UILU-ENG-2009-2501

THIRTIETH ANNUAL REPORT OF THE POWER AFFILIATES PROGRAM

University of Illinois at Urbana-Champaign
Department of Electrical and Computer Engineering
1406 W. Green St.
Urbana, IL 61801

PAP-TR 09-1

May 2009

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FOREWORD

This report provides a summary of the activities of the Power Affiliates Program (PAP) in the Department of Electrical and Computer engineering at the University of Illinois at Urbana-Champaign for the calendar year 2008. The information is intended to be a progress report to the affiliate companies listed below. The PAP is the foundation of the industrial liaison effort in the power and energy systems area. The active affiliates associated with the PAP are:

Advanced Analogic Technologies, Inc.
Ameren
Bitrode Corporation
BP America
City Water, Light & Power, Springfield, IL
Electrical Manufacturing & Coil Winding Association, Inc.
Exelon
MidAmerican Energy Company
Patrick Engineering
PowerWorld Corporation
S&C Electric Company
Sargent & Lundy Engineers

2008 was an active year for the PAP and the highlights are covered in this report. We acknowledge the valuable interaction of the Affiliates and are most thankful to these companies for their continued support.

Pete Sauer, Director
Patrick Chapman
Kevin Colravy
Alejandro Domínguez-García
George Gross
Phil Krein
Tom Overbye
M. A. Pai

1. INTRODUCTION AND SUMMARY

The Power Affiliates Program (PAP) was initiated in January 1979 as part of a major effort to strengthen the power and energy systems area. The original objectives were to:

- Maintain stimulating, meaningful and high quality undergraduate and graduate programs in electric power engineering.
- Increase university-industrial interaction at all levels of education and research in electric power engineering.

These objectives are as much valid today as they were in 1979. The multi-faceted activities in 2008 under the PAP umbrella clearly were in support of these objectives.

Throughout the past thirty years, the Power Affiliates Program has maintained a stable financial base during times of rapid change in the power industry. This base provided the seed money for research, which led to additional funding by other sources. This base has also made it possible for students to be exposed to industrial problems and to participate in technical and professional meetings. With the cyclical nature of funding by government agencies, the Power Affiliates Program is a critically important source of support.

This annual report is organized as follows. The financial statement for the 2008 calendar year is given in Section 2. Section 3 describes how the power program fits into the departmental structure. There is no official degree or option associated with the Power Program, but there is a significant level of specialization which is possible in this area through a set of courses developed and offered by the group of faculty who constitute the Power and Energy Systems Area. Section 4 gives a brief description of the courses for specializing in electric power and tabulates the enrollment figures for the most recent offerings. Included in this section is a historical record of the number of graduates who have taken three or more of these courses. Section 5 lists the activities of both the students and the faculty members during the 2008 calendar year. Section 6 gives information about the graduate students in the power area. In addition to personal data and interests, each student has written a brief abstract of his or her research work. Laboratories and other facilities of the power area are discussed in Section 7. The report concludes with a directory in Section 8 and the list of 2008 publications is given in Section 9.

2. FINANCIAL STATEMENT

The following tabulation of income and expenditures for the calendar year 2008 was prepared from a detailed University statement as of December 31, 2008.

Income carried over from the calendar year 2007	$ 16,764
Total income during calendar year 2008 *	66,844
Total available income during calendar year 2008	$83,608

Expenditure	**Expenditure Amount**
Personnel and Services	$37,301
Materials/Supplies/Equipment	7,002
Transportation/Travel	6,565
Total expenditures	$50,868

Summary

Amount of funds available during calendar year 2008	$83,608
Amount of expenses during calendar year 2008	50,868
Balance as of December 31, 2008	$32,740

* This does not include funds that were received in 2008, but not posted on the university accounting system until 2009.

3. THE POWER PROGRAM WITHIN THE DEPARTMENT

Electrical engineering undergraduate students are required to complete 128 hours of course work for a B.S.E.E. degree. Detailed descriptions of the undergraduate program and suggested curriculum in Power are given in [1]. All M.S.E.E. students are required to complete a minimum of 32 credit hours (old system was 8 units) including a graduate thesis. All Ph.D. students must qualify through a written examination and complete course and thesis requirements. A detailed description of the graduate program is given in [2].

The Electrical and Computer Engineering Department is subdivided into seven distinct technical areas as follows:

Bioengineering, Acoustics and Magnetic Res. Engineering
Circuits and Signal Processing
Communications and Control
Computer Engineering
Electromagnetics, Optics and Remote Sensing
Microelectronics and Quantum Electronics
Power and Energy Systems

While the Department does not have official degree-granting options in each of these areas, in practice, the seven areas serve as the appropriate grouping of the faculty activities and interest. In terms of size, the Power and Energy Systems area represents about 7% of the total active faculty and about 10% of the total student enrollment. The faculty committee in each area has the responsibility for administering courses and research in that area within the Department.

The Power and Energy Systems Area Committee and associated faculty for the 2008 - 2009 academic year together with their fields of interest are:

P. Chapman	(machines, power electronics, circuits)
A. Domínguez-García	(reliability theory and analysis)
G. Gross	(power system economics, planning and operations; reliability; electric regulatory policy; industry restructuring; market design)
P. T. Krein	(power electronics, machines, electrostatics)
T. J. Overbye	(operations, visualization and restructuring of power systems)
M. A. Pai	(dynamics, stability and computational methods in power systems)
P. W. Sauer	(modeling and simulation of machines and power systems)

Two of the primary responsibilities of the Power and Energy Systems Area Committee are to improve, keep current and staff the courses assigned to the Power and Energy Systems Area. In 2008-2009 those courses were

ECE 307	Techniques for Engineering Decisions
ECE 398RES	Renewable Energy Systems
ECE 430	Power Circuits and Electromechanics
ECE 431	Electric Machinery
ECE 432	Advanced Electric Machinery
ECE 464	Power Electronics
ECE 469	Power Electronics Laboratory
ECE 476	Power System Analysis
ECE 477	Power System Operation & Control
ENG 491FEC	Future Energy Challenge
ECE 530	Analysis Techniques for Large-Scale Electrical Systems
ECE 568	Modeling and Control of Electromechanical Systems
ECE 573	Power Systems Control
ECE 576	Power System Dynamics and Stability
ECE 588	Electricity Resource Planning
ECE 590I	Seminar in Special Topics: Power Systems
ECE 598PE	Power Electronic Drives and Systems
ECE 598PH	Hybrid Systems Analysis of Power System Dynamics
ECE 598TO	Issues in Competitive Electricity Markets
ECE 598PLC	Advanced Topics in Power Electronics

The four-hundred level courses are advanced undergraduate or beginning graduate courses, while the five hundred level courses are graduate. The Power and Energy Systems Area Committee periodically evaluates each course outline for possible revision for future offerings. A brief description of each of these courses, together with the enrollment of the past year, is included in the next section. In addition, the Power Faculty supervises numerous student projects performed in ECE 445. This is the capstone design course for our seniors.

4. COURSES AND ENROLLMENT

As one of seven major areas in Electrical and Computer Engineering, the Power and Energy Systems Area is responsible for the development and offering of a considerable number of courses. The current courses assigned to the power area are described briefly below. The total enrollment for courses offered in the academic year 2008-2009 is also given for each course.

ECE 307 Techniques for Engineering Decisions

This course is concerned with modeling of decisions and analysis of models to develop a systematic approach to making decisions. The focus is on the development of techniques for solving typical problems faced in making engineering decisions in industry and government. Topics include resource allocation, logistics, scheduling, sequential decision-making and explicit consideration of uncertainty in decisions. Extensive use of case studies gets students involved in real world decisions. The course has two required texts: Operations Research: Principles and Practice, A. Ravindran, D. T. Phillips and S. S. Solberg and Making Hard Decisions: An Introduction to Decision Analysis, R. T. Clemen. The total enrollment for the academic year 2008-2009 was 6.

ECE 398RES Renewable Energy Systems

A new course on the challenges of meeting the future energy needs using renewable resources taught by Prof. T. Overbye. A three-hour technical elective for engineering undergraduate students with a background in electric circuits at an introductory level. The course explores the technical, economic, environmental and policy aspects of renewable and alternative energy systems to provide a comprehensive picture of their role in meeting society's electricity needs. The upsurge in the world-wide demand for oil-based resources, the restructuring of the electricity industry, the advances in engineering technology and the increasing interest in environmental protection are presenting unparalleled challenges to the electric power industry. The role of new energy resource technologies, the application of power electronics, the use of demand-side management, and the effects of market forces in addressing these challenges are discussed. The course covers the basics of energy production from renewable sources, the relevant thermodynamics background, the structure and nature of the interconnected electric power system and the critical need for environmentally sensitive solutions. In addition, the economic and regulatory policy aspects of electricity and electricity markets are treated. The total enrollment for the academic year 2008-2009 was 59.

ECE 430 Power Circuits and Electromechanics

ECE 430 is a course in power circuits and electromechanics. It is a new course after the restructuring of the undergraduate curriculum. The course starts with a review of phasors followed by three phase power circuits, mutual inductance, magnetic circuits and transformers. Electromechanical systems are analyzed using energy balance concepts. Introduction to synchronous, induction, dc and small machines is given. The required text was Power Circuits and Electromechanics by M.A. Pai. The total enrollment for the academic year 2008-2009 was 160.

ECE 431 Electric Machinery

This four-hour course contains a laboratory one credit hour component, which is an elective in a list of 14 from which students select two. The fifteen experiments typically include power measurement, power factor correction, transformer characteristics, three-phase transformer connections, induction motor tests, induction motor torque-speed characteristics, synchronous machine tests, synchronous machine power characteristics, digital simulation of machine dynamics, motor control, and a written plus oral project presentation on power and energy system topics. The required text was Electric Machinery, by Fitzgerald, Kingsley, and Umans. The total enrollment for the academic year 2008-2009 was 57.

ECE 432 Advanced Electric Machinery

This three-hour course contains advanced theory and analysis of rotating and linear machines and drives. It includes power electronic drives for dc and ac motors. The analysis uses d-q transformations and related techniques. Emphasis is placed on the time scale modeling of electromechanical devices and on their function in drives. The required text was Analysis of Electric Machinery and Drive Systems, by P.C. Krause, O. Wasynczuk and S.D. Sudhoff, IEEE Press. This class was not offered in the 2008-2009 academic year.

ECE 464 Power Electronics

This three-hour course is a comprehensive treatment of switching power conversion systems and the devices used to build them. Concepts of switch control are developed from general switching functions. Phase control, pulse width modulation, and phase modulation are studied for applications in all types of converters. Converter topologies are introduced along with design concepts for power filters and interfaces. Devices such as diodes, thyristors, bipolar transistors, field effect transistors, capacitors, and magnetic components are examined in the context of high-power switching applications. The required text was Elements of Power Electronics by P. T. Krein. The total enrollment for the academic year 2008-2008 was 36.

ECE 469 Power Electronics Laboratory

This two-hour course is a laboratory study of circuits and devices used for switching power converters, solid-state motor drives, and power controllers, including dc-dc, ac-dc, and dc-ac converters and applications. It includes high-power measurements for silicon-controlled rectifiers, diodes, capacitors, power transistors and magnetic components. The course is designed to accompany ECE 364. A lab manual by P. Krein is used for the course. The total enrollment for the academic year 2008-2009 was 22.

ECE 476 Power System Analysis

This three-hour course is the first of two courses on power system analysis. Topics included are transmission line parameter calculations, equivalent circuits, network analysis, load flow, fault analysis, symmetrical components, unsymmetrical fault analysis, and introduction to economic dispatch. The course is designed to be a stand-alone introduction to the fundamentals of power system analysis and provide the basis for all subsequent courses in the power system analysis. The required text was <u>Power System Analysis & Design</u>, by Glover and Sarma. The total enrollment for the academic year 2008-2009 was 50.

ECE 477 Power System Operation & Control

This three-hour course is the second of two courses on power system analysis. Topics included are economic operation of power systems, optimal load flow concepts, automatic generation control, state estimation, classical transient stability, modeling for dynamic and transient stability, and d-c transmission. The recommended text is <u>Power Generation, Operation and Control</u>, 2nd edition, by Wood and Wollenberg. This class was not offered in the 2008-2009 academic year.

ENG 491FEC Future Energy Challenge

This three-hour course is a special topics course focusing on the Future Energy Challenge (FEC) student team competition. This competition is an international event sponsored by IEEE, the U.S. Department of Energy, the U.S. Department of Defense, and other sponsors. Schools compete in two topic areas: a fuel-cell power processing topic and a motor system topic. Illinois is one of just 7 schools selected, based on our proposal, to be part of the motor topic competition. The final events are in May after graduation. This class was offered as a General Engineering course for the 2008-2009 academic year.

Graduate Courses:

ECE 530 Analysis Techniques for Large-Scale Electrical Systems

This is a newly developed graduate course in the modeling of power systems in the steady state and dynamic regimes. It includes the analysis and simulation techniques for power and power electronic systems as well as computational issues in power systems and power electronics. Topics covered are: advanced power flow, sparsity techniques, power flow control, least squares and estimation applications averaging techniques for power electronic systems, numerical integration of differential equations and Krylov subspace applications. The course uses the notes of George Gross in lieu of a text. The total enrollment for the academic year 2008-2009 was 7.

ECE 568 Advanced Modeling and Control of Electromechanical Systems

This course addresses issues of electrical drives in a modern control and circuit framework. Dynamic models of electric machines are presented. There is special emphasis on field-oriented control methods for ac motors. Power electronic systems for high-performance drives are studied. Nonlinear system methods such as periodic transformations, averaging, geometric control, and feedback linearization are presented. Special topics covered include electrostatic micromachines and permanent magnet machines. The required text was Analysis of Electric Machines, 2nd edition by P. Krause, O. Wasynczuk and S. Sudhoff the recommended text was Control of Electrical Drives, 2nd edition by W. Leonard and. The total enrollment for the academic year 2008-2009 was 10.

ECE 573 Power Systems Control

The course provides an overview of power system operations and control with major emphasis on security and economics. The role of the EMS (energy management system) and the principal EMS functions are discussed in depth. The major topics include: optimal power flows; economic dispatch problems; role of reactive power; resource scheduling and commitment; state estimation; observability; bad data identification/detection, analysis and processing; electricity restructuring; competitive electricity markets; market design; congestion management; and, ancillary services. The two suggested texts are Power Generation, Operation and Control, 2nd edition by Wood and Wollenberg, and State Estimation in Electric Power Systems: A Generalized Approach by A. Monticelli, Kluwer Academic Publishers, Boston, 1999. This class was not offered in the 2008-2009 academic year.

ECE 576 Power Systems Dynamics and Stability

The course includes the dynamic representation of interconnected power systems - electrical plus mechanical, linearized dynamic models of multimachine systems, methods of coherency identification, order reduction by singular perturbation, time scale decomposition and aggregation techniques, dynamic equivalents, direct methods of stability analysis and power system stabilizer design. The required text was Power Systems Dynamics and Stability by P. W. Sauer and M. A. Pai. The total enrollment for the academic year 2008-2009 was 10.

ECE 588 Electricity Resource Planning

This course provides coverage of the basic techniques in electricity resource planning including methodologies for reliability evaluation and assessment, production costing, marginal costing, supply-side and demand-side planning and integrated resource planning. Throughout the course, probabilistic approaches are emphasized. In place of a text, notes specifically prepared by George Gross are used. The total enrollment for the academic year 2008-2009 was 13.

