairman: (Prysmian)*	Sessione 3.3.a *La futura distribuzione elettrica: controllo e gestione delle reti attive* *Chairman: D. Lucarella (AEE)*
13,30	Colazione di Lavoro		
15,00	Sessione 2.a *Tecnologie innovative nella generazione elettrica* *Chairman: (Enel Green Power)*	Sessione 3.1.b *Criteri metodi e tecnologie per la sicurezza ed efficienza del sistema elettrico* *Chairman: (Terna)*	Sessione 3.3 *La futura distribuzione elettrica: controllo e gestione delle reti attive* *Chairman: S. Massucco Università di GE*
16,30	Coffee Break		
17,00	Sessione2.b *Tecnologie innovative nella generazione elettrica* *Chairman: R. Napoli Politecnico TO*	Sessione 3.2 a *La Distribuzione elettrica nella transizione verso il futuro* *Chairman: (Enel)*	Sessione 3. 4 *La Power Quality nella distribuzione* *Chairman: A. Testa Università di Napoli 2*

18,30 Chiusura Lavori

Martedì 29 Settembre

8,30	Aula Magna: ***Apertura lavori***
9,00	*Tavola Rotonda*: "***Trasporti a propulsione elettrica: sviluppi e interazioni con il sistema elettrico***" *Panellists*: *Roberto Bacci - CEI* *Michele Elia - RFI* *Piercipriano Rollo - Fincantieri* *Andrea Valcalda - Enel Innovazione e Ambiente*

10,30 Coffee Break

	Aula Magna	Aula D02	Aula D03
11,00	Sessione 2.c *Tecnologie innovative nella generazione elettrica (aspetti tecnico-economici)* *Chairman: (GSE)* Sessione 3.2b *La Distribuzione elettrica nella transizione verso il futuro* *Chairman: (Enel)*	Sessione 4.1.a *Tecnologie per l'efficienza energetica nelle utilizzazioni elettriche* *Chairman: E. Pagano Università di Napoli*	Sessione 5. *Tecnologie per l'efficienza energetica nei trasporti* *Chairman: (Fiat) o (Fincantieri)*

13,30 Colazione di Lavoro

15,00	Sessione 6. *Metrologia nel settore energetico* *Chairman: F. Ferraris Pres. SSD Misure elettriche ed elettroniche*	Sessione 4.1.b *Tecnologie per l'efficienza energetica nelle utilizzazioni elettriche* *Chairman: L. Fellin Università di Padova*	Sessione 7. *Il ruolo delle telecomunicazioni nelle infrastrutture energetiche* *Chairman: R. Saracco Telecom Italia*

16,30 Coffee Break

17,00	Sessione 9. *Diagnostica di Reti, Macchine e componenti*	Sessione 4.2 *Tecnologie per l'efficienza energetica nella generazione distribuita* *Chairman: F. Benzi - Università di Pavia*	Sessione 8. *Micro e nano-tecnologie per l'ingegneria energetica* *Chairman: (STMicroelectronics)*

18,30 Chiusura Lavori

Sessioni di lavoro del CONVEGNO AEIT 2009

Lunedì 28 Settembre

AULA MAGNA

Ore 11,00-13,00
1. Scenari energetici e prospettive tecniche ed economiche nella produzione elettrica
Chairman: A. Silvestri - Politecnico di Milano

Determinazione del mix energetico mediante la teoria dei giochi e gli algoritmi genetici coevolutivi
E.M. Carlini, P.P. Pericolo - Terna, C. Genesi, P. Marannino, M. Montagna, S. Rossi, I. Siviero – Università di Pavia

Scenari di produzione da fonti rinnovabili: quali sono i giusti incentivi per raggiungere gli obiettivi al 2020?
P. Marannino, M. Montagna, C. Genesi, S. Rossi, I. Siviero - Università di Pavia, G. Gentile - Enel Green Power, L. Desiata - Enel

Gli obiettivi e gli strumenti europei di incentivazione economica delle fonti rinnovabili, di contenimento delle emissioni-serra e di incentivo all'efficienza energetica
M. Ballicu, M. Governatori - EGL Italia

European Institute of Innovation and Technology - le iniziative per le energie sostenibili
G. Colombo