ECE 590I Seminar in Special Topics: Power Systems

This course is a graduate seminar on advanced topics of current interest. Both faculty and students participate by presenting either current research results or topics of interest in journal publications. Guest speakers from industry and other universities are also scheduled periodically throughout the semester. Approximately 63 students participated in this course for both semesters.

ECE 598PE Power Electronic Devices and Systems

This advanced course in power electronics considers the unique devices and models used for switching energy conversion systems. Emerging nonlinear approaches to operation and control are discussed. Design issues for fast dynamic converters are presented. The goal of the course is to provide students with a rich background in the broad issues of high-performance power electronics at the graduate level. Specific topics include magnetic device design, power semiconductor device models, interfaces and gate drives, small-signal and large-signal converter control models. Averaging methods are presented for power converters. Concepts and methods of geometric control are addressed. The required text is Elements of Power Electronics by P.T. Krein. This class was not offered in the 2008-2009 academic year.

ECE 598PH Hybrid Systems Analysis of Power System Dynamics

The purpose of the course is to present a new approach to the analysis of large scale complex networks, such as power systems, by viewing them as interconnections of dynamic devices, discrete devices and algebraic constraints. Such hybrid systems can display very interesting forms of behavior. Trajectory sensitivity analysis used as a tool for security monitoring, stability analysis and model verification. Aspects of hybrid system control are presented. This class was not offered in the 2008-2009 academic year.

ECE 598TO Issues in Competitive Electricity Markets

This course provides an introduction to competitive electricity markets. The course covers topics including market structures and paradigms, transmission services, transmission congestion management, allocation of real power losses, optimal bidding strategies, and market power analysis. This class was not offered in the 2008-2009 academic year.

ECE 598PLC Advanced Topics in Power Electronics

This course extends the topics of the undergraduate power electronics course. The goal is provide the students with a theoretical basis for advanced research in power electronics. Device and converter modeling are studied in detail. Analog and digital pulse width modulation methods are explored. Averaging and nonlinear control theory relevant to power electronics is studied. The course includes a large-team design project that requires the students to draw from current literature. This class was not offered in the 2008-2009 academic year.

NUMBER OF ELECTRIC POWER AND ENERGY SYSTEM AREA GRADUATES IN RECENT YEARS

Annual Average Power Area Graduates

1950-1970

B.S.E.E.	-	25
M.S.E.E.	-	3

1970-1980

B.S.E.E.	-	44
M.S.E.E.	-	7

1980-1990

B.S.E.E.	-	32
M.S.E.E.	-	5
Ph.D.		2

1990-1995

B.S.E.E.	-	40
M.S.E.E.	-	6
Ph.D.	-	2

1995-2000

B.S.E.E.	-	35
M.S.E.E.	-	9
Ph.D.		3

2000-2005

B.S.E.E.	-	40
M.S.E.E.	-	8
Ph.D.	-	3

2005-2006

B.S.E.E.	-	41
M.S.E.E.	-	10
Ph.D.	-	2

2006-2007

B.S.E.E.	-	47
M.S.E.E.	-	7
Ph.D.	-	10

2007-2008

B.S.E.E.	-	43
M.S.E.E.	-	7
Ph.D.	-	7

2008-2009

B.S.E.E.	-	48
M.S.E.E.	-	10
Ph.D.	-	8

5. ACTIVITIES

The faculty and students in the Power and Energy Systems Area participated in a considerable number of special activities during the calendar year 2008. The major events are listed below:

January

- Philip Krein presented a seminar and participated in the IEEE Applied Power Electronics Conference (APEC), Austin, TX
- Tom Overbye participated as a guest speaker for the IEEE RRV Section and IAS Chapter Meeting, Rockford, IL
- Hawaiian International Conference on System Science, Waikoloa, HI
  - Pete Sauer chaired a mini-track
  - Tom Overbye chaired EMS Applications
- Pete Sauer participated in an NAE search executive workshop, Washington, D.C.

February

- Patrick Chapman attended and managed USDA proposal panel, Washington, D.C.
- Philip Krein attended the IEEE Applied Power Electronics Conference and Committee Meetings of the IEEE Power Electronics Society, Austin, TX
- Tom Overbye attended the PSCC TRC Meeting, Madrid, Spain
- Pete Sauer attended the PSERC Executive Committee Retreat, Astoria, OR
- Pete Sauer attended the NAE Gordon and Grainger Prize Ceremonies, Washington, D.C.

March

- Patrick Chapman attended Illinois Department of Transportation (IDOT) Wind Turbine Meeting and Program Review, Springfield, IL
- George Gross attended the PSERC Executive Forum, New York City, NY
- Philip Krein participated in IEEE Technical Activities Board strategic planning meeting, Manhattan Beach, CA
- Philip Krein presented invited lectures at Michigan State University, East Lansing, MI
- Philip Krein presented an invited talk at National Semiconductor, Sunnyvale, CA
- Tom Overbye presented an invited talk at the University of Missouri-Rolla Science and Technology, Rolla, MO
- Tom Overbye attended the PSERC PMU Meeting with ComEd Transmission Operations,

Lombard, IL

April

- Patrick Chapman presented as an invited speaker at the German-American Frontiers in Engineering Conference, Irvine, CA

- Tom Overbye gave an invited IEEE Technical Presentation and visited New England ISO, Holynoke, MA

- Pete Sauer and Tom Overbye attended the IEEE/PES Transmission and Distribution Conference Exposition, Chicago, IL

May

- George Gross gave invited presentations at various universities in Italy, Milano, Pavia, Salerno, Palermo, Italy

- Pete Sauer attended workshop on wind power, Denver, CO

- Pete Sauer, Tom Overbye, George Gross and Alejandro Dominguez-Garcia attended the PSERC Research Center Industrial Advisory Board Meeting, Ames, IA

- Pete Sauer participated in review of the DOE/CERTS research program at Pacific Northwest National Laboratory, Pasco, WA

- Participated in UWIG/NREL Workshop on Windpower, Denver, CO

June

- Patrick Chapman, Philip Krein and Alejandro Dominguez-Garcia attended and presented papers at the IEEE Power Electronics Specialists Conference PESC 2008, Rhoades, Greece

July

- Patrick Chapman delivered an invited lecture at Texas Instruments, Dallas, TX

- Alejandro Dominguez-Garcia attended a meeting at MIT for UIRAD, Boston, MA

- Alejandro Dominguez-Garcia explored prospective research collaboration opportunities at John Deere, Moline, IL

- George Gross attended the ERPI Project Review Meeting, Palo Alto, CA

- George Gross attended a planning meeting for Smart Grid Symposium and the 16th Power Systems Computation Conference, Edinburgh and Glasgow, Scotland

- Philip Krein attended the IEEE Technical Activities Board Nominations and Appointments Committee Meeting, Denver, CO
- Tom Overbye attended the PSERC visit with BPA, Vancouver, WA
- Tom Overbye presented at the PSERC visit to ERPI, Knoxville, TN
- Tom Overbye met with City Water, Light and Power, Springfield, IL
- Pete Sauer delivered a presentation on the TCIP Project at the Electric Power Research Institute, Akron, OH
- Pete Sauer, Tom Overbye, George Gross and Alejandro Dominguez-Garcia attended the IEEE Power & Energy General Meeting, Pittsburg, PA
- Pete Sauer made TCIP presentation at the DHS/NSF/DOE Workshop, Washington, D.C.

August

- Patrick Chapman attended the Intel Corporation Proposal Meeting, Chandler, AZ.
- George Gross participated in a meeting with the Grainger Foundation, Lake Forest, IL
- George Gross presented an invited talk at Boeing Corporation, Seal Beach, CA
- George Gross presented as the keynote speaker in the 2008 IEEE PES Transmission and Distribution Conference and Exposition Latin America, Bogota, Colombia
- Philip Krein participated and presented papers at the IEEE Workshop on Control, Modeling, and Simulation for Power Electronics, Zurich, Switzerland
- Pete Sauer, Tom Overbye, George Gross and Alejandro Dominguez-Garcia attended the Power Systems Engineering Research Center Summer Planning Workshop, South Lake Tahoe, CA

September

- Patrick Chapman presented an invited talk at the International Workshop on Power Supply, Cork, Ireland
- Patrick Chapman attended the IEEE Applied Electronics and Exhibition Conference (APEC) Planning Meeting, Washington, D.C.
- Patrick Chapman attended the General Electric Wind Energy Meeting, Greenville, S.C.
- Tom Overbye attended the consortium for Electric Reliability Technology Solutions Project Review Meeting, Ithaca, NY

- Tom Overbye attended and participated in the North American Power Symposium, Calgary, Alberta, Canada

- Pete Sauer chaired a subcommittee of the National Academy of Engineering Gordon Prize, Washington, D.C.

October

- Philip Krein made a research visit regarding solar energy to Caterpillar, Mossville, IL

- Philip Krein attended committee meetings of the IEEE Power Electronics Society, Edmonton, Alberta, Canada

- Philip Krein presented a seminar at Texas Instruments, Dallas, TX

- Tom Overbye NERC North American SynchronizPhasor Initiative Workshop, Charlotte, NC

- Tom Overbye participated in the Visualization & Controls Program Peer Review Meeting, Washington, D.C.

- Pete Sauer presented report at the Section 6 Meeting of the National Academy of Engineers, Washington, D.C.

- Pete Sauer participated in the National Academy of Engineers Nominating Committee, Washington, D.C.

- Pete Sauer participated in the Department of Energy CERTS Review, Washington, D.C.

November

- Alejandro Dominguez-Garcia attended and presented paper at the IEEE Energy 2030 Conference, Atlanta, GA

- George Gross attended a PSERC Industrial Advisory Board Meeting, Dallas, TX

- George Gross presented an invited guest lecturer at the University of California at Berkeley, Berkeley, CA

- Philip Krein gave an invited presentation at the MIT Auto Consortium Meeting, Cambridge, MA

- Philip Krein attended research meeting for a funded project, West Lafayette, IN

- Pete Sauer presented a Distinguished Lecturer Seminar at Washington State University, Pullman, WA

- Pete Sauer participated in an IEEE/PES Executive Committee collaborative workshop, Washington, D.C.

December

- Tom Overbye and Alejandro Dominguez-Garcia attended the PSERC Industrial Advisory Board Meeting, College Station, TX

- Pete Sauer attended the PSERC IAB Meeting and Executive Committee Meeting, College Station, TX

- Pete Sauer participated in a power grid workshop simulator workshop, Argonne, IL

During the 2008 calendar year, the power area group hosted the following guest speakers:

- Charles Debries and Chris Thornton, Texas Instruments, Warrenville, IL "TurboTrans Enhancement Of The Dynamic Performance Of DC/DC Converters", February
- Tarek Abdallah, U.S. Army Engineer Research and Development Center, Champaign, IL, "Remote Sensing Concepts For Urban Utility Systems: Remote Sensing of Power Generation Equipment" January
- Byung Ha Lee, Department of Electrical Engineering, University of Incheon, South Korea, "Assesment of Total Transfer Capability Using IPLAN: An Application of UPFC For Total Transfer Capability Enhancement" January
- Kevin Kepley, Principle Engineer, Bitrode Corporation, Fenton, Missouri, "High-Performance Active Test And Formation Equipment For Batteries" February
- Roch Ducey, U.S. Army Engineer Research and Development Center, Champaign, IL, "The Development Of Scalable And Deployable Military Microgrids" February
- Thomas G. Habetler, Professor, Georgia Institute of Technology, Atlanta, GA, "Medium Voltage Motor Diagnostics" March
- Dale Osborn, Transmission Technical Director, Transmission Asset Management, Midwest ISO, "Midwest ISO Market And Reliability Initiatives" March
- Steven Pekarek, Associate Professor, Purdue University, West Lafayette, IN, "A Comparison Of Nodal and Mesh-Based Magnetic Equivalent Circuit Models" April
- Woo-Hyun Whang, Korean Electric Power Company (KEPCO), Seoul, Korea, "The KEPCO Distribution Automation System" April
- Soumitro Banerjee, Department of Electrical Engineering, Indian Institute of Technology, Kharagpur, India, "Nonlinear Phenomena In Power Electronics" May
- Daniel Saban, Ph.D., Director of Technology, Direct Drive Systems, Cerritos, CA, "Design of Inverter Driven Induction Machines" and "Experimental Evaluation Of A High-Speed Multi- Megawatt SMPM Machine" July
- Scott Donahue, Sargent and Lundy, L.L.C., Chicago, IL, "Power Generating Facility AC Auxiliary Power Systems Analysis" September
- Mark Hagen, Senior Systems Engineer, Texas Instruments Digital Power Group, Rochester, MN, "Utilizing A Digital PWM Controller To Monitor The Health Of A Power Supply" October
- Richard W. Tomaszkiewicz, Senior Director of GE Energy's Domestic T & D Projects, General Electric Company, Oakbrook Terrace, Illinois, "The Variable Frequency Transformer: A Simple And Reliable Interconnection Technology" October
- Franklin H. Holcomb, Project Manager, U.S. Army Research and Development Center, "Energy Security Planning For Army And DOD Installations" November
- Dr. Longya Xu, Department of Electrical and Computer Engineering, Ohio State University, "Doubly Excited Brushless Reluctance Machine For Advanced Wind Power Generation" December
- Regan Zane, Associate Professor of Electrical and Computer Engineering, University of Colorado at Boulder, "Low-Power Energy Harvesting For Wireless Sensors" December

During the 2008 calendar year, the power faculty and students presented the following seminars to our local audiences:

- Joseph E. Tate, “Power System Data Contouring Using Graphical Processing Units” January
- Patrick Chapman, “Residential Solar Power In The Midwest” February
- Trishan Esram, “2007 Solar Decathlon An Electrical Engineering Perspective” February
- Shanshan Liu, “Real-Time Estimation Of Power System Dynamics” March
- Steven L. Judd, “An Evaluation Of The Impacts Of Plug-In Hybrid Electric Vehicles On Power System Disturbance Response And Economics” March
- Melanie D. Johnson, “Modeling The Magnetic Field Generated By Corroding Metals” April
- Nicolas Maisonneuve, “Incorporation Of Wind Intermittency In Production Costing” April
- Timothy C. O’Connell, “Electric Machine Design: Current Status And Alternatives For Improved Performance” September
- Kate Rogers, “Distributed Flexible AC Transmission System (D-Facts) Device Applications In Power Systems, September
- Trishan Esram, “Alternating-Current Photovoltaic Modules” September
- Gui Wang, “Complicating Factors In Unit-Commitment Based Day-Ahead Markets” October
- Ali M. Bazzi, “Application Of Ripple Correlation Control To Induction Motor Power-Loss Minimalization” October
- Philip T. Krein, “Overview Of Power Electronics For Hybrid Vehicles” November
- Sean Safavinejad, “Arc Flash” November

6. STUDENT PROJECTS

This section of the report contains information on the graduate students whose major research efforts were supervised by faculty in the Power and Energy Systems Area. While not all of these students received financial aid from the Power Affiliates Program in terms of Research Assistantships, they were all associated with the program through the active involvement of their respective advisors. Those students supported by the Power Affiliates Program received maximum one-half time Research Assistantships for 11 months. The results of each student's work will be made available to all affiliate companies in the form of technical reports. The following students were associated with the Power and Energy Systems Area and their work is described in the following pages:

Adzima, Alan (M.S.)
Aquino-Lugo, Angel (Ph.D.)
Bazzi, Ali (Ph.D.)
Beltran, Hector (Ph.D.)
Bollman, Andrew (M.S.)
Davis, Charles M. (Ph.D.)
Davoudi, Ali (Ph.D.)
Dhople, Sairaj (M.S.)
Dutta, Sudipta (M.S.)
Esram, Trishan (Ph.D.)
Friedl, Andrew (M.S.)
Guille, Christophe (M.S.)
Güler, Teoman (Ph.D.)
Johnson, Melanie (M.S.)
Judd, Steven (M.S.)
Kowli, Anupama (M.S.)
Kroeze, Ryan (M.S.(
Kuai, Yingying (Ph.D.)
Lam, Shanshan (Ph.D.)
Liu, Shanshan (Ph.D.)
Maisonneuve, Nicolas (M.S.)
Monge-Guerrero, Linda (Ph.D.)
Negrete, Matias (Ph.D.)
Nelli, Rajesh (M.S.)
O'Connell, Timothy (Ph.D.)
Pang, Liang (M.S.)
Pitel, Grant (Ph.D.)
Pulgar, Hector (Ph.D.)
Raczkowski, Brian (Ph.D.)
Revelo, Renata (M.S.)
Rogers, Katherine (M.S.)
Ruiz, Pablo (Ph.D.)
Safavinejad, Sean (M.S.)
Sander, Jonathan (M.S.)
Sayyah, Arash (M.S.)
Shenoy, Pradeep (M.S.)
Sithimolada, Viboon (Ph.D.)
Smater, Sebastian (M.S.)
Tate, Zeb (Ph.D.)
Wang, Gui (Ph.D.)
Wiczkowski, Piotr (M.S.)
Xiong, Leilei (M.S.)
Yeu, Rodney (Ph.D.)

Alan Adzima

Date of Birth:	March 31, 1985
Place of Birth:	Greenville, PA
B.S.:	May 2008, Gannon University
Status:	Working towards M.S. at UIUC
Professional Interests:	Power Electronics, Electric Machine Design, and Motor Control.

Accelerating Electric Machine Analysis with Graphic-Processing Units

Alan Adzima with Advisor P.T. Krein

Supported by the Grainger Center for Electric Machinery and Electromechanics

ABSTRACT

The numerical field analysis required to analyze electromagnetic systems is computationally intensive. The difference between computational ability of a standard desktop CPU and the capability required for real-time simulations of electric machines makes it prohibitive to conduct real-time simulation. Taking into account the development of CPUs and assuming this development rate remains constant, it will be decades before real-time simulation is a practical option in the desktop environment. Fortunately, the desktop environment has another computational element available. The insatiable need by the computer gaming industry for high-speed image processing has created graphic-processing units (GPUs) that offer massive computational power. This new generation of GPUs is vastly different than previous generations in computational power. Modern GPUs now incorporate hundreds of processing cores and large banks of high bandwidth memory almost equivalent in size to the actual system memory. As these new GPUs developed, manufacturers created C-based coding languages to access the computational power. Compute Unified Device Architecture (CUDA) is NVidia's versions of a C-based language for accessing the GPU's computational abilities, and it is supported on laptops, desktops, and workstations. MATLAB provides the ability for existing methods to be ported to C code. This allows existing MATLAB methods to be converted to execute on a CUDA capable GPU of a system. Conversions of N-Body Simulations and Fast Fourier Transformations to CUDA processes have been shown to provide 50x to 150x faster completion times than on a traditional CPU. This is the equivalent of a decade leap in desktop hardware technology, and presents a large opportunity for electric machine analysis. Currently, the porting ability of MATLAB is being used to incorporate CUDA based routines in numerical analysis of basic electromagnetic systems. It is the goal of this research to explore the acceleration potential of electric machine numerical field analysis by incorporating GPUs.

Angel Aquino-Lugo

Date of Birth:	September 1, 1981
Place of Birth:	Bayamón, Puerto Rico
B.S.:	May 2004, University of Puerto Rico, Mayagüez, Puerto Rico
M.S.	May 2006, University of Puerto Rico, Mayagüez, Puerto Rico
Status:	Working towards Ph.D. at UIUC

Distributed Intelligent Agents for Power System Decentralized Control Applications

Angel A. Aquino-Lugo with advisor T.J. Overbye

Supported by NSF TCIP Project and a University of Puerto Rico Fellowship

ABSTRACT

Under normal circumstances, the power systems are operated and coordinated in a centralized way. Every time that the power network fails because of a disturbance or some reconfiguration is needed, the central control center determines which system elements to switch and which control actions to implement. In this research, we are investigating the concept of delegating these functions to agents distributed throughout a distribution network. These agents would be in charge of the system switching response in case of a system failure, while determining the control actions needed for certain applications, such as distribution network power losses minimization, system restoration and load control. Each agent interacts and communicates which other agents in the system to exchange information of the system as well as coordinating control actions in the power distribution network. Currently, this work is also exploring the agent's concept in the transmission system to implement decentralized optimization algorithms for specific control applications.

Ali M. Bazzi

Date of Birth: September 30, 1984

Place of Birth: Bint Jbeil, Lebanon

B.S.: June 2006, American University of Beirut, Lebanon

M.S.: July 2007, American University of Beirut, Lebanon

Status: Working towards Ph.D. in Electrical Engineering at UIUC

Professional Interests: Power electronics, motor control, nonlinear control and estimation, renewable energy.

Induction Motor Power Loss Minimization

Ali Bazzi with Prof. Philip T. Krein

Supported through a Small Business Technology Transfer project grant through the National Science Foundation and the Office of Naval Research

ABSTRACT

This project investigates loss minimization techniques for induction motors. These minimization techniques can be categorized as model-based, physics-based, and hybrid. While model-based techniques utilize a motor model to estimate power losses and minimize them, physics-based techniques drive the control or minimization variable towards minimum input power based on the motor voltage and current measurements, regardless of the motor model. We were also able to classify a group of hybrid techniques where the motor model is partially utilized while driving the input power or power loss to a minimum. This classification is new to the literature. As a continuation of previous work, we also verified that a physics-based technique, ripple correlation control, can be applied to induction machines. This technique utilizes ripple in power electronics for reaching an optimum. Our current research focuses on designing a compensator for the motor in order to utilize high frequency ripple, and achieve fast convergence to the minimum input power.

Héctor Beltrán Mora

Date of Birth: May 31, 1982

Place of Birth: Mexico City

B.S.: January 2005, National University of Mexico

Status: Working towards M.S. at UIUC

Professional Interests: Renewable Energies and Power Systems Planning.

Modern Portfolio Theory applied to Electricity Generation Planning

Héctor Beltrán with advisor Thomas Overbye

ABSTRACT

To meet electricity demand, electric utilities develop growth strategies for the generation, transmission, and distributions systems. Nowadays and for a long time those strategies have been obtained applying least-cost methodology analyzing stand-alone resources just adding the cheapest resources instead of analyzing complete portfolios. As a consequence, least-cost methodology bias in favor of fossil fuel-based technologies completely ignoring the benefits of adding non-fossil fuel technologies to generation portfolios, especially renewable energies. For this reason, we are interested in Modern Portfolio Theory (MPT) to gain a more profound insight about generation portfolios performance using generation cost and risk metrics. We discuss all necessary assumptions and modifications to this finance technique for its application within power systems planning and we work on a real case of analysis.

Andrew Bollman

Date of Birth:	August 7, 1979
Place of Birth:	Rochelle, IL
B.S.:	December 2007, University of Illinois at Urbana-Champaign
Status:	Working towards M.S. at UIUC
Professional Interests:	Power Electronics, Distributed Generation, Renewable Energy

Control of Distributed Generation in Micro-grids

Andrew Bollman with advisor P. T. Krein

Supported through the Army Corps of Engineers Engineering Research and Development Center – Construction Engineering Research Laboratory

ABSTRACT

This work focuses on the control of distributed generation within a microgrid to provide a robust supply of power in a dynamic environment. The goal is to create a control scheme that will create a power system that provides a high quality of power and allows the connection and subtraction of generation sources and loads in an unpredictable manner. A droop-control scheme will alleviate some of the issues associated with a low inertia system and create a plug-and-play ability for the operators. Currently diesel engines are used as the prime sources, but the integration of alternative energies needs to be accounted for to meet U.S. Army energy mandates and to create a more secure energy network.

Charles Davis

Date of Birth:	May 6, 1980
Place of Birth:	Arkansas, USA
B.S.:	May 2002, Louisiana Tech University, Ruston, Louisiana
M.S.	August 2005, University of Illinois, Urbana, Illinois
Ph.D.:	May 2009, University of Illinois at Urbana-Champaign

Multiple Element Contingency Screening

Charles Davis with advisor T.J. Overbye
Supported by NSF TCIP Project and the Grainger Foundation

ABSTRACT

Evaluating multiple contingencies is a very computationally intensive process. A contingency list that contains every double outage contingency can easily contains tens to hundreds of millions of contingencies. Since solving millions of contingencies is not possible in realistic time frames, a method of determining the contingencies that will result in violations a head of time is needed. To address this problem, several algorithms have been developed. The algorithms use linear sensitivities, line flow information, and line limit information to determine a list of contingencies that are likely to be severe. The algorithms were tested against the full double outage (dc) contingency analysis for a 5,395 bus section of the North American Eastern interconnect. One algorithm was very good at detecting the double outage contingencies that result in violations. It detected around 99% of the contingencies that result in violations.

Ali Davoudi

Date of Birth:	March 26, 1982
Place of Birth:	Ramhormoz, Iran
B.S.:	July 2003, Sharif University of Technology, Tehran, Iran
M.S.:	May 2005, The University of British Columbia, Vancouver, Canada
Status:	Working toward Ph.D. at UIUC
Professional Interest:	Computational prototyping of power electronics-based systems

Multi-Resolution Simulation of Power Electronics-Based Systems

Ali Davoudi with advisor Patrick L. Chapman

ABSTRACT

Flexible simulation tools for switching power converters are needed for dynamic characterization, transient studies, and real-time simulation. Simulation of power converters includes the mixture of continuous and discrete events, where the presence of parasitic and switching transients introduces a wide range of time scales that span several orders of magnitude. Thus multi-rate simulations of the power electronics-based systems become necessary. An approach for simulating linear switched networks, such as PWM dc-dc switching converters, is set forth. A highly detailed model, that includes parasitic elements and precise representation of switch and passive components, is considered first. The state equations are automatically extracted based on the netlist of the converter under study. When a switching event is detected, the simulator proceeds among different state vectors while a succession of initial value boundary problems is solved. For each possible switching instance (two instances in continuous conduction mode and three in discontinuous conduction mode), standard state equations are formulated in detail. Lower resolution models are numerically formed by automated model order reduction. The order reduction techniques used here include state elimination, modal reduction, pole-zero cancellation, and Krylov subspace. The user determines the bandwidth (i.e., level of resolution) that is desired for a specific phase of design. In the proposed multi-resolution framework, several resolutions of the reduced model are constructed. This results in different state matrices and state vectors for a given switching instance, where the state continuity is insured across resolutions as well as switching events. The simulation proceeds with the assigned resolution level until a higher resolution is desired (e.g., to inspect a switching transient), where analyst changes the simulation resolution for a short time. The bandwidth of the reduced-order model may be adjusted, even during a simulation run, yielding different simulation resolutions and speeds.

Sairaj Vijaykumar Dhople

Date of Birth:	October 31, 1986
Place of Birth:	Dharwar, India
B.S.:	Dec 2007, University of Illinois at Urbana-Champaign
Status:	Working toward M.S. at UIUC
Professional Interests:	Power Electronics, Photovoltaics.

Performance and Reliability Improvements in Topologically Redundant Dc-Dc Converters for Photovoltaic Energy Systems

Sairaj Dhople with advisor P.L. Chapman

Supported by the Grainger Center for Electric Machinery and Electromechanics

ABSTRACT

Multi-phase, dc-dc converters of varied topologies have been adopted in a wide range of applications, including but not limited to voltage regulator modules, power factor correction circuits, hybrid electric vehicles, distributed power conversion systems, and recently, photovoltaic (PV) systems. For PV applications, multi-phase boost converters employing interleaved switching have received considerable interest. Compared to conventional boost converters, multi-phase converters can be designed to enjoy lower input current ripple, lower output voltage ripple, enhanced dynamic performance and they offer improved reliability given the inherent structural redundancy.

The steady-state characterization of a multi-phase, interleaved boost converter for photovoltaic applications is employed to specify the failure rates of circuit components and establish the effects of ambient temperature, insulation, number of phases, and device ratings on system reliability. Since the failure modes are state-dependent, a Markov reliability model is derived to assess the reliability of a generic *N*-phase converter. The proposed analytical tools provide a methodical framework for design of fault-tolerant multi-phase converters employed as front ends in a wide range of photovoltaic systems.

Sudipta Dutta

Date of Birth:	September 19, 1983
Place of Birth:	Durgapur, India
B.S.:	May 2005, Jadavpur University, India
M.S.:	June 2007, Banaras Hindu University, India
Status:	Working towards Ph.D. at UIUC
Professional Interests:	Renewable energy, integration of wind power into existing power grid, forecasting wind for prediction of power generation and management of storage, analysis of state-of-the art visualization tools.

Management of Energy Storage of Wind Farms with Short Term Wind Forecasting

Sudipta Dutta with advisor T. J. Overbye

ABSTRACT

Aggressive research efforts are underway with goal of attaining 25% renewable energy based power supply in the United States by the year 2025. The key to attaining this goal is penetration of wind energy into the existing power grids by stable interfacing. One of the most critical problems encountered with the generation of power from wind energy is the unpredictable nature of wind. Significant amount of excess power is generated by the turbines when wind speed is higher than the rated speed. This excess power needs to be dissipated in order to maintain the rated bus voltages. On the other hand, an energy shortage is encountered in a scenario when wind speed is lower than the rated, and energy support is required by turbines to meet scheduled loads. Battery based storage of energy can effectively handle both excess and shortage of power generation by either storing or supplying as required. However, a critical bottleneck can be encountered due to different response times of storage batteries and turbine rotors. Therefore, an optimized design approach is required based on energy generation capability of turbines and energy storage capacity of batteries for increasing reliability of wind energy systems.

In spite of large unpredictability of wind flow, a fairly accurate estimate of wind speed can be made on a short term basis. One such scheme consists of prediction of wind speeds at a location based on the wind speed data measured at a number of locations surrounding it. Using a mesh of wind speed measurement towers, real time data can be acquired and processed to predict the pattern and speed of wind movements. An estimation of this kind is extremely helpful in managing resources at a wind farm. Excellent control of storage batteries and pitch control mechanism of turbine blades are possible if the wind farm operator knows the wind pattern from a prediction made in above fashion. Such analysis with careful implementation has the potential to increase the reliability of wind farms and increase wind penetration into the existing power grid thereby facilitating the vision 2025.

Trishan Esram

Date of Birth:	March 8, 1980
Place of Birth:	Quatre Bornes, Mauritius
B.S.:	June 2003, Northeastern University
M.S.:	December 2004, University of Illinois at Urbana-Champaign
Status:	Working towards Ph.D. at UIUC
Professional Interests:	Power Electronics, Alternative Energy Sources, Control Systems

Cycloconverter Theoretical Model

Trishan Esram with advisor P. L. Chapman

ABSTRACT

Laboratory experiments have shown that a state-machine control can solve current commutation problems commonly related to a square-wave high-frequency link, pulse-width modulation cycloconverter (Figure 1). The cycloconverter, along with the state-machine control, has also been simulated in Dymola, producing results matching the empirical ones. Despite its success in hardware and simulation, the cycloconverter has never been modeled theoretically. Our goal now is to derive an average-value model based on multiple reference frames for the cycloconverter. Using the model, the behavior of the cycloconverter with a photovoltaic (PV) source, while connected to the utility grid, will then be investigated. The model will further help in formulating additional algorithms, not only to perform maximum power point tracking of the PV source, but also to monitor and control the interface with the utility grid to meet all the regulatory codes and standards.