A short summary on renewable energy sources
E. Pagano, L. Piegari, P. Tricoli - Università di Napoli Federico II

I meccanismi di promozione per le fonti rinnovabili: analisi di efficacia e valutazione di soluzioni alternative
A. Mattucci, M. Calisi - ENEA

Il futuro dell'energia eolica
P. Caramuscio, G. Potenza - ENEL Politiche di Ricerca e Sviluppo

Patrimonio nucleare in Italia
E. Mainardi - Ansaldo Nucleare

The New Power Plant Projects and Technology Perspectives of Enel
L. Arrighi – Enel Generation, S. Pasini – Enel Engineering & Innovation Division

Ore 15,00-16,30
2.a Tecnologie innovative nella generazione elettrica
Chairman: (Enel Green Power)

Solare termodinamico e fotovoltaico: il futuro dell'energia pulita dal sole
A.P. Bondi - Siemens

Analisi delle potenzialità di un sistema solare termodinamico per la produzione di energia elettrica e termica
M. Dicorato - Politecnico di Bari

Confronto delle prestazioni di differenti sistemi fotovoltaici a concentrazione prototipali in reali condizioni di esercizio
F. Aleo, M.L. Lo Trovato, A. Lotta, G. Gigliucci - Enel Ingegneria e Innovazione

Confronto termico tra differenti tecnologie di pannelli fotovoltaici
R. Faranda, S. Leva - Politecnico di Milano

Sistemi di generazione fotovoltaici: il contributo dell'industria nella progettazione e realizzazione dei componenti elettrici, elettronici e dei sistemi ICT a supporto
D. Bisci, C. Giancaspro – TerniEnergia

Il progetto Archimede: dimostrazione della tecnologia solare termodinamica più efficiente al mondo nella centrale di Priolo Gargallo
D. Consoli, L. Merlo, G. Liberati, G. Gigliucci - Enel Ingegneria e Innovazione

Gli sviluppi tecnologici per la produzione mini-hydro: una nuova turbina per salti bassissimi a basso impatto ambientale
M. Arquilla – Ste Energy

Idrogeno come futuro vettore energetico: possibili scenari di dispiegamento in Italia
A. Mattucci, F. Di Mario, M. Ronchetti - ENEA

Ore 17,00-18,30

2.b Tecnologie innovative nella generazione elettrica
Chairman: R. Napoli - Politecnico di Torino

Studio per l'ottimizzazione di un impianto cogenerativo industriale
G. Passarello, G.M. Tina - Università di Catania

La cattura della CO2: nuovo orizzonte per le celle a combustibile a carbonati fusi
L. Gallo, A. Torazza - Ansaldo Fuel Cells

L'integrazione di cogenerazione e produzione di idrogeno on-site per la realizzazione di un distretto energetico
S. Bruno, S. Lamonaca, M. La Scala, G. Rotondo, U. Stecchi - Politecnico di Bari

Software per la definizione del punto di lavoro ottimo e la valutazione degli investimenti in Distretti Cogenerativi
A. Gelmini, C. Chemelli, M.P.E. Marciandi - ERSE

Centrale di Trigenerazione ad Elevata Efficienza
G. Vergerio - Enipower, D. Barlini – Eniservizi

Trigenerazione: efficienza energetica e riduzione degli impatti ambientali. Ferrari, un caso esemplare
V. De Rul - Fenice

La cogenerazione/trigenerazione come servizio comune integrato nelle smartgrid
G. Parise, L. Martirano, G. Vescio - Università Sapienza di Roma

Il ruolo dell'ambiente nello studio delle applicazioni dei sistemi di cogenerazione
P. Mancarella - Imperial College London, UK, G. Chicco - Politecnico di Torino

Dimensionamento di un banco prova per impianti CHPV a media concentrazione
C. Cinelli, M. De Lucia, P. Giovannetti, C.P. Mengoni, S. Toccafondi - Università di Firenze

AULA D02

Ore 11,00-13,00

3.1 a Criteri metodi e tecnologie per la sicurezza ed efficienza del sistema elettrico
Chairman: (Prysmian)

Deterministic and probabilistic approaches to operational power systems security assessment
C. Battistelli, U. De Martinis - Federico II University of Naples

Una piattaforma integrata per la valutazione della sicurezza dei sistemi elettrici
E. Ciapessoni, D. Cirio, D. Lucarella - ERSE Milano, S. Grillo, S. Massucco, F. Silvestro - Università degli Studi di Genova

Valutazione probabilistica del rischio di esercizio per reti elettriche di trasmissione
E. Ciapessoni, D. Cirio, E. Gaglioti - ERSE Milano, S. Grillo, S. Massucco, A. Pitto - Università degli Studi di Genova

Espansione del sistema di trasmissione
S. Quaia - Università di Trieste

Aspetti di ottimizzazione della gestione e dell'efficienza delle linee elettriche aeree
G. Pirovano, C. Valagussa, P. Omodeo Gianolo, F. Mazzarella, C. Cherbaucich, G. Rizzi - ERSE

Conduttori di Nuova Generazione per Linee AT
M. Pompili - Università di Roma La Sapienza

Conduttori per alto limite termico e con deformazioni ridotte agli alti carichi (low sag) con portanti costituiti da fili compositi ibridi (fibre di carbonio e filati di vetro)
G. Civili, D. Valori - Tratos Cavi

Cavi sottomarini in corrente continua: soluzioni per il mediterraneo
M. Marelli, A. Orini, E. Zaccone - Prysmian PowerLink

Recenti sviluppi della tecnica HVDC
R. Mazzocchi, G. Cordioli - Siemens

Linee elettriche in cavo c.a. e c.c. in infrastrutture ferroviarie/stradali esistenti e future: un utilizzo affidabile delle sinergie
R. Benato, R. Caldon, L. Fellin – Università di Padova, E. Di Bartolomeo – TERNA

Analisi Economica per l'Individuazione degli Ambiti di Convenienza di Linee di Trasmissione Innovative Tetrafase
G. Mazzanti - Università di Bologna, S. Quaia - Università di Trieste

Ore 15,00-16,30

3.1 b Criteri metodi e tecnologie per la sicurezza ed efficienza del sistema elettrico
Chairman: (Terna)

Controllo di Sovraccarichi Termici in Linee Aeree ad Alta Tensione
J.S.A. Carneiro - ERSE, L. Ferrarini - Politecnico di Milano

Incremento di efficienza e sicurezza dei sistemi T&D tramite componenti a superconduttore: limitatori delle correnti di corto-circuito
M. Bocchi, M. Ascade, V. Rossi, L. Martini - ERSE

Limitatori di Corrente Superconduttivi nel sistema elettrico del futuro
A. Morandi - Università di Bologna

Ultra Fast Distance Protection
P. Gaggero - GE

Reducing Conventional Copper Signaling in High Voltage Substations with IEC 61850 Process Bus System
D. McGinn, M. Adiamak, M. Goraj, J. Cardenas - GE

Impatto degli interventi di sviluppo della RTN sulla dispacciabilità della generazione eolica
E.M. Carlini, P.P. Pericolo - Terna, C. Genesi, P. Marannino, M. Montagna, S. Rossi, I. Siviero - Università di Pavia

Impatto dello sviluppo della RTN sull'utilizzo più efficiente del parco produttivo e conseguente riduzione della CO2
E.M. Carlini, P.P. Pericolo, F. Vedovelli - Terna, B. Cova, M. Stabile, A. Venturini - CESI

Shore to ship power connection
C. Kluzer - Siemens

Progetto High Voltage Shore Connection (HVSC) per l'elettrificazione di una banchina del porto di Civitavecchia
A. Frisone, E. D'Ubaldo, I. Agostini - Enel - Divisione Ingegneria e Innovazione

Ore 17,00-18,30
3.2 a La Distribuzione elettrica nella transizione verso il futuro
Chairman: (Enel)

Stazione di alimentazione dei servizi ausiliari di cabine primarie
A. Fatica, R. Calone, G. Di Lembo - Enel Distribuzione

Distribuzione dell'impianto di terra globale come servizio pubblico
G. Parise – Università Sapienza di Roma

Enel Work Force Management System
M. Maffeis - Enel Distribuzione

Apparato per Monitoraggio, Automazione e Controllo di un Nodo di Connessione del Sistema Elettrico di Potenza
S. Conti, N. Messina - Università di Catania, L. Galvagno, P. Grillo, R. Gulino, F. Ridolfo, M. Scalisi - Col Giovanni Paolo Moncalieri