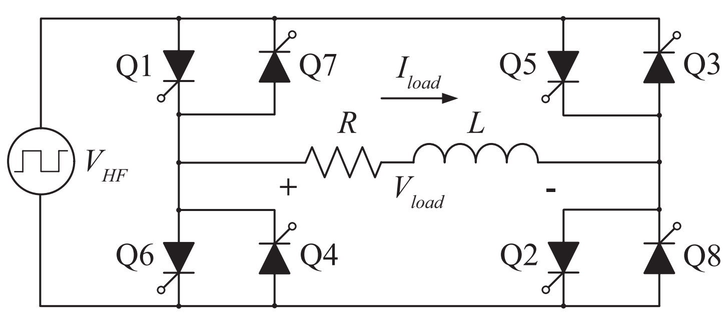

Figure 1. Cycloconverter

Andrew Friedl

Date of Birth: March 29, 1984
Place of Birth: Oak Lawn, Illinois
B.S.: May 2007, University of Illinois at Urbana-Champaign
Status: Working towards M.S. at UIUC

Professional Interests: Power Electronics, Electric Machine Design, and Motor Control.

Comparative Performance Analysis of Drives for Induction Motors

Andrew Friedl with Advisor P.T. Krein

Supported by the Grainger Center for Electric Machinery and Electromechanics

ABSTRACT

A modular inverter designed by Prof. Krein's graduate students a few years ago was recently built and is currently being used to implement induction motor control via direct torque control (DTC), indirect field-oriented control (IFOC), vectorized volts per hertz control, and feedback linearization. These controls will be applied to determine which application they best fit: electric and hybrid-electric vehicles, industrial 3-phase motors for lathes and milling, and consumer appliances such as washing machines, air conditioners and compressors. In the same system an encoder with 11-bit resolution was attached to a dynamometer running as a speed feedback device. DTC and IFOC have been simulated and are operational in Matlab-Simulink.

A literature review was performed and it was found that the literature mainly focuses on steady-state performance of drives by comparing torque and current ripple, motor power losses, tracking command quantities, etc. Not much work has gone into comparing drives' dynamic responses numerically. Also found in the literature was the fact that most comparisons between drives has typically been associated with specific switching schemes, such as hysteresis current control with IFOC, and a switching table with DTC. In fact, the switching scheme can be completely decoupled from the drive control method itself which is being demonstrated in our current research. For example, both IFOC and DTC can use space-vector pulse-width modulation (SVPWM). With such an arrangement, direct comparison becomes possible. The dynamic performance of IFOC and DTC are being compared using two common switching schemes: either SVPWM or hysteresis control. Sensitivity analysis has also been considered when comparing the two drives: the magnetizing inductance, rotor resistance, and rotor inductance become relevant in IFOC, while the stator resistance plays a key role in DTC.

Christophe Guille

Date of Birth: December 23, 1985

Place of Birth: Paris, France

B.S.: July 2007, Supélec, France

Ph.D.: May 2009, University of Illinois at Urbana-Champaign

Design of a conceptual framework for the vehicle-to-grid (V2G) implementation

Christophe Guille with advisor George Gross

ABSTRACT

The rising energy independence and environmental concerns are key drivers in the growing popularity of battery vehicles or *BV*s – electric and plug-in hybrid cars. Studies indicate that for 90 % of the Americans who use their cars to get to work every day, the daily commute distance is less than 50 *km* – or 30 *miles* – and, on the average, the commuter car remains parked is about 22 *hours* per day. The *BV*s have in common the batteries, which provide storage capability that can be effectively harnessed when the vehicles are integrated into the grid. The entire concept of using the *BV*s as a distributed energy resource – load and resource – is known as the *vehicle-to-grid* or *V2G* concept. Our work addresses the needs to make *V2G* reality by constructing a framework that is amenable to implementation. A thorough analysis of battery characteristics provides the basis to determine which services can be provided by the *BV*s. As each individual *BV* represents only "noise" to the power system, the *BV*s need to be grouped into large aggregations whose combined impacts can be felt by the grid. We investigate the deployment of a *BV* aggregation for the provision of frequency regulation and energy supply for load shaving. Similarly, we study the impacts of such an aggregation on levelizing the loads during the off-peak periods including the utilization for *down regulation* service. We develop a modeling approach in order to take into account the variability inherent to the behavior of the *BV* owners and the variability among the *BV* battery characteristics. We show that for aggregations of sufficient size, the effect of the uncertainty related to the behavior of the individual *BV*s can be smoothed out and that, consequently, the aggregated *BV*s are a reliable resource. Such a result emphasizes the importance of the role of the Aggregator in making sure that the modules corresponding aggregated *BV*s are of large size. The framework makes effective use of the *BV* aggregation but leaves the identity of each *BV* unchanged. Conceptually, we may view the framework to consist of a physical layer, where the flows are *MW*, *MWh*, battery service and parking service, which is accompanied by a separate layer with information flows to reflect control commands, monitoring data, billing information and any other communication that may be necessary among the various players. The framework provides a basis for planning and operations purposes as it takes into account the physical characteristics of each individual *BV*. To push along the implementation of the framework, we propose approaches to tackle two key implementational challenges. We present an approach for the computer/communication/control network that can be fully integrated into the smart grid to enable the integrated battery vehicles to effectively participate in the operation of the grid and electricity markets.

Teoman Güler

Date of Birth: November 14, 1976

Place of Birth: Samsun, Turkey

B.S.: July 1999, Bogazici University, Istanbul Turkey

M.S.: May 2001, Rensselaer Polytechnic Institute

Status: Working towards Ph.D. at UIUC

Professional Interests: Electricity Market Monitoring and Mitigation, Market Behavior and Market Power.

Electricity Markets and System Reliability

Teoman Güler with advisor G. Gross

ABSTRACT

The assurance by the RTOs of secure system operations strongly depends on, and directly impacts, electricity markets due to the tight system and market operations coupling. Typically, electricity is traded in a sequence of markets that are cleared at different frequencies and with different lead times. In this paper, we focus on the hourly day-ahead markets (DAMs) and their associated real-time markets (RTMs). The DAMs' clearing impacts the nature and the extent of the participants' responses to real-time conditions and system operations, which, in turn, impact system security. We quantitatively characterize the linkages between the real-time system security and the DAMs and investigate the role of the financial entities in a multisettlement system. Our approach allows us to quantify the auction surplus of the multi-settlement system and evaluate the impacts of the DAMs on market participants' bid/offer surpluses and on improving the attainment of security. We illustrate its application on the ISO-NE multi-settlement system using historical data. The studies indicate that the anticipation of financial entities leads to the convergence of the DAM and the associated RTM prices, such participation leads to improved forecasts of the real-time system operations, and results in improved assurance of system security.

Eric Hope

Date of Birth: March 10, 1987

Place of Birth: Des Plaines, IL

B.S.: May 2008, Illinois Institute of Technology, Chicago, IL

Status: Working towards M.S. at UIUC

Professional Interests: Power Electronics, Reliability in Power and Energy Systems

Design Validation of Power Electronics Systems Subject to Uncertainty

Eric M. Hope with advisor Alejandro Dominguez-Garcia

ABSTRACT

The operation of power electronics systems is subject to uncertainty. These uncertainties may be classified as either operational uncertainties or structural uncertainties. Operational uncertainty is used to classify random changes in the load or supply of the converter. Structural uncertainty is associated with changes to the physical structure of the system. During the design stage of any power electronics system, it is necessary to carry out an extensive analysis to make sure the system behaves as expected for all possible operational conditions that arise due to operational and structural uncertainty. This analysis is usually conducted through extensive time domain simulations of all possible inputs and faulted configurations that arise due to operational and structural uncertainty. This is a very painstaking and time intensive process. The objective of this project is to develop an analytically tractable method for computing the set of reachable states of power electronics systems that arise due to all possible operational and structural uncertainties. The resulting set of reachable states may then be used to validate the system design.

The proposed method for computing the set of reachable states applies an unknown-but-bounded uncertainty model to the operational uncertainties of the power electronics system. For example, the current demanded by the load may have a minimum and a maximum value. In this case, it may be assumed that the value of the current at any given time is bounded between these two extremes. The unknown-but-bounded uncertainty model has been successfully applied to compute the set of reachable states for a buck converter circuit operating in both an open-loop and boundary-controlled configuration. The computation of the resulting set was completed in several minutes, whereas several hours were required for time domain simulations to produce a similar, but less complete result. The goal of this project is to apply the proposed uncertainty modeling method to a wide range of power electronic systems and evaluate the performance of each system after component faults have occurred.

Brian Johnson

Date of Birth: October 25th, 1983
Place of Birth: El Paso, Texas
B.S: May 2008, Texas State University
Status: Working towards M.S. at UIUC
Professional Interests: Power Electronics, Power Systems, and Renewable Energy

Modeling of Microgrid Transient Behavior and Control

Brian Johnson with adviser P.L. Chapman
Supported by SURGE Fellowship and Graduate College Fellowship

ABSTRACT

A microgrid system can be described as a power system composed of a small number of loads and power sources that is capable of disconnecting from the main grid and delivering power to its loads autonomously. Although several types of energy sources can be integrated into the microgrid, it is very common to use engine driven generators that are interfaced to the rest of the system using controllable power electronic inverters.

A model has been developed using MATLAB/Simulink to capture all transient behavior during islanding and load shedding. Furthermore, the operation of the generator inverters uses a control system to provide frequency adjustment, ensure voltage magnitude regulation, and ensure that all necessary power is reaching the loads. Efforts are currently focused to model a mesh type topology for a microgrid system. Future work will incorporate the Automated State Model Generation circuit modeling technique that is commonly used for switched power electronic circuits.

Melanie Johnson

Date of Birth:	April 28, 1984
Place of Birth:	South Charleston, West Virginia
B.S.:	May 2006, University of Texas at Austin
M.S.:	May 2008, University of Illinois at Urbana-Champaign
Professional Interests:	Power Electronics and Power Systems

Modeling The Magnetic Field Generated By Corroding Metals

Melanie Johnson with advisor P. L. Chapman

ABSTRACT

Damage caused by corrosion of reinforcing steel plagues civil infrastructure in the United States. Corrosion damage causes an estimated 6 to 10 billion dollars of damage per year to bridge decks alone. Despite this cost, no reliable non-destructive testing method exists to detect the presence of corrosion or the rate at which corrosion occurs. Existing methods, such as visual inspection and half-cell potential measurements, are unable to fully characterize damage. The goal of this project is to develop a new sensing technique based on magnetic field measurements that will accurately measure both the state and rate of corrosion in reinforcing steel.

Working jointly with a group in the Civil Engineering Department, the project seeks to employ giant magneto-resistive (GMR) sensors to measure the small magnetic field generated by electric currents caused by corrosion. However, to extract the magnetic field information from background noise, a model is necessary to determine the defining characteristics of the corrosion magnetic field. Three models have been developed to simulate the corrosion magnetic field. These models calculate the magnetic field based on random current distributions designed to reflect the behavior of currents in general micro-cell corrosion. The models use finite element analysis and two variations on Biot-Savart law to calculate the magnetic field. Measuring the change in this simulated magnetic field shows promise in revealing corrosion magnetic field characteristics.

Steven L. Judd

Date of Birth: April 30, 1984

Place of Birth: Houston, Texas

B.S.: December 2006, University of Illinois at Urbana-Champaign

M.S.: May 2008, University of Illinois at Urbana-Champaign

An Evaluation Of Plug-In Hybrid Electric Vehicle Contributions To Power System Disturbances And Economics

Steven Judd with advisor Thomas Overbye
Supported by PSERC

ABSTRACT

During 2005, the United States imported 10.4 million barrels of crude oil per day in addition to the 5.18 Mb/day that are produced domestically. Over two-thirds of this fossil fuel is refined into gasoline to power passenger vehicles and trucks. The effects of this "addiction" have greater effects on our economy and political elements every day. With world-wide demand increasing and OPEC controlling 75% of the world's proven reserves, market prices have recently sky-rocketed to over $110 per barrel. This along with increasing pressure to reduce greenhouse gas emissions from the burning of fossil fuels has intensified the pursuit of alternate technologies. It becomes critical for our nation to find a solution to reducing our overall consumption of oil and finding an alternative for the future.

Several solutions have been proposed to solve this enormous problem: finding more oil (for example the drilling of ANWR in Alaska), increasing the fuel economy of our vehicle fleet, implementing the use of ethanol, and widening the use of conventional hybrid electric vehicles (HEVs). A newer option has emerged in the past few years, the Plug-In HEV (PHEV). The only difference between a standard hybrid and a PHEV is an increase in the capacity of the battery pack and a modification to the power electronics. PHEVs have a new advantage of running in all-electric-mode for longer distances, typically 30-60 miles, and could become a new source of energy storage for the bulk power grid.

Current HEVs charge their batteries from the cars' internal combustion engine and by using regenerative breaking then deplete their energy while the car is stationary. This method is referred to as *charge-sustaining* since the batteries will maintain a set state of charge. The major change in a PHEV is the use of a *charge-depleting* strategy where the car batteries will be steadily used while driving to maximize fuel efficiency and the state of charge will decrease over time. The car will also be connected to the power-grid while not in use to provide energy to the batteries from the grid and/or provide support to the grid in time of emergency during hours.

This thesis will focus on the support PHEVs can provide to the grid security and the economic benefit for grid operation. PHEVs have a large potential to save money to those that own one. An analysis of the economic benefit to individual owners will be described. An in-depth formulation of how much power PHEVs can provide will also be shown. To show the economic benefit of grid connection, the IEEE 24, IEEE 118, and a utility 2,574 bus test system will demonstrate costs associated with PHEVs. Simulating these systems with several different levels of support will be tested to see what potential cost benefits and increased grid security can be achieved.

Anupama Kowli

Date of Birth: February 16, 1984

Place of Birth: Mumbai (Bombay), India

B.S.: July 2006, Mumbai University, India

M.S.: Working towards M.S. at UIUC
Professional Interests: Power System Economics, Power System Operations and Control, Electricity Markets and Auctions, Demand-side management

Long-term Production Costs Evaluation with Explicit Consideration of Demand Response Resources

Anupama Kowli with advisor George Gross
Supported by the Grainger Endowments

ABSTRACT

Growing environmental concerns and difficulties in project finance are spearheading the wider implementation of various demand-side activities, including the development of demand response resources (*DRR*s). Both energy services providers, such as distribution utilities, and system operators, such as *ISO*s/*RTO*s, are depending on demand response as a resource to meet the load requirements during periods of high load demands. A *DRR* provides the ability to curtail loads for specified time periods and in specified amounts and competes against conventional supply-side resources in the competitive electricity markets. The *DRR* participation impacts the market outcomes, transmission utilization and the electricity consumption. Moreover, increasing penetration of *DRR*s into the resource mix influences the investments in resources on both the supply- and the demand-sides. In this work, we develop a framework which may be applied to the simulation of the side-by-side operations of the wholesale electricity markets and the regional grid system operated by an *ISO* or a *RTO*. The resulting simulations may be used for assessing the economics of electricity supply in a competitive environment over multi-year study horizons and such simulations are particularly useful in the context of resource investment analyses, transmission planning and policy analyses. We illustrate the application of the proposed framework to the study and the evaluation of the impacts of *DRR* integration into wholesale electricity markets. We provide representative simulation results which demonstrate the capabilities of the proposed framework. We find that energy prices and congestion costs decrease up to 10 % in scenarios in which both, the supply-side and *DRR* sellers participate in the market, as compared to the scenarios in which only supply-side sellers compete in the market. We also arrive at the significant finding based on numerous studies that a depth of penetration of *DRR* capacity may defer the need for the installation of peaking generation.