I sistemi DMS per l'incremento delle prestazioni delle reti di distribuzione a media tensione: l'esperienza di Enel Distribuzione Lombardia
A. Birga, S. Danesi, I. Misesti - Enel

Criteri e metodologie di previsione dei carichi sulla rete MT di Enel Distribuzione
F. Cazzato, S. Botton - Enel Distribuzione, A. De Nando - CESI

Un approccio globale alla riduzione delle perdite nelle reti di distribuzione
R. Buda - Enel

Progettazione e realizzazione di una micro-rete sperimentale di distribuzione in corrente continua
L. Martini, C. Tornelli, C. Bossi, M. Verga - ERSE, E. Tironi, G. Superti-Furga, L. Piegari – Politecnico di Milano

Approccio neuro-fuzzy per la classificazione di reti rappresentative del sistema di distribuzione MT italiano
M. Delfanti, M. Merlo, V. Olivieri, M. Pozzi - Politecnico di Milano, M. Gallanti - ERSE

AULA D03

Ore 11,00-13,00
3.3.a La futura Distribuzione elettrica: controllo e gestione delle reti attive
Chairman: D. Lucarella (AEE)

Impatto della generazione diffusa sulle reti di distribuzione
M. Delfanti, D. Falabretti, M. Merlo, A. Silvestri - Politecnico di Milano, M. Gallanti - ERSE

Multiobjective programming to assess the impact of Regulation on the active distribution network development
G. Celli, G.G. Soma, F. Pilo - Università di Cagliari

Smart Grid
M.M. De Nicolo - E-Utile

Smart Grid: l'Evoluzione delle Reti Elettriche e il Ruolo delle Power-Line Communications
S. Bois, P. Bisaglia - DORA, STMicroelectronics Group, R. Cappelletti - STMicroelectronics

Distribution Management System (DMS) per la gestione intelligente di reti elettriche
S. Grillo, S. Massucco, A. Morini, F. Silvestro - Università degli Studi di Genova, S. Scalari - ENEL Ingegneria e Innovazione Pisa, P. Scalera - ABB–Power System Division Genova

Modelli dinamici per la generazione elettrica distribuita da fonte rinnovabile e convenzionale
M. Marinelli, S. Massucco, A. Pitto, F. Silvestro - Università degli Studi di Genova, E. Pasca, G. Petretto - ENEL Ingegneria e Innovazione Pisa

A Simplified Approach to Voltage Sensitivity Analysis in Radial MV Distribution Networks with Constant Current Models for Loads and Generators
S. Conti, S. Raiti, G. Vagliasindi - Università degli Studi di Catania

Un ottimizzatore per la gestione di reti attive di distribuzione
A. Borghetti, M. Bosetti, C.A. Nucci, M. Paolone - Università di Bologna, S. Grillo, S. Massucco, F. Silvestro - Università di Genova, S. Scalari - Enel Ingegneria e Innovazione

Ore 15,00-16,30
3.3. b La futura Distribuzione elettrica : controllo e gestione delle reti attive
Chairman: S. Massucco – Università di Genova

Gestione coordinata di risorse distribuite in reti elettriche MT
L. Carradore, R. Turri - Università di Padova

Decentralized voltage control in Distribution networks: the PV generation opportunity
A. Cagnano, E. De Tuglie, P. Pugliese, F. Torelli - Politecnico di Bari

Integrazione di grandi campi eolici nella rete elettrica
C. Bovo, M. Merlo - Politecnico di Milano

Strategie di controllo di generatori eolici per la regolazione della tensione
V. Calderaro, L. Egiziano – Università del Sannio, A. Piccolo – C.U.G.RI.

Regolazione delle Reti Attive di Distribuzione mediante Approccio Spot Price
F. Bignucolo, R. Caldon, A. Sacco - Università di Padova

Ottimizzazione tecnico-economica di risorse distribuite: prove su microrete sperimentale
D. Moneta, M. Marciandi, P. Mora - ERSE

EMS decentralizzato per la gestione negoziata tra distributore e clienti domestici dell'energia elettrica
G. D'Antona, R. Faranda - Politecnico di Milano, M. Signa - Whirpool Corporation, S. Zanini - A2A

Il microsistema elettroenergetico
G. Parise, L. Martirano, P. Di Laura Frattura, F. Massarella - Università Sapienza di Roma

Ore 17,00-18,30
3.4 La Power Quality nella Distribuzione
Chairman: A. Testa – Seconda Università di Napoli

Riduzione della durata delle interruzioni tramite l'impiego di telecontrollo per la rete bassa tensione. Primi risultati di una sperimentazione di Enel Distribuzione
M. Dota, L. Giansante - Enel Distribuzione

Campagna di monitoraggio della qualità della tensione sulla rete MT di Enel Distribuzione
G. Valtorta, S. Sartore, L. D'Orazio - Enel Distribuzione, E. De Berardinis - CESI

Premium Power Park: evoluzione di una soluzione per il miglioramento della Qualità del servizio
R. Chiumeo, C. Gandolfi, C. Pincella - ERSE, S. Quaia - Università di Trieste

Filtro Attivo con Supercapacitori per il Miglioramento della Power Quality nelle Reti di Distribuzione in BT
E. Micolano - ERSE, V. Musolino - Politecnico di Milano, M. Preziani – Elettronica Preziani

Posizionamento degli interrutori MT lungo linea e miglioramento della qualità del servizio
Calone, D'Orazio, Salusest, Valtorta - Enel Distribuzione

Stima delle sorgenti armoniche nei sistemi elettrici di distribuzione
G. D'Antona - Politecnico di Milano, C. Muscas, S. Sulis - Università di Cagliari

Impiego di tecnologie innovative per il miglioramento della Power Quality nelle reti di distribuzione
R. Chiumeo, C. Gandolfi - ERSE, R. Faranda - Politenico di Milano

Martedì 29 Settembre

AULA MAGNA

Ore 11,00-13,00
2.c Tecnologie innovative nella generazione elettrica (aspetti tecnico-economici)
Chairman: (GSE)

Analisi tecnico-economica di impianti fotovoltaici ad inseguimento
S. Gagliano, S. Sardella, G. Tina - Università di Catania

Generatori fotovoltaici dinamici: aspetti tecnici e valutazioni economiche per il loro impiego
V. Di Dio, C. Rando, G. Zizzo - Università degli Studi di Palermo

Problematiche di sviluppo, installazione ed esercizio di impianti da fonti rinnovabili
P. Lionetto, L. Maculan, M. Bosatra - Foster Wheeler Italiana - Corsico

Applicazione al mercato elettrico di modelli SFE mediante GA
A.M.A.K. Abeygunawardana, C. Bovo, A. Berizzi - Politecnico di Milano

Aspetti tecnici ed economici nella progettazione di un impianto elettrico di una wind farm
G. Di Tuoro - Siemens

Generatori fotovoltaici dinamici: aspetti tecnici e valutazioni economiche per il loro impiego
V. Di Dio, C. Rando, G. Zizzo - Università degli Studi di Palermo

Ore 13,00-13,30
3.2 b La Distribuzione elettrica nella transizione verso il futuro (Continuazione)
Chairman: (Enel)

Connessione della generazione distribuita alla rete di Enel Distribuzione nel periodo di transizione dalla rete passiva alle SmartGrid
F. Cazzato, S. Botton - Enel Distribuzione

Automazione di rete per contrastare l'invecchiamento del sistema di distribuzione?
E. Ghiani, S. Mocci, F. Pilo - Università di Cagliari

Studio sperimentale di un impianto fotovoltaico con batterie connesso alla rete
F. Pappalardo, G.M. Tina - Università di Catania

Ore 15,00-16,30
6. Metrologia nel settore energetico
Chairman: F. Ferraris (Pres. SSD Misure elettriche ed elettroniche)

Terminologia e metrologia
R. Buccianti - CEI, M. Cibien - UNI, L. Mari - Università Cattaneo, B.I. Rebaglia - ITIA - CNR

Grid-Connected Photovoltaic Systems: Energy Account Problems
R. Carbone - University "Mediterranea" of Reggio Calabria, R. Langella, A. Testa - Second University of Naples

La verifica dei contatori statici di energia reattiva in presenza di armoniche. Problematiche di misura e possibili soluzioni
A. Cataliotti, V. Cosentino, A. Lipari, S. Nuccio - Università di Palermo