Ryan Carter Kroeze

Date of Birth: April 28^{th}, 1983

Place of Birth: Arlington Heights, Illinois

B.S.: August 2006, University of Illinois at Urbana-Champaign

M.S.: October 2008, University of Illinois at Urbana-Champaign

Electrical Battery Model for Use in Dynamic Electric Vehicle Simulations

Ryan Kroeze with advisor P. Krein

ABSTRACT

Simulation of electric vehicles, hybrid electric vehicles, and plug-in hybrid electric vehicles over driving schedules within the University of Illinois (UIUC) Hybrid Electric Vehicle Simulator requires a new battery model capable of predicting the state-of-charge and I-V characteristics of different battery types. A Lithium-ion battery model capable of reproducing nickel-metal hydride and lead-acid I-V characteristics (with minimal model alterations) has been proposed. A multiple (three) time-constant battery model suitable for modeling Lithium-ion batteries is currently being verified in the Matlab/Simulink programming environment; model time constants in the second/minute and hour ranges have already been verified in numerous research articles and a time-constant in the millisecond range has been verified with experiments. Accurate state-of-charge (SOC) prediction is attained through a separate circuit model which includes self-discharge of the battery, capacity-fade during high-current charging and discharging profiles, as well as SOC deterioration due to cycling. Comparisons of driving schedules run in the software environment on modeled battery packs and current discharge/charge profiles on real battery packs show minimal error between the simulated and actual battery packs terminal voltage, SOC, and discharging/charging power.

Yingying Kuai

Date of Birth:	April 24, 1980
Place of Birth:	Tonghua, P.R. China
B.S.	July 2001,University of Electronic Science and Technology of China, Chengdu P. R. China
M.S.:	December 2005, North Dakota State University, Fargo, ND
Status:	Working towards Ph.D. at UIUC

Package-embedded Magnetic Inductors for Voltage Regulators Powering the CPU

Yingying Kuai with advisor P. L. Chapman

Supported by the Power Affiliates Program and Grainger CEME

ABSTRACT

The research for Voltage Regulators (VRs) has lately concentrated on topologies and control methods to optimize the transient response. This project focuses on a new paradigm of power conversion, where the converter and processor load will be integrated as part of one package to eliminate unwanted parasitics. Integrated VRs require chip-embedded inductors with high Q, low DC resistance, and minimal area. The goal of this project is to develop a time-domain hysteresis model to properly utilize the B-H curve and predict core losses. The developed model will become part of a comprehensive design methodology for embedded inductor.

A laboratory system was designed and built to measure B-H loops for two candidates of magnetic materials. The experimental set-up was developed in accordance with IEEE Standards. The measured induced voltage was then saved to a PC for further processing. MATLAB software was used to perform numerical integration and compute the corresponding B and H field from experimental data. These curves serve as valuable reference data for the hysteresis modeling work.

To create the desired time-domain hysteresis model, Preisach modeling techniques are investigated. The Preisach operator is a mathematical tool that has been used to model the phenomena of hysteresis for many years. Part of what is needed to describe the Preisach operator for a particular system is a density function defined for certain parameters. In this work, Preisach model identification is accomplished by dividing the Preisach plane into discrete cells. This method utilizes centered B-H circles, instead of first-order reversal curves that are difficult to obtain experimentally. Once the model is established, it is then possible to obtain desired magnetic characteristics, such as power losses, permeability and inductance, by means of simulation. The deliverables of this task includes 3-D graphs and/or tables that could facilitate embedded magnetic design dramatically.

Frank J. Lam

Date of Birth:	December 20, 1985
Place of Birth:	Bloomington, Illinois
B.S.:	May 2008, University of Illinois at Urbana-Champaign
Status:	Working toward M.S. at UIUC
Professional Interest:	Power Systems, Reliability in Power and Energy Systems

Efficient Algorithms for Performance and Reliability Modeling and Analysis of Fault-Tolerant Systems

Frank J. Lam with advisor Alejandro Dominguez-Garcia

ABSTRACT

Reliability and, in particular, fault-tolerance are qualities essential in the successful design and implementation of any electronic system to ensure the designs perform as intended despite faults that may occur in the system. Accordingly, there has been numerous tools developed that measure reliability and performance. This project aims to develop alternative approaches and algorithms to increase the effectiveness of a particular MATLAB/Simulink performance and reliability simulation tool based off of InPRESTo, the tool developed by Dr. Alejandro Dominguez-Garcia while at MIT. In the fall of 2008, the main focus was to profile and develop algorithms to increase the runtime of the tool for very large models.

Currently the focus is to build upon this tool further by expanding the framework of this tool to be that of a probabilistically-informed design. At the present, the tool takes one input, injects faults throughout the system, and computes the performance and reliability of the system for that one input. The goal is to analyze the system for all possible inputs by using ellipsoids as bounds for the input and accordingly, using ellipsoids to bound the state space reach set. Additionally, there is a focus placed on developing a new way of computing the fault coverage of the system and a plan to integrate this new concept into the existing implementation of the tool.

Shanshan Liu

Date of Birth:	November, 1978
Place of Birth:	Jiangsu, China
B.S.:	July 2000, Tsinghua University
M.S.:	July 2002, Tsinghua University
Status:	May 2009, University of Illinois at Urbana-Champaign
Professional Interests:	Power systems, machinery and control

The Development of Power System Load Models Using PMU Data

Shanshan Liu with advisor P. W. Sauer

Supported by the Grainger Foundation

ABSTRACT

The accuracy of system models are essential for system analysis, planning and design in electrical power systems. Having accurate load models can help to understand the dynamic phenomena and design the control system. More important, load representation has a significant impact on system stability analysis.

While scientifically accurate and detailed models have been proposed for generators, lines, transformers and control devices, the same has not occurred for load models because of the random nature of a load composition. We can determine the aggregate load model parameters if the parameters of all separate loads are well known, which is often not available. In the absence of the precise information, one of the most reliable ways to obtain the trustable load model is to apply identification techniques. Now with the installation of PMU, it is possible to get the real-time data of the power system. Since the loads are actually evolving with time, it is more useful and also more challenging to update the load model timely to assure the best performance.

This project is to develop an automatic method for the determination of variable parameters of the dynamic load model under normal operation condition of power system

Nicolas Maisonneuve

Date of Birth: August 25, 1986

Place of Birth: Saint-Brieuc, France

B.S.: June 2007, Ecole Supérieure d'Electricité (Supélec), Paris, France

Status: Working towards M.S. at UIUC

Professional Interests: Power Systems Operations and Control, Renewable Energies, Electricity Markets

Impacts of Wind Power Intermittency On Electrical System Operating Costs

Nicolas Maisonneuve with advisor G. Gross

ABSTRACT

The rapid increase of wind power capacity over the past ten years has benefited tremendously from the technology developments that resulted in significantly reducing the capital investment costs. In addition, with increasing concern about climate change, several countries have adopted policies that foster the use of renewable energy sources so as to reduce CO_2 emissions. Several jurisdictions around the world have specified ambitious targets of the fraction of capacity to come from renewable resources, thereby further stimulating the investment in wind. As a result, wind is the fastest growing source of new capacity for electricity. As the fraction of wind resources becomes larger, the solution of some of the challenging issues in the integration of these resources becomes more pressing. One key issue is the wide variability and difficulty in predictability of wind energy. The intermittent nature of wind and the attendant lack of dispatchability present major difficulties to system operators. In order to operate the system securely, operators must take steps that result in additional operating costs. Such costs have been quantified and analyzed in a number of wind integration studies indicating that these costs become pronounced as the penetration of wind energy approaches the 20% level of the total installed capacity of a system. We are focusing our analysis on developing an improved understanding of the nature of these costs by investigating the impacts of wind integration in a production costing framework. Specifically, we are investigating the modeling of the intermittency impacts and the manner in which they effect the unit commitment schedules. The objective is to construct a practical procedure to explicitly represent the uncertainty in wind regimes in areas with wind farms.

Linda M. Monge-Guerrero

Date of Birth:	July, 31. 1981
Place of Birth:	San Juan, Puerto Rico
B.S.:	May 2004, University of Puerto Rico, Mayaguez, Puerto Rico
M.S.:	July 2006, University of Puerto Rico, Mayaguez, Puerto Rico
Status:	Working towards Ph.D. at UIUC
Professional Interest:	Power Systems Dynamics, Operation, and Control, Voltage Stability, Load Modeling

Data-Driven Power Systems Analysis

Linda Monge-Guerrero with advisor Pete Sauer
Supported by the Grainger Endowments and The University of Puerto Rico

ABSTRACT

We focus on the application of time-synchronized phasor measurements in power systems dynamic modeling and voltage stability analysis. These time-synchronized phasor measurements are currently available from phasor measurement units (PMUs). PMUs being a fairly new technology, there has not been a significant amount of work on the applications of PMUs data for voltage stability analysis, much of which is solely based on static analysis of the system. In this work, we aim to perform voltage stability studies by using equivalent dynamic models of the system obtained from PMUs data. First, a method is developed to simplify the model of a large power system network connected to a load bus into a simple equivalent dynamic model. This simplified model consists of a single generator, which is modeled using the synchronous generator classical model, and a single lossless transmission line connected behind the load bus. The model parameters are estimated using the PMU data available at the load bus and the Gauss-Newton method to solve nonlinear least-squares problems. Next, possible applications of the equivalent dynamic models for voltage stability analysis, such as small signal stability, will be studied.

Matias Negrete-Pincetic

Date of Birth:	August 19, 1978
Place of Birth:	Santiago, Chile
B.S.:	July 2003, Pontifical Catholic University of Chile
M.S. in Physics:	August 2005, Pontifical Catholic University of Chile
Status:	May 2009, University of Illinois at Urbana-Champaign

Professional Interests: Electricity Markets, Complex Systems, Random Processes

Emerging Issues On Power Systems And Electricity Markets

Matias Negrete-Pincetic with advisor G. Gross

Supported by Fulbright Fellowship

We focus on the study of emerging issues emanating from the interactions between the markets and the physical grid system. The salient characteristics of the physical power generation and the grid network structure, the various sources of uncertainty and the large-scale nature of a regional transmission organization can have huge impacts on the market performance. Conversely, the outcomes of electricity markets drive the state in which the power system operates. The characterization of the interactions help in the understanding of phenomena observed in the restructured environment and provides insights in improving market design.

We have investigated the nature and steps toward quantification of cyber security of the power grid. As a tool in the understanding of the impacts of cyber attacks on the power grid, we deploy a conceptual four-layer framework that represents the physical, communication/control, market levels of the electricity infrastructure, and a cyber security investment layer. We characterize each layer and analyze the nature of the inter-relationships among the four layers. We are developing metrics to help in the quantification of the impacts.

A second area of focus is the study of product definition issues in future electricity auctions for mid- and long-term supply. Our investigation has resulted in conclusive findings that some of the currently used product definitions in electricity auctions have serious deficiencies leading to lack of economic efficiency, due to information asymmetry and the growth in market share of particular players. From the lessons learned from those findings, we develop an alternative way to define contracts for future supply auctions using block-based products that are more in line with the way electricity is generated by the various suppliers. In this way, we overcome some of the issues identified in the currently used definitions. We perform several numerical studies using idealized auction models to illustrate the efficiency improvements resulting from the use of block-based products.

Rajesh Nelli

Date of Birth: September 11, 1983

Place of Birth: Manipal, India

B.S.: May 2005, National Institute of Technology, Karnataka, India

Ph.D.: May 2009, University of Illinois at Urbana-Champaign

Impacts of Demand Response Resources on Scheduling and Prices in Day-Ahead Electricity Markets

Rajesh Nelli with advisor G. Gross

ABSTRACT

We consider the explicit representation of demand-side resources as participants in the day-ahead electricity markets and assess their impacts on scheduling and prices. These resources offer to reduce their loads and compete side-by-side with the supply-side resources in the hourly auctions in the day-ahead markets for energy and capacity-based ancillary services. We refer to these demand-side market participants as demand response resources (*DRR*s). We use the unit commitment problem as the vehicle for our study and evaluate the changes in the operating schedules of the supply-side resources and the resulting prices. In the study, we assess the load recovery effects that accompany the load curtailment that *DRR*s provide. We use a mixed integer programming solver to explicitly represent the integral nature of the decision variables involved in determining the optimal schedules for next day system operations. We study the solutions of the unit commitment problem to develop appropriate insights into the impacts of *DRR*s on the prices and quantities of *MWh* of energy and *MW* of capacity-based ancillary services in the hourly auctions for the next day. The testing is performed on a number of systems, including a test system with 24 supply-side resources, to quantify the role of the *DRR*s in the joint electricity markets for energy and capacity-based ancillary services.

Tim O'Connell

Date of Birth:	March 10, 1981
Place of Birth:	Columbia, Missouri, USA
B.A.:	June 2003, Carleton College, (Physics)
M.S.:	May 2005, University of Illinois at Urbana-Champaign
Ph.D.:	May 2009, University of Illinois at Urbana-Champaign
Professional Interests:	Electric machine simulation, design and analysis; computational electromagnetics; power electronics

Boundary-Based Field Analysis of Electromechanical Systems

Timothy C. O'Connell with advisor P. T. Krein

ABSTRACT

Boundary-based field analysis methods for electromechanical systems are examined as an alternative to the well-known domain-based finite element analysis (FEA). Boundary methods are well-suited to electric machines where the majority of the important force-generating electromechanical interaction occurs in the air gap close to its interface with the rotor. Thus, boundary methods may have benefits in both accuracy and computational efficiency since they can focus computational resources on the most important regions.

Work is being conducted to apply the boundary element method (BEM) to three-dimensional (3D) problems. BEM is a numerical solution procedure utilizing an integral equation formulation of a system's governing differential equations. This is in contrast to FEA, which solves the differential form of the system equations. As a first step a BEM analysis of a two-dimensional (2D) electromechanical actuator has been successfully carried out. This preliminary study verifies that the 2D BEM solution tracks both experimental data and a known idealized analytical solution. The current work aims to implement a 3D BEM electromechanical model capable of modeling eddy currents. Experiments using a linear induction motor with various rotor arrangements are planned to verify the theory.

Liang Pang

Date of Birth:	October 07, 1985
Place of Birth:	Nanjing, China
B.S.:	June 2008, Nanyang Technological University, Singapore
Status:	Working towards M.S. at UIUC
Professional Interests:	GaN-based high power devices using Molecular Beam Epitaxy

Enhancement of Breakdown Voltage Using Selective-Area Growth By PAMBE

Liang Pang with advisors Kyekyoon (Kevin) Kim, Patrick L. Chapman, and Phillip T. Krein

Supported by the Grainger Center for Electric Machinery and Electromechanics

ABSTRACT

GaN-based materials have been extensively studied for optoelectronic and electronic devices. To realize high-performing devices, low-resistance ohmic contacts and high breakdown voltage are critical. Ion implantation is generally used to achieve low contact resistance. However, high energy radiation is required for high doping, resulting in radiation damage at the surface and in the doped region. In an effort to resolve these difficulties, Selective Area Growth (SAG) using highly doped *n*-type GaN can be employed. In previous studies, using SAG technique facilitated by plasma-assisted molecular beam epitaxy (PAMBE), we achieved a record low contact resistivity of $1.8x10^{-8}\Omega$ cm^2, as well as extremely low non-alloyed contact resistance of 0.6 Ω mm. Furthermore, due to the damage-free nature of SAG technique, we deduce it would provide higher breakdown voltage than implantation, which is crucial for high power GaN devices. In this study, we examine the advantages of SAG over ion implantation on high electron mobility transistors (HEMTs). We present that compared to ion implantation, SAG not only provides better contact resistance and dc performance, but also offers much higher breakdown voltage. Two different substrates, sapphire and silicon were used in this study to demonstrate that the advantages of SAG are consistent, regardless of the substrate used. These favorable results indicate that using SAG technique by PAMBE is very effective for the fabrication of HEMTs for high power devices.

Grant Pitel

Date of Birth:	November 8, 1980
Place of Birth:	Dover, New Jersey
B.S.:	May 1999, Cornell University
M.S.E.E.:	October 2005, University of Illinois at Urbana-Champaign
Ph.D.:	December 2008, University of Illinois at Urbana-Champaign
Professional Interests:	Automation , microprocessor/DSP development, power electronics control and analysis.

High Performance Dc-Dc Converters

Grant Pitel with advisor P. T. Krein
Supported by the Grainger Endowments

ABSTRACT

High-performance power electronics are essential components in the microelectronics industry. They must deliver clean voltage in the presence of fast load steps, maintain low cost, and achieve high efficiency. Limits in IC fabrication have spawned processors that run at low voltages and use multiple cores and on-board power management in order to improve instructions per Watt. These design choices have greatly stressed the capabilities of power electronics. In my research I explore the fundamental performance limits in power processing and propose digital control and topology strategies that will overcome these challenges.

A common problem with high-performance large-signal and optimal controllers is that they need knowledge about attached loads. The best dc-dc converter performance occurs only when the controller has complete knowledge of its components and the load—the latter being the more difficult to obtain.

I am investing online load identification, a process where a digital controller can find load values in real-time and in a way that does not drastically affect output voltage. With this knowledge a dc-dc converter can achieve performance that approaches its theoretical limit.

Hector Pulgar

Date of Birth:	April 11, 1977
Place of Birth:	Los Angeles, Chile
B.S.:	March 2001, University of Concepcion, Chile
M.S.:	January 2003, University of Concepcion, Chile
Status:	Working towards Ph.D. in E.E. at UIUC
Professional Interests:	Power Systems

Power system stability considering wind-power generation

Hector Pulgar with advisor P. W. Sauer

Supported by Grainger Endowments

ABSTRACT

Due to the notorious impact on environmental problems and the depletion of fossil fuels, renewable energy sources has been considered appealing to face the forthcoming energy scenario. Among these, hydroelectric power is the most robust and reliable, in addition of having high rated power levels. However, its main drawbacks are the scarce available locations and the negative impact on the local ecosystem by flooding extensive areas. Among the other alternatives, wind power is the most qualified for mass production in power systems. Additionally, it has the fastest payback period, the lowest project gestation period and a low operation-maintenance cost. These attractive characteristics have caused a sustained increment of the worldwide installed wind-power capacity over the last years— it is expected over 150 [GW] by the end of 2009.

The energy scenario is changing and an important percentage of the generation will come from wind power. There is uncertainty about what could be the critical wind power penetration in the system to keep adequate security and reliability levels. Similarly, there is uncertainty about the modes of oscillations in the system and if it will be a detriment in the system frequency response. To answer these questions, appropriate models for wind power generation are required. So far, a reduced order model for a doubly fed induction wind generator has been obtained. System simulations under small and large disturbances are going to be performed. As a preliminary result, wind power has little impact in the small signal stability of a three bus system but it is more crucial under large disturbances. Additionally, reactive power control in a wind farm is an interesting issue that is going to be explored.

Brian Raczkowski

Date of Birth:	September 17, 1981
Place of Birth:	Downers Grove, IL
B.S.:	May 2003, University of Illinois at Urbana-Champaign
M.S.:	August 2005, University of Illinois at Urbana-Champaign
Ph.D.:	May 2009, University of Illinois at Urbana-Champaign
Professional Interests:	Power System Operational Reliability, Wind\Alternative Energy, Electric Machinery

Ensuring Survival of Equilibrium after Any Single Line Outage

Brian C. Raczkowski with advisor P. W. Sauer
Supported by the Grainger Endowments

ABSTRACT

For a given power system network, many lines contribute to the goal of delivering power from point A to point B - some more important than others. There exists the challenge of identifying the lines that need to be upgraded to ensure the existence of an equilibrium condition after any single line outage. The concepts of Static Transfer Stability Limits (STSLs) and Transfer Loss Stability Limits (TLSL) have a strong relation in minimum cutsets of lines. The Line Outage Loss Condition (LOLC) arise from making a discrete event of a line outage into a continuous set of events. These ideas help reveal more information about the system as it approaches static collapse. A method based on the LOLC is proposed for detecting the limiting lines. This method recommends the amount of change in line impedance of the limiting lines to avoid static collapse from line outages. Multiple power system models are analyzed to experimentally support the conjecture and the method.

Renata A. Revelo

Date of Birth: December 17, 1985

Place of Birth: Quito, Ecuador

Permanent Residency: Mundelein, IL

B.S.: May 2007, University of Illinois at Urbana-Champaign

Status: Working towards M.S. at UIUC

Professional Interests: Power Systems, Frequency Regulation, Renewable Energies

Impact Assessment of Plug-in Hybrid Electric Vehicles in Power System Regulation and Control

Renata A. Revelo with advisor Thomas J. Overbye

Supported by PSERC

ABSTRACT

Plug-in Hybrid Electric Vehicles (PHEVs) are emerging as a prominent solution to many questions in automotive technology, clean energy advancements and power systems. In comparison to the hybrid vehicle, a PHEV is equipped with a battery with higher energy density and an electric plug to charge the battery. As a result, the pluggable vehicle is envisioned to accommodate up to 40-mile commutes in all-electric mode. Such an energy capacity unless used, will be idle most of the time as cars are parked the majority of the time. In power systems, the batteries are specially suited to serve for frequency regulation, where generation and demand is matched every two seconds using Automatic Generation Control (AGC).

In this project, various aspects of the regulation scheme using PHEVs have been assessed. An AGC model has been developed to compare the performance of Lithium Ion batteries and generators. This model reassures that PHEVs' batteries are fast responding and are able to accurately respond to a control dispatch signal from the system operator. In addition, a study using supercapacitors as energy buffers has been performed which gives an understanding of the impact supercapacitors have when using them for peak power buffering in the regulation scheme. Finally, a comparative analysis was performed on communication technologies for the regulation scheme, where the three main technologies analyzed include: Ethernet, Power Line Carrier and wireless.

Katherine Rogers

Date of Birth: June 15, 1985

Place of Birth: Houston, Texas

B.S.: May 2007, University of Texas at Austin

Status: Working towards M.S. at UIUC

Professional Interests: Power Systems Analysis, Power System Protection.

Power System Control with D-FACTS Devices

Katherine Rogers with advisor T.J. Overbye

Supported by the Trustworthy Cyber Infrastructure for the Power Grid
and the Power Systems Engineering Research Center

ABSTRACT

Distributed Flexible AC Transmission System (D-FACTS) devices can be placed on transmission lines and used to effectively change line impedances and thus control real or reactive power flow. They are small enough to attach directly to the transmission line and are powered from the line itself. The distributed nature of D-FACTS devices allows the devices to be deployed over a period of time corresponding to demand growth. Some of the power electronics work to develop these devices has been done at Georgia Tech by Prof. D. Divan. Communication and control of FACTS devices are likely to be deciding factors for whether widespread deployment would be feasible in practice. D-FACTS devices must be implemented with a secure communication system; improper control of the devices could have destructive consequences.

In examining the effects of changing line impedance on the power grid, there are many issues to be researched. Losses can lead to more economical operation of a power system, it is crucial to understand the impact these devices could have on system losses. Examining where in the system more losses occur and understanding how those losses are affected by the changing the line impedances can help illustrate which lines, are better choices for installing D-FACTS devices. D-FACTS devices can also be used for line flow control and voltage control. By choosing to target independently-controllable line flows and by selecting the most effective locations and settings for D-FACTS devices to achieve that control, comprehensive power flow control may become a reality. The versatile control over line flows, losses, and voltages provided by D-FACTS devices can be beneficial to utilities and makes them good candidates for wide scale

Pablo Ariel Ruiz

Date of Birth:	August 4, 1978
Place of Birth:	Santa Fe, Argentina
B.S.:	July 2002, Universidad Tecnológica Nacional, Santa Fe, Argentina.
M.S.:	July 2005, University of Illinois at Urbana-Champaign.
Ph.D.:	October 2008, University of Illinois at Urbana-Champaign
Professional Interests:	Power systems computations, planning and economics

Pablo Ariel Ruiz with advisor P. W. Sauer

Supported by a Roberto Rocca Fellowship, Grainger Endowments and AREVA T&D.

ABSTRACTS

Uncertainty Management in the Unit Commitment Problem

Multi-stage decision making, a fundamental tenet of stochastic programming, resonates well with electricity markets. The day-ahead market, used to commit the generators, bears uncertainty in the power demand and physical conditions of the generators and transmission lines. The situation becomes less uncertain in the real-time market, where the dispatch is decided. Although traditional approaches such as operating reserve requirements have been effectively employed to ensure reliable system operations, the incorporation of stochastic methods offer the potential for superior solutions. In this project we propose a general approach for uncertainty management in the unit commitment problem by combining stochastic methods with reserve requirements. Numerical results show that a proper amount of reserve requirement in a stochastic formulation leads to superior unit commitment policies.

Reserve Valuation in Power Systems

Operating reserve is idle capacity connected to the system with the purpose of ensuring reliable system operations in the case of equipment outages and unexpected load variations. The reserve has an economic value since it prevents load shedding. In several electricity markets, reserve demand functions have been implemented to take into account the value of reserve in the market clearing process. These often take the form of a step-down function at the reserve requirement level, and as such they may not appropriately represent the reserve value. The value of spinning reserve is impacted by the reliability and dynamic characteristics of system components, the system operation policies, and the economic aspects such as the risk preferences of the demand. The objective of this project is to compute the reserve value explicitly taking into account all these aspects. The value of reserve is used to build reserve demand functions for electricity markets and to obtain improved reserve requirements for vertically integrated utilities. Numerical results show that the demand functions constructed satisfy the usual reliability criteria.

Sean Safavinejad

Date of Birth: December 30, 1983

Place of Birth: Tehran, Iran.

B.S.: May 2007, University of Illinois at Urbana-Champaign

M.S.: December 2008, University of Illinois at Urbana-Champaign

Professional Interests: Power Systems, Automated Analysis of Distribution Systems

Automated Power Distribution

Sean Safavinejad with advisor Peter Sauer
Supported by Grainger Foundation and ECE Department

ABSTRACT

Advanced distribution automation is a revolutionary approach to managing and controlling distribution systems. It achieves a fully controllable and automated distribution system including the integration of distributed resources to optimize system performance. Designing and operating the distribution system efficiently and economically requires distribution engineers to perform various analytical studies frequently. This project is currently studying automated analysis of such distribution systems.

Jonathan Sander

Date of Birth: July 16, 1984

Place of Birth: St. Louis, Missouri

B.S.: May 2007, University of Illinois at Urbana-Champaign

Status: Working towards M.S. at UIUC

Professional Interests: Power Electronics, Ferroelectric Materials, and Motor Control.

Degradation Mitigation of Ferroelectric Electrodes

Jonathan Sander with advisor P.L. Chapman and Charles Marsh

Supported by U.S. Army Corps of Engineers CERL

ABSTRACT

Ferroelectric electrodes provide a promising new means of high-density electron current emission for use in a variety of applications including X-ray devices and lasers. Application of a high voltage signal induces breakdown on the surface of the crystals yielding electron beams with currents in excess of 0.2A/cm^2. Unfortunately, a serious limitation of the devices is their short lifespan due to surface degradation and pitting. It is believed that plasma formed on the surface of the crystal strips atoms off of the crystal face in an effort to sustain its discharge. Also, charge imbalance as a result of electron emission may cause heavy ions in the plasma to impact the surface at high velocities, further exacerbating the degradation effect. This project aims to address these issues by offering alternative means for plasma formation while still maintaining the high current densities as well as investigating the addition of sacrificial electrodes to minimize sputtering from ion bombardment.

Arash Sayyah

Date of Birth: September 6, 1983

Place of Birth: Shiraz, IRAN

B.S.: June 2007, Shahid Beheshti University, Tehran, IRAN

Status: Working towards M.S. at UIUC

Professional Interests: Biomechanical Energy Harvesting, Optimization and Control Theory.

Harvesting Walking Energy for Mobile Electronics

Arash Sayyah with advisor P.L. Chapman

Supported by the National Science Foundation

ABSTRACT

The growing use of portable electronic devices, such as cellular phones, personal digital assistants, music players, and so forth, has caused increasing demand for mobile power delivery. Power is a limiting factor in the use of mobile devices, which is currently served mainly by lithium-ion batteries that are nearing their practical limits. By harvesting energy normally wasted from ordinary human activity, this problem may be alleviated. So far researchers in the field have concentrated on putting devices in the shoe. Due to almost no mechanical work (force times distance) on a hard surface under normal circumstances, such “heel-strike” devices have permitted only small levels of electrical energy generation (10 mW to 20 mW). Although one can make the shoe compliant so that the foot moves a small distance, this is problematic because increasing compliance leads to declining maneuverability and stability. Although considerable effort has done in this field, the small magnitude of the mechanical energy source still remains a limitation.

In prior works, it has been shown that magnetic generators are likely to have the highest power output, showed significantly more power than heel-strike devices, but was inefficient and heavy due to the complicated mechanical apparatus. Small electric generators, connected to loads through sophisticated power electronics, would provide an alternative power source. The project seeks to minimize the parasitic weight of such a generating device while also providing electrical power storage and utilization. In addition, the effort would seek to optimize the effects of the other human loading such as carrying efficiency.

Pradeep Shenoy

Date of Birth: June 6, 1985

Place of Birth: Silver Spring, Maryland

B.S.: May 2007, Illinois Institute of Technology, Chicago, IL

Status: Working towards M.S. at UIUC

Professional Interests: Power Electronics, Digital Control, Alternative Energy Applications

Uneven Load Sharing in ISOP Push-pull Converters with Local Control

Pradeep Shenoy with advisor Phil Krein

Supported by the National Science Foundation under grant ECS 06-21643

Input series-output parallel (ISOP) converters are especially useful when stepping down the voltage in systems with a high voltage ratio. Simply based on the structure of the converter, the total input voltage is divided among the modules (sometimes called cells or phases), and the output voltage for each module is the same as the other modules. Similarly, each converter module has the same input current and provides a portion of the total load current. The push-pull topology is well suited for the ISOP approach since it provides isolation and has balanced magnetics.

The current research project is exploring how an ISOP converter will behave when the push-pull modules are designed to unevenly share the load current based on their power rating. The goal is to have truly independent modules with that are locally controlled using sensorless current mode (SCM) control instead of by a supervisory controller. Interleaving the switching times of the modules is a challenging task when the modules are controlled locally. Switch interleaving results in lower output ripple and allows the output filter of the converter to be smaller. Applications of this research range from sleep modes on electronic devices to easily expandable computer server power supplies.