Misure di energia e di qualità del servizio in alta tensione: i trasformatori di misura
C. Cherbaucich, P. Mazza, G. Rizzi - ERSE

Smart Metering
M.M. De Nicolo - E-Utile

Smart meters interfacing the domestic home
F. Benzi - Università di Pavia

Sistemi multimetering di seconda generazione a supporto delle reti elettriche intelligenti
G. Mauri, D. Moneta, P. Gramatica, G. Colombo - ERSE

Ottimizzazione energetica di reti di sensori cluster-based mediante algoritmi evolutivi
A. Gandelli, F. Grimaccia, R.E. Zich - Politecnico di Milano

Derivazione dei parametri di una cella o un pannello fotovoltaico da misure di corrente-voltaggio sotto diretta illuminazione solare
C. Chibbaro - Università di Catania

Il contatore di energia elettrica e il processo di telelettura/telegestione - Misure di protezione da potenziali influenze e alterazioni accidentali o intenzionali sulle caratteristiche metrologiche e sui dati di misura
V. La Fragola, S. Saracino - IMQ

Ore 17,00-18,30
9. Diagnostica di reti, macchine e componenti
Chairman:

Hybrid Wind-Diesel Stand-Alone System Sizing Accounting for the Expected Life of Batteries and Diesel Generators
V. Carpentiero, A. Carpinone, R. Langella, A. Testa - Seconda Università degli Studi di Napoli

Metodi diagnostici avanzati per la valutazione delle condizioni di vita di trasformatori e di cavi di media tensione
J. Borghetto, C. Cherbaucich, S. Meregalli, R. Passaglia, G. Rizzi - ERSE, A. Contin - Università di Trieste

Misure di Scariche Parziali e Prove di Invecchiamento Elettrico in Presenza di Forme d'Onda Pulsate
F. Guastavino, G. Coletti, A. Dardano, A. Ratto, S. Squarcia, E. Torello - Università degli Studi di Genova

Misure e prove elettriche in campo per garantire di ottimizzare gli investimenti in macchinario: il caso della diagnostica sui trasformatori
R. Brusetti - Doble Engineering

Modellistica di generatori sincroni per l'analisi di guasti interni
F. Delfino, G.B. Denegri, M. Invernizzi, F. Pampararo, R. Procopio - Università di Genova

Approccio allo Sviluppo di Sistemi Diagnostici per il Funzionamento Fault Tolerant delle Micro-grid
A.O. Di Tommaso, S. Favuzza, F. Genduso, R. Miceli, G. Ricco Galluzzo - Università di Palermo

Sviluppo di sensoristica innovativa basata su sistemi elettro-ottici per la diagnostica di componenti e macchine
U. Perini, C. Cherbaucich, L. De Maria, I. Gianinoni, E. Golinelli, S. Musazzi, G. Rizzi - ERSE

Application of digital portable ultrasound technology as a diagnostic tool in electrical systems
M. Logrippo - Sielte

Metodi di Calcolo del Campo Magnetico Generato da Cavi Elicordati per la Distribuzione dell'Energia Elettrica
G. Mazzanti - Università di Bologna

AULA D02

Ore 11,00-13,00
4.1.a Tecnologie per l'efficienza energetica nelle utilizzazioni
Chairman: E. Pagano – Università di Napoli Federico II

Il punto sull'attività normativa internazionale e nazionale in materia di efficienza energetica
F. Bua - ECD Engineering Consulting and Design

Applicazione di cicli ORC a recuperi termici da processi industriali
N. Palestra, E. Morandi - E.ON Energia, R. Vescovo - Turboden

Miglioramento del rendimento e oscillazioni del nodo di fase dei buck converter sincroni
S. D'Urso - Università degli Studi di Catania, F. Fusillo, F. Scrimizzi - STMicroelectronics

Diodi al Carburo di Silicio ed IGBT Trench-Gate in una Applicazione per Azionamento Motore Asincrono: Caratterizzazione e Confronto con Dispositivi Tradizionali
G. Sorrentino, M. Melito - STMicroelectronics, F. Portoghese, S. Musumeci, A. Raciti - Università di Catania