Viboon Sithimolada

Date of Birth:	October 12, 1978
Place of Birth:	Vientiane, Laos
B.S.:	December 2002, Royal Melbourne Institute Technology University, Melbourne, Australia
Status:	Working towards M.S. at UIUC
Professional Interests:	Power System Reliability, Data Center Power Distribution, and Smart Grid

Facility-level DC vs. Conventional AC Distribution for Critical Data Center Loads: A Comparative Reliability Analysis

Viboon Sithimolada with advisor P. Sauer

ABSTRACT

Today's large data centers constitute some of the most highly energy-intensive and fastest growing loads. A data center houses IT equipment such as servers and storage devices that are essentially DC-based loads. Therefore, by deploying a facility-level DC distribution rather than a conventional AC system, a number of conversion steps in the power delivery system can be eliminated, and so distribution losses are substantially reduced. However, to make a case for a widespread adoption of the DC system, reliability needs to be extensively investigated, as power failures can significantly impact the uptime of the critical loads in data centers. This project carries out a comparative reliability analysis of the DC distribution (in a range of 400 V) versus the typical AC distribution. Reliability function and inherent availability are used as the quantitative reliability metrics. Reliability models for various common configurations are developed and assumptions are established to allow a meaningful comparison and evaluation between the two systems.

Sebastian Smater

Date of Birth:	July 24, 1984
Place of Birth:	Warsaw, Poland
B.Eng.:	February 2007, Warsaw University of Technology
M.Eng.:	June 2008, Warsaw University of Technology
Status:	Working towards M.S. at University of Illinois at Urbana Champaign
Professional Interests:	Power Systems Protection, Control and Dynamics, Wind Energy in Power System Operational Reliability and Control

Mechanism for Reliable Operation of Wind Turbines after Grid Disturbances

Sebastian Smater with advisor Alejandro Dominguez-Garcia

ABSTRACT

With the increase of wind power penetration new means of control and protection of power system have to be developed. Research in this field is essential to maintain the high level of system reliability with economically reasonable costs of overall generation. In systems with small wind power penetration wind turbines are shutdown during a close grid disturbance. Unfortunately this type of operation is not desired for high penetration. Sudden shutdown of large wind farms will cause frequency and voltage stability problems. This is why many grid operators demand that newly installed wind turbines have to support the system with active and reactive power during grid disturbance. This requirement has high impact on wind turbine design and control and what is more on power system operation and reliability. The strategy that wind turbine has to follow during a grid disturbance may also depend on disturbance type and duration. For example different reactions have to be created for lightning strike than for reactive power imbalance after far short-circuit. Lightning strike may require fast converter reaction or another way of dissipating gathered energy. At the same time, supporting system with additional amount of reactive power after system disturbance may create need for additional energy storage devices. Currently three main sources of wind turbine power control are pitching of rotor blades, stall control and electrical converter control. Problem of adequate turbine behavior during a grid disturbance may be solved mainly by proper converter algorithm design (only for Doubly Fed Induction Generators or Generators with Full Conversion) and by using energy storage or energy dissipation device. What is also important, this new turbine reaction and behavior has to be properly modeled and included into power system design and control. It may be beneficial to develop a probability-informed optimization framework that will include statistical data with possible correlations such as disturbance causes, their effect on the grid and wind variability. The result of this study will yield the optimal solution in terms of equipment and operational reliability.

Zeb Tate

Date of Birth:	December 16, 1980
Place of Birth:	Opelousas, Louisiana
B.S.:	May 2003, Louisiana Tech University
M.S.:	May 2005, University of Illinois at Urbana-Champaign
Ph.D.:	October 2008, University of Illinois at Urbana-Champaign
Professional Interests:	Power System simulation, visualization and operation

Current Research Topics:

- Event detection based on phasor measurement unit (PMU) data
- Rapid visualization of power system information using graphics processing unit (GPU) programming techniques
- Development of interactive educational materials for K-12 education

Line Outage Detection with Phasor Measurement Units

Zeb Tate with Advisor T. Overbye

Supported by a NSF Graduate Research Fellowship and the Trustworthy Cyber Infrastructure for the Power Grid project

ABSTRACT

The deployment of phasor measurement units (PMUs) throughout the power grid has increased substantially in recent years, and this growth is expected to continue. With these new measurement devices, new techniques must be developed to take advantage of the wealth of information that they provide. My work focuses on how the voltage and current phasor angles obtained from these PMUs can be used to increase the wide-area situational awareness of grid operators through improved processing and presentation techniques. Using PMU data to detect single line outages on both small- and large-sized power systems has already been demonstrated, and we are continuing to investigate the applicability of these methods in detecting other event types, e.g., generator outages and simultaneous line outages. In addition, we are investigating how utilizing graphical processing units (GPUs) can significantly improve the performance of power system visualizations and allow for direct visualization of PMU data.

Marco J. Tavernini

Date of Birth:	May 20, 1984
Place of Birth:	Norwood, Massachusetts
B.S.:	May 2003, Boston University, Boston, Massachusetts
Status:	Working towards M.S. at UIUC
Professional Interests:	Power Electronics, Alternative Power and Energy Systems

Real-time low-level simulation of hybrid vehicle systems for hardware-in-the-loop applications

Marco J. Tavernini with advisor Philip T. Krein
Supported by the Grainger Center for Electric Machinery and Electromechanics

ABSTRACT

Possessing the capability to run a low-level simulation of a hybrid electric vehicle in real-time has the potential to open the doors to new means of automotive system analysis. With the ever increasing processing power of today's computing resources, what was thought of a few years ago as only a dream can now be achieved. A real-time capable simulation clears the way for a hardware-in-the-loop (HIL) test bed to be constructed, allowing for in-the-loop testing and evaluation of components of the hybrid vehicle's drive train and energy storage system. This would enable a means of rapidly evaluating different vehicle configurations, including the size of the battery pack, the aerodynamics of the vehicle, or the type of motor control being used.

Figure 1 below shows the basic layout of the proposed HIL simulator. A personal computer running a real time operation system is at the heart of the design, acting as central processing and coordination entity charged with performing the dynamic calculations of the vehicle behavior as the vehicle traverses the programmed drive cycle. The computer directs the attached hardware to perform as it would in a real vehicle, and the dynamic responses of the components under test are relayed back to the simulation for interpretation and evaluation. The key components to be interfaced are the battery pack and motor drive, allowing for efficient and fast evaluation of different components available, and as a result reducing development time and cost.

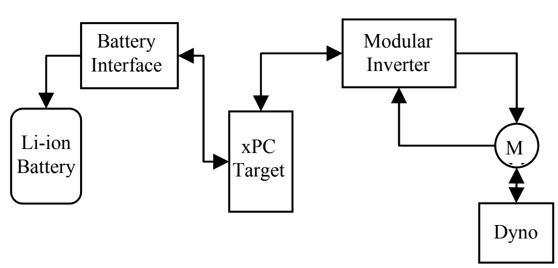

Fig. 1: High level overview of the hardware-in-the-loop simulator

Gui Wang

Date of Birth:	September 13, 1982
Place of Birth:	Nanyang, China
B.S.:	July 2004, Xi'an Jiaotong University, China
M.S.:	June 2007, Xi'an Jiaotong University, China
Status:	Working towards Ph.D. at UIUC
Professional Interests:	Electricity Markets, Power System Economics

Existence of Equilibriums and the Incentive Effects of Side Payments in Competitive Electricity Markets under Discrete Decisions

Gui Wang with advisor G. Gross

ABSTRACT

The physical characteristics of generation resources introduce discrete decisions into electricity markets arising with the need to explicitly consider the costly start-up and shut-down processes of generation units. These discrete decisions invalidate the continuity and convexity assumptions widely employed in the economics literature. The objective of our research is to analytically characterize the impacts of these discrete decisions so as to provide guidelines for market design of competitive electricity markets. We focus on the widely adopted electricity market auction mechanism for unit-commitment-based day-ahead markets with fixed demands. Under a set of assumptions, we determine sufficient and necessary conditions for the existence of an equilibrium in such a market. Furthermore, such an equilibrium established by the ISO in a market with all the sellers being price-takers is a competitive equilibrium. Unfortunately, the conditions fail to hold in a unit-commitment-based day-ahead market because of the complications that arise from the need to consider the start-up and no-load prices and the physical constraints on generating units. One way an ISO can clear the market is by the introduction of an uplift mechanism, through which additional payments are made to the sellers so as to explicitly account for the unit commitment effects. We study the impacts of this unit commitment uplift mechanism on the sellers' behavior by analyzing the incentive effects the sellers receive. We compare these effects and the resulting prices that the buyers must pay to those under a benchmark truth-revealing auction. Our analysis indicates that in the uniform-price auctions used by an ISO with uplift payments, sellers can easily mark up their offers. In this way, the resulting prices may exceed those in the benchmark auction.

Piotr Wiczkowski

Date of Birth: August 28, 1985

Place of Birth: Krakow, Poland

B.S.: May 2007, University of Illinois at Urbana-Champaign

Ph.D.: December 2008, University of Illinois at Urbana-Champaign

Professional Interests: Power Electronics, Renewable Energy Systems

Wind Powered Electrical Systems – Highway Rest Areas and Weigh Stations and Team Section Buildings

Piotr Wiczkowski with advisor P.L. Chapman

Supported by the Illinois Department of Transportation

ABSTRACT

The Illinois Department of Transportation (IDOT) has expressed interest in supplying many of their sites with clean renewable wind energy. These sites include all of their rest areas, weigh stations, and team section buildings operated by IDOT within Illinois. For every of the more than 75 sites historical minute-by-minute data is being analyzed and compared with wind turbines available on the market to maximize potential power output. The project also includes a financial analysis that will help the IDOT come to final decisions on an individual site by site basis.

Leilei Xiong

Date of Birth: May 5, 1987

Place of Birth: Shanghai, P.R. China

B.S.: December 2007, University of Illinois at Urbana-Champaign

Status: Working towards M.S. at UIUC

Professional Interests: Power systems, numerical analysis, and visualization.

Visualizing Market Power in Real-Time Electric Power Systems

Leilei Xiong with advisor T. J. Overbye

Supported by the Consortium for Electric Reliability Technology Solutions

ABSTRACT

Identifying the abuse of market power by generating firms in deregulated electricity markets is frequently difficult, because the true costs of generation have become private information, which are not disclosed to market operators except by special request. Rapid identification of market power abuse is increasingly important as government oversight of the market has been drastically reduced. The ability to visualize market power can aid in spotting trends in the abuse of market power and facilitate a better understanding of the complex dynamics of the deregulated energy market. Effective visualization tools are developed to communicate the scale and severity of abuses to policymakers and to the public.

Rodney Yeu

Date of Birth:	December 16, 1979
Place of Birth:	Seoul, Korea
B.S.:	December 2002, University of Illinois at Urbana-Champaign
M.S.:	December 2004, University of Illinois at Urbana-Champaign
Status:	Working towards Ph.D. at UIUC

Tracking of Unstable Eignevalues

Rodney Yeu with adviser P. W. Sauer
Supported by Grainger Endowments

Small signal stability analysis of a power system is done to determine if the power system can withstand small disturbances and operate in a satisfactory manner. This is traditionally done by looking at the eigenvalues of a linearized power system. Once it is found that a power system is unstable a corrective measure needs to be taken place so that instability does not result.

One common problem that exists in the modern power system is low frequency oscillations that lead to instability. This problem was solved by using power system stabilizer (PSS) to damp out the unwanted oscillations. A question that arises from the use of PSS is to which machine a PSS should be placed. Traditionally sensitivity analysis of the eigenvalues was done to determine which states participate the most to instability and a PSS is placed at the machines with those states.

In this research a new method for the placement of PSS was developed. This method tracks the eigenvalues of the power system as it is being decoupled to a system of single machine infinite buses. The mode associated with the single machine that tracks backs to the unstable mode of the power system determine where the PSS should be placed.

7. LABORATORY FACILITIES

The Power Area has assembled some of the nation's finest facilities for experimental and computer-based research and teaching. Both undergraduate and graduate students can take advantage of these facilities. These laboratories have generated wide interest.

The Grainger Power Engineering Software Laboratory is located near the office areas on the third floor of Everitt Laboratory. The Laboratory has eleven advanced personal computers. All stations are connected to the campus network and Internet.

A major objective of the laboratory is to develop an extensive library of commercial software and large-scale databases for power area applications. Software is based on Windows XP. Some of the commercial software packages currently in use include:

Mathematica (an advanced symbolic mathematics package)
Matlab and Simulink
Mathcad
PSS/E (Power Technologies Inc. Software Package)
RISKSYM (Henwood package for energy market analysis)
PowerWorld
Power System Tool Box (PST Version 2.0)
Dymola (general-purpose simulation environment with hierarchy)
acslXtreme (general-purpose simulation environment)
ANSYS (finite element modeling)
Ansoft Maxwell and RMxprt (finite element modeling specific to electromagnetics)
The software library is being expanded continually.

The **Grainger Electrical Machinery Laboratory** is located on the ground floor of Everitt Laboratory. This facility is primarily for undergraduate teaching, and is used for ECE 431, ECE 469, many ECE 445 projects, and student projects including the Future Energy Challenge. Ten self-contained machinery workstations are available. Each has an integral horsepower machine set with a servo-based dynamometer. Instrumentation includes digital wattmeters, oscilloscope, speed and torque displays, and other electronic support instruments. The equipment is suitable for the study of induction, synchronous, and dc machines. Small portable machine sets are used to introduce stepper motors and brushless dc machines. Transformers, resistor units, capacitors, SCR circuits, and power FET units are provided to support a full range of experiments in all aspects of power and power electronics. The facility has a dedicated 225 kVA three-phase supply and a 50 kW dc rectifier bank.

The **Advanced Power Applications Laboratory** is adjacent to the Grainger Electrical Machinery Laboratory. This laboratory serves as a general research facility for all hardware aspects of power electronics, machines, and power systems. The laboratory shares motor test sets with the Machinery Lab, with an additional precision dynamometer for more advanced studies. Additional equipment is available for the study of harmonic effects, high-performance switching converters, and digitally-controlled converters and drives. Computers are available throughout the laboratory for automation of experiments using LabView, Matlab, and other software environments. The Simulink Real-Time Toolbox is an important component. Additional laboratory space is available on the third floor of Everitt for low-power experiments.