Dispositivi di potenza innovativi in convertitori DC-DC per la produzione di energia da campi fotovoltaici
A. Raciti, S. Musumeci, S. Tomarchio - Università di Catania, R. Scollo, S. Buonomo, L. Abbatelli - STMicroelectronics

L'unificazione europea verso la riduzione delle perdite nei trasformatori di distribuzione: La Norma EN 50464-1
A. Baggini - Università degli Studi di Bergamo, F. Bua - Dalmine Italia Pavia

Un sistema UPS intelligente da fonte solare fotovoltaica
C. Cavallaro, S. Musumeci, C. Santonocito, M. Pappalardo - Università di Catania

Un dispositivo di risparmio energetico applicabile ai frigoriferi domestici esistenti
P. Pelacchi - Università di Pisa, P. Pogliano - Sorgenia

Circuiti di Pilotaggio ad Alto Rendimento per Lampade a LED
L. Ribellino, K. Blaha, J. Milsimer, S. Pioppo - STMicroelectronics

Building automation e risparmio energetico negli edifici della pubblica amministrazione
L. Martirano, F. Massarella - Università Sapienza di Roma

Ore 15,00-16,30

4.1.b Tecnologie per l'efficienza energetica nelle utilizzazioni

Chairman: L. Fellin – Università di Padova

Risparmio energetico e qualità della luce: sorgenti luminose a confronto
A. Bovo, F. Giorgi - IMQ

Sistemi per il Monitoraggio e il Controllo Remoto di un Impianto di Pubblica Illuminazione tramite Tecnologia ZigBee®
S. Conti, A.E. Greco, N. Messina - Università di Catania, C. Oriti - Controlli Ambientali

Attuali campi di applicazione, nel settore dell'illuminazione, nei quali l'utilizzo dei LED risulta vantaggioso
R. Faranda, S. Guzzetti, S. Leva - Politecnico di Milano

Illuminazione a risparmio energetico
C. La Mura - Osram

Tecnologie domotiche per la pubblica amministrazione: l'edificio della Regione Molise
L. Martirano, F. Massarella - Università Sapienza di Roma

Il contributo della domotica e della building automation per il risparmio energetico
N. Perico - Gewiss

Il Laboratorio per lo Sviluppo Sostenibile e il Risparmio Energetico (SDESLab) nell'ambito industriale siciliano
R. Miceli, D. La Cascia, C. Rando, R. Liga, A.O. Di Tommaso, F. Genduso, V. Di Dio, G. Ricco Galluzzo, V. Cecconi - Università degli Studi di Palermo

Edifici Eco Passivi Intelligenti "Progetto Botticelli"
C. Sapienza - Casa Eco-Passiva Sicilia

Comportamento al sisma degli ospedali: funzionalità ed affidabilità degli impianti tecnologici
G. Parise, L. Martirano - Università degli Studi "La Sapienza" Roma

La realizzazione degli impianti elettrici e le norme di buona tecnica
G. Gambino - St. Ass. Gambino G. Zanotti M.

Ore 17,00-18,30

4.2 Tecnologie per l'efficienza energetica nelle generazioni

Chairman: F. Benzi - Università di Pavia

Convertitori per bassissima tensione per singole celle a combustibile
S. Di Mauro, S. Musumeci, A. Raciti, F. Pinieri - Università di Catania

Convertitori DC/AC per Pannello Fotovoltaico
M. Cacciato, A. Consoli, V. Crisafulli – Università di Catania

Convertitore con controllo MPPT per Pannelli Fotovoltaici
F. Pulvirenti - STMicroelectronics

Circuito di Bypass a Bassa Dissipazione per Pannelli Fotovoltaici
F. Pulvirenti, A. La Scala - STMicroelectronics, S. Pennisi - Università di Catania

Feedback Linearization Control Technique for the Use of PV Units as Reactive Power Providers
F. Delfino, G.B. Denegri, M. Invernizzi, R. Procopio - Università di Genova

Tecnica PWM a Basse Perdite per Sistemi di Generazione Monofase Connessi alla Rete
M. Cacciato, A. Consoli, V. Crisafulli, G. Frascadore – Università degli studi di Catania

AULA D03

Ore 11,00-13,00
5. Tecnologie per l'efficienza energetica nei trasporti
Chairman: (FIAT) o (Fincantieri)

Risparmio Energetico e Contenimento delle Emissioni in un Sistema di Trasporto Urbano Integrato
M. Brenna – Politecnico di Milano, M.C. Falvo - Università di Roma Sapienza, F. Foiadelli – Politecnico di Milano, D. Poli - Università di Pisa

Affidabilità di Componenti Microelettronici di Potenza Sottoposti a Stress di Cortocircuito in Applicazioni Automobilistiche
G. Zuccarello, A. Raciti - Università degli Studi di Catania, D. Patti, R. Crisafulli - STMicroelectronics

Gestione dell'energia di bordo ad alta efficienza per catamarano ibrido
R. Brancati, S. Bolognani, L. Sgarbossa – Università di Padova

Convergence of Renewable Energy and Electrical Car
P. Perlo - Centro Ricerche Fiat

All electric ships: present and future after 20 years of research and technical achievements
G. Sulligoi – Università di Trieste

Accumulo di Energia Magnetica mediante Superconduttore (SMES) a bordo di Veicoli Ibridi alimentati con Combustibile Liquido a Bassa Temperatura
A. Morandi, L. Trevisani, F. Negrini, P.L. Ribani, M. Fabbri - Università di Bologna

Ore 15,00-16,30
7. Il ruolo delle Telecomunicazioni per le infrastrutture energetiche
Chairman: R. Saracco - Telecom Italia

Efficienza energetica nelle reti TLC ed ICT
F. Cucchietti, C. Bianco - Telecom Italia

Energia: problemi ed opportunità per reti e servizi TLC
F. Cucchietti, C. Bianco - Telecom Italia

ICT, the Economy and the Environment
P. Ghiggino – Ericsson

Il ruolo delle Telecomunicazioni nel progetto di sistemi sostenibili
A. Magaldi - Schneider Electric

"COEPHONE" Un sistema Smart Phone per i centri di controllo
L. Ottaiano, G. Fiorenza - Enel Distribuzione

Il sistema di acquisizione delle segnalazioni di guasto in Enel
L. Ottaiano, R. Casavecchia - Enel Distribuzione

Esperienze di impiego del protocollo IEC 61850 per applicazioni di Generazione Distribuita
G. Proserpio, C. Tornelli, L. Capetta - ERSE

Comparazione di Soluzioni di Rete di Telecomunicazioni per la Riduzione Combinata del CAPEX e del Consumo Energetico
R. Gemelli, A. Paparella, G. Bellotti - Alcatel-Lucent Italia

Sistema di comunicazione su GD: protetto Milano Wi-Power
M. Merlo - Politecnico di Milano

Nuove tecnologie di comunicazione nei "Sistemi di Automazione delle Sottostazioni Elettriche" Aspetti di ridondanza e sincronizzazione
M. Quarantelli, A. Pasino - Selta

Una nuova e versatile generazione di RTU per il telecontrollo nella produzione rinnovabile distribuita
E. Colaiacovo - Itaco Systems

Ore 17,00-18,30
8. Micro e nano-tecnologie per l'ingegneria energetica
Chairman: (STMicroelectronics)

Una Via Elettrochimica per la Fabbricazione di Celle Solari a Semiconduttori Nanostrutturati
R. Inguanta, S. Piazza, C. Sunseri, A. Cino, V. Di Dio, D. La Cascia, R. Miceli, C. Rando, G. Zizzo - Università di Palermo

Crescita della arborescenza elettrica in materiali nanocompositi EVA-fillosilicato
F. Guastavino, A. Dardano, E. Torello, A. Ratto, S. Squarcia, G. Coletti - Università degli Studi di Genova

Impiego della tecnologia PCB (Printed Circuit Board) per la realizzazione di Fuel Cells miniaturizzate alimentate ad idrogeno
C. Dall'Oglio, A. Lazzara, S. Leonardi, G.E. Spoto - STMicroelecttronics

Sensore di luce ambientale per il risparmio energetico in dispositivi portatili
S. Leonardi, S. Abbisso, M.E. Castagna, A. Muscarà, G. Catania, L. Maddonia - STMicroelectronics

HAN per Energy Management: un'implementazione in scenari reali
A. Cucuccio, N. Dipaola, M. Panzica - STMicroelectronics