8. DIRECTORY

THE UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
COLLEGE OF ENGINEERING

Ilesanmi Adesida, Dean of Engineering
(217) 333-3097
iadesida.uiuc.edu

Michael B. Bragg, Executive Associate Dean for Academic Affairs
(217) 333-2152
mbragg@uiuc.edu

Molly Tracy, Associate Dean for Development
(217) 244-9918
mollyt@uiuc.edu

Bruce A. Vojak, Associate Dean for Administration
(217) 333-6057
bvojak@uiuc.edu

Umberto Ravaioli, Interim Associate Dean for Undergraduate Education and Programs
(217) 333-2280
ravaioli@uiuc.edu

Victoria L. Coverstone, Associate Dean for Graduate and Professional Education
217-333-0678
vcc@uiuc.edu

Addresses: University of Illinois College of Engineering
306 Engineering Hall
1308 W. Green St.
Urbana, IL 61801
Fax: (217) 244-7705
www.engr.uiuc.edu

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING ADMINISTRATION

Prof. Andreas Cangellaris, Interim Head
(217) 333-2301
blahut@uiuc.edu

Prof. Steven Bishop, Associate Head Graduate Affairs
(217) 333-2302
sgbishop@uiuc.edu

Prof. Erhan Kudeki, Associate Head Undergraduate Affairs
(217) 333-0716
erhan@uiuc.edu

Ms. Jeannette Beck, Assistant to the Head
(217) 333-9699
jgbeck@uiuc.edu

Ms. Beth Katsinas, Director of External Relations
(217) 265-8749
katsinas@ad.uiuc.edu

Address: University of Illinois at Urbana-Champaign
Department of Electrical and Computer Engineering
Everitt Laboratory
1406 W. Green St., MC702
Urbana, IL 61801
Fax: (217) 333-1162
www.ece.uiuc.edu

POWER AND ENERGY SYSTEMS AREA

Josh McNattin, Secretary
(217) 333-6592
mcnattin@illinois.edu

Prof. Peter W. Sauer, Director of Power Affiliates Program
(217) 333-0394
psauer@illinois.edu

Prof. Patrick Chapman
(217) 333-4694
plchapma@illinois.edu

Prof. Alejandro Domínguez-García
(217) 333-3953
aledan@illinois.edu

Prof. George Gross
(217) 244-1228
gross@illinois.edu

Prof. Philip T. Krein
(217) 333-4732
krein@illinois.edu

Prof. Thomas J. Overbye
(217) 333-4463
overbye@illnois.edu

Prof. M. A. Pai
(217) 333-6790
mapai@illinois.edu

Kevin Colravy, Research Engineer
(217) 333-1056
colravy@illinois.edu

Address: University of Illinois at Urbana-Champaign
Department of Electrical and Computer Engineering
1406 W. Green Street, MC-702
Urbana, IL 61801
Fax: 217-333-1162
energy.ece.illinois.edu

ADVANCED ANALOGIC TECHNOLOGIES, INC.

Mr. Richard Williams
Advanced Analogic Technologies, Inc.
830 East Arques Avenue
Sunnyvale, CA 94085

Mr. Kevin D'Angelo
Advanced Analogic Technologies, Inc.
830 East Arques Avenue
Sunnyvale, CA 94085

AMEREN

Dr. Kirit Shah
Ameren Services
1901 Chouteau Avenue
P.O. Box 149
St. Louis, MO 63166
kshah@ameren.com

Mr. Joseph G. Jaegers
Ameren Services
1901 Chouteau Avenue
P.O. Box 149
St. Louis, MO 63166

BITRODE CORPORATION

Mr. Kevin Kepley
1642 Manufacturers Drive
Fenton, MO 63026
(636)343-6112
kkepley@bitrode.com

BP AMERICA

Ms. Keri Fieser
BP America
2815 Indianapolis Boulevard
P.O. Box 710
Whiting, IN 46394-0710
(219)395-2611
fieserkj@bp.com

CITY WATER, LIGHT AND POWER, SPRINGFIELD, IL

Mr. Karl E. Kohlrus
City Water, Light and Power
1000 E. Miller Street
Springfield, IL 62757
(217)789-2120
kkohlrus@cwlp.com

ELECTRICAL MANUFACTURING AND COIL WINDING ASSOCIATION, INC.

Mr. Charles E. Thurman
EMCWA
P.O. Box 278
Imperial Beach, CA 91933
(619)575-4191
cthurman@emcwa.org

EXELON

Ms. Jennifer Sterling
Exelon
Two Lincoln Centre
Oakbrook Terrace, IL 60181
(630)437-2764
Thomas.kay@exeloncorp.com

Mr. Tom Kay
Exelon
Two Lincoln Centre
Oakbrook Terrace, IL 60181
(630)437-2758
Thomas.kay@exeloncorp.com

MIDAMERICAN ENERGY COMPANY

Mr. Richard W. Polesky
MidAmerican Energy
One River Center Place
106 E. Second Street, P.O. Box 4350
Davenport, IA 52801
(319)333-8187
rupolesky@midamerican.com

PATRICK ENGINEERING

Mr. William Winnerling
Patrick Engineering
4970 Varsity Drive
Lisle, IL 60532
(630)795-7428, Fax: (630)724-9290
bwinnerling@patrickengineering.com

POWERWORLD CORPORATION

Dr. Mark Laufenberg
PowerWorld Corporation
1816 South Oak Street
Champaign, IL 61820
(217)384-6330
lauf@powerworld.com

Dr. James Weber
PowerWorld Corporation
1816 South Oak Street
Champaign, IL 61820
(2178)384-6330
weber@powerworld.com

S & C ELECTRIC COMPANY

Dr. William Kennedy
S&C Electric Company
6601 North Ridge Boulevard
Chicago, IL 60626
(773)338-1000
BKennedy@sandc.com

Dr. Michael G. Ennis
S&C Electric Company
6601 North Ridge Boulevard
Chicago, IL 60626-3997
(773)338-1000
mennis@sandc.com

SARGENT & LUNDY ENGINEERS

Ms. Carol Talaronek
Sargent & Lundy Engineers
55 East Monroe Street
Chicago, IL 60603
(312)269-3578
CAROLTALARONEK@sargentlundy.com
Or contact Linda Kelnosky
Linda.e.kelnosky@sargentlundy.com

Mr. Roger Schiavoni
Sargent & Lundy Engineers
55 East Monroe Street
Chicago, IL 60603
(312)269-6246
Roger.m.schiavoni@sargentlundy.com

9. REFERENCES AND PUBLICATIONS

[1] A. Davoudi, P.L. Chapman, and J. Jatskevich, "State-space average-value modeling of capacitor-based switching stages: including conduction losses," Electronics Letters, vol. 43, no. 16, pp. 893-895, August 2008.

[2] N. Benavides and P.L. Chapman, "Mass-optimal design methodology for dc-dc converters in low-power, portable fuel cell applications," IEEE Transactions on Power Electronics, vol. 23, no. 3, pp. 1545-1555, May 2008.

[3] A. Khaligh, P.L. Chapman, J.R. Wells, and P.T. Krein, "Dead-time distortion in generalized selective harmonic control," IEEE Transactions on Power Electronics, vol. 23, no. 3, pp. 1511-1517, May 2008.

[4] H.-C. Seo, S.J. Hong, H.-I. Cho, J.-H. Lee, P.L. Chapman, and K. Kim, "Formation of low-resistance ohmic contact by damage-proof selective-area growth of single-crystal n+-GaN using plasma assisted molecular beam epitaxy (PAMBE)", Journal of Electronic Materials, Vol. 37, pp. 635-640, 2008.

[5] N. Benavides and P.L. Chapman, "Modeling the effect of voltage ripple on the power output of photovoltaic modules," IEEE Transactions on Industrial Electronics, vol. 55, no. 7, pp. 2638-2643, July 2008.

[6] A. Davoudi, Jatskevich, and P.L. Chapman, "Computer-aided dynamic characterization of fourth-order PWM dc-dc converters," IEEE Transactions on Circuits and Systems II: Express Briefs, vol. 55, no. 10, pp. 1021-1025, October, 2008.

[7] H.-C. Seo, P.L. Chapman, H.-I. Cho, J.-H. Lee, and K. Kim, "Ti-based nonalloyed metal contacts for Al_0.15Ga_0.85N/GaN high electron mobility transistors using regrown n+-GaN by plasma assisted molecular beam epitaxy," Applied Physics Letters, 93 (102102), 2008.

[8] G. Gallo, J. Popovic, M.S. Johnson, and P.L. Chapman, "Passive and active corrosion sensing for metals using magnetic sensors," in Proceedings of SPIE - The International Society for Optical Engineering, v 6935, Health Monitoring of Structural and Biological Systems, 2008, pp. 69350U-1-69350U-6.

[9] A. Khaligh and P.L. Chapman, "Reduction of Output Capacitance in Dc-Dc Converters using Anticipated Load Transients," IEEE 2008 Applied Power Electronics Conference, pp. 818-823.

[10] P. Niu, P.L. Chapman, L. DiBerardino, and E.T. Hsiao-Weckler, "Design and optimization of a biomechanical energy harvesting device," in 2008 IEEE Power Electronics Specialists Conference, pp. 4062-4069.

[11] A. Davoudi, P.L. Chapman, and J. Jatskevich, "Nonlinear order reduction in dynamic magnetic equivalent circuits of electromechanic actuators : incorporating relative motion and back EMF," in 20087 IEEE Power Electronics Specialists Conference, pp. 3992-3995.

[12] Y. Chen, A. Davoudi, and P.L. Chapman, "Multifrequency modeling of a multiple-input dc-dc converter," in 2008 IEEE Power Electronics Specialists Conference, pp. 4604-4610.

[13] L. Qu and P.L. Chapman, "Extraction of dynamic low-order models for multiwinding magnetic devices based on finite element analysis," in 2008 IEEE Power Electronics Specialists Conference, pp. 4611-4616.

[14] Ali Davoudi, Patrick L. Chapman, and Juri Jatskevich, "Multi-resolution simulation of PWM dc-dc converters," Accepted in IEEE International Telecommunications Energy Conference (INTELEC '08), February 2008.

[15] Sina Chiniforoosh, Pooya Alaeinovin, Ali Davoudi, Juri Jatskevich, and Patrick L. Chapman, “Numerical average-value modeling of a micro wind turbine generator system,” IEEE International Telecommunications Energy Conference (INTELEC’08), February 2008.

[16] A. Davoudi, A. Bazzi, and P.L. Chapman, "Application of Synergetic Control Theory to Non-Sinusoidal PMSMs via Multiple Reference Frame Theory," in 2008 IEEE Industrial Application Society Annual Conference, in press.

[17] P. Alaeinovin, S. Chiniforoosh, A. Davoudi, J. Jatskevich, and Patrick L. Chapman, "Average-Value Modeling of Automotive Alternator-Rectifier Systems," in 2008 IEEE Industrial Application Society Annual Conference, in press.

[18] P.T. Krein, R. Balog, T. Esram, B. Kuhn, and P.L. Chapman, "The meaning of grid parity in power electronics," Energy 2030 Conference, Atlanta, GA, 2008.

[19] A. D. Dominguez-Garcia, J. G. Kassakian, and J. E. Schindall, and J. J. Zinchuk, "An integrated methodology for the dynamic performance and reliability evaluation of fault-tolerant systems," Journal of Reliability Engineering & System Safety, vol. 93, no. 11, pp 1628-1649, Nov 2008.

[20] A. D. Dominguez-Garcia and P. T. Krein, "Integrating Reliability into the Design of Fault-Tolerant Power Electronic Systems," in Proceeding of the 39th IEEE Power Electronics Specialist Conference, Rodhes, Greece, June 2008.

[21] A. D. Dominguez-Garcia and P. T. Krein, "A Framework for Multi-Level Reliability Evaluation of Electrical Energy Systems," IEEE Conference on Global Sustainable Infrastructure, Atlanta, GA, November 2008.

[22] P. A. Ruiz and G. Gross, "Short-Term Resource Adequacy in Electricity Market Design," IEEE Transactions on Power Systems, vol. 23, no 3, pp.916-926, August 2008.

[23] M. Liu and G. Gross, "Congestion Rents and FTR Evaluations in Mixed Pool-Bilateral Systems," International Journal of Electrical Power and Energy Systems, vol. 30, 2008.

[24] L. de Castro, M. Negrete-Pincetic and G. Gross, “Product Definition for Future Electricity Supply Auctions: The 2006 Illinois Experience,” The Electricity Journal, vol. 21, issue 7, pp. 50-62, August-September 2008.

[25] M. LeMay, R. Nelli, G. Gross, and C. A. Gunter, " An Integrated Architecture for Demand Response Communications and Control," Proceedings of the 41st Hawaii International Conference on System Sciences, January 2008.

[26] J. Contreras, G. Gross, I. Ruiz–Gómez and J. M. Arroyo, “A Scheme For Incentivizing Investments And Cost Sharing In Transmission Enhancements,” Proc. PSCC XVI, Glasgow, July 2008.

[27] E. Bompard, G. Gross, R. Napoli and F. Xue, "The Analysys Of Information Impacts In Coordinating Defense Against Malicious Attacks For Interconnected Power Systems, " Proc. PSCC XVI, Glasgow, July 2008.

[28] G. Gross and M. Negrete-Pincetic, “Management of Uncertainty in Supply Contract Auctions,” Proceedings of the IEEE PES General Meeting, Pittsburgh, PA, July 20 - 24 2008.

[29] T. Güler, G. Gross, E. Litvinov and R. Coutu, "Economic Impacts of Security Criterion Compliance," Proceedings of the IEEE PES General Mtg, Pittsburgh, PA, Jul. 20 - 24 2008.

[30] G. Chicco and G. Gross, "Current Issues In Reactive Power Management: A Critical Overview," Proceedings of the IEEE PES General Meeting, Pittsburgh, PA, July 20 - 24 2008.

[31] Pablo A. Ruiz and Peter W. Sauer, “Spinning Contingency Reserve: Economic Value and Demand Functions”, IEEE Transactions on Power Systems, Vol. 23, No. 3, pp. 1071-1078, August, 2008.

[32] Pablo A. Ruiz and Peter W. Sauer, “Valuation of Reserve Services”, Proceedings 2008 Hawaii International Conference on System Sciences, Waikoloa, HI, pp. 1-9, January 2008.

[33] P. A. Ruiz, C. R. Philbrick, E. Zak, K. W. Cheung, P. W. Sauer, “Applying Stochastic Programming to the Unit Commitment Problem”, ID number 98, Proceedings, 10th International Conference on Probabilistic Methods Applied to Power Systems, Rincon, Puerto Rico, May 27, 2008

[34] P. A. Ruiz and P. W. Sauer, “Spinning Contingency Reserve Valuation in Systems with Non-Identical Generators”, ID number 98, Proceedings, 10th International Conference on Probabilistic Methods Applied to Power Systems, Rincon, Puerto Rico, May 27, 2008

[35] J.E. Tate, T.J. Overbye, J.S. Sebestik, G. Reese, "Interactive lessons for pre-university power education," IEEE Transactions on Power Systems, vol. PWRS-23, pp. 824-830, Aug 2008.

[36] J.E. Tate, T.J. Overbye, "Line Outage Detection using Phasor Angle Measurements," IEEE Transactions on Power Systems, vol. PWRS-23, pp 1644-1652, Nov 2008.

[37] J.E. Tate, T.J. Overbye, "Contouring for power systems using graphical processing units," Proc. 41st Hawaii International Conference on System Sciences, Waikoloa, HI, January 2008.

[38] T.J. Overbye, "Wide-area power system visualization with geographic data views," Proc. IEEE PES 2008 General Meeting, Pittsburgh, PA, July 2008.

[39] T.J. Overbye, "Visualization enhancements for power system situational assessment," Proc. IEEE PES 2008 General Meeting, Pittsburgh, PA, July 2008.

[40] T.J. Overbye, "Integration of realistic simulation software with design into a power system curriculum: power flow and transient stability case studies," Proc. IEEE PES 2008 General Meeting, Pittsburgh, PA, July 2008.

[41] J.E. Tate, J. Sebestik, T.J. Overbye, "Collaboration and dissemination efforts related to pre-university power lessons," Proc. IEEE PES 2008 General Meeting, Pittsburgh, PA, July 2008.

[42] J. Cardell, I. Dobson, W. Jewell, M. Kezunovic, T.J. Overbye, P.K. Sen, D. Tylavsky, L. Beard, F. Galvan, D. Hawkins, "The electric power industry and climate change: US research needs," Proc. IEEE PES 2008 General Meeting, Pittsburgh, PA, July 2008.

[43] C. Roe, A.P. Meliopoulos, J. Meisel, T.J. Overbye, "Power system level impacts of plug-in hybrid electric vehicles using simulation data," Proc. IEEE Energy 2030 Conference, Atlanta, GA, Nov 2008.