

Curriculum Vitae

1. Judith B. Cardell

2. Address

352 Ford Hall
100 Green Street
Smith College
Northampton, MA 01063
(413) 585-4222

3. Degrees

Doctorate: August 1997; Massachusetts Institute of Technology
Dissertation: Control Strategies and Dynamic Pricing for Small Scale
Distributed Generation in a Deregulated Market

Master's: February 1994; Massachusetts Institute of Technology
Technology and policy; electric power engineering

Bachelor's: May 1989; Cornell University BS in electrical engineering
 May 1989; Cornell University AB in government

4. Awards and Honors

- Best Thesis on Technology and Policy, MIT, 1998.
- MIT Graduate Student Council Teaching Award, 1994.
- Alfred Keil Fellowship for the Wiser Uses of Science and Technology, MIT, 1994.
- Bernard Rabinowitz Fellowship for Leadership and Service, MIT, 1994.
- Tau Beta Pi honor society.
- Eta Kappa Nu honor society.

5. Employment History

Associate Professor 2008 to present
Smith College, Northampton, MA.
Joint appointment in the Picker Engineering Program and Department of Computer Science.
Chair of Smith College Committee on Sustainability

Clare Boothe Luce Assistant Professor of Computer Engineering 2002 to 2007
Smith College, Northampton, MA.
Joint appointment in the Picker Engineering Program and Department of Computer Science.

Adjunct Associate Professor 2008 to present
School of Electrical and Computer Engineering, Cornell University, Ithaca, NY.

Visiting Assistant Professor 2006 to 2007
School of Electrical and Computer Engineering, Cornell University, Ithaca, NY.

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- Lecturer in Technology and Policy** Spring, 2002
Massachusetts Institute of Technology, Cambridge, MA.
 Led a graduate level seminar on Energy Systems and Economic Policy Development.
- Senior Associate** 2000 to 2002
Tabors Caramanis & Associates, Cambridge, MA.
 Consultant analyzing electric power systems, electricity policy and market issues.
- Electrical Engineer and Policy Analyst** 1997 to 2000
Federal Energy Regulatory Commission, Washington, DC.
 Participated in developing Commission policy for industry restructuring, corporate mergers and regional transmission organizations.
- Graduate Instructor in Energy Systems and Economic Development** 1994 to 1996
Massachusetts Institute of Technology, Cambridge, MA.
 Developed curriculum for masters level seminar course.
- Teaching Assistant in Regulation and Electricity Economics** Summer 1995
University of Strathclyde, Scotland
 Developed curriculum modules for the University of Strathclyde, Scotland
- Research Assistant** Summer 1995
Harvard Electricity Policy Group, Cambridge, MA.
 Researched issues of potential market power in the restructured electric power industry.
- Teaching Assistant in Technology and Policy** 1993 to 1994
 Massachusetts Institute of Technology, Cambridge, MA.
- Policy Analyst** Summer 1994
Union of Concerned Scientists, Cambridge, MA.
 Researched and documented the technical and economic potential for renewable, distributed generation and storage technologies in the Boston Edison service territory.
- Signal Integrity Engineer** 1989 to 1991
Digital Equipment Corporation, Boxboro, MA.
 Analog design engineer for the Alpha processor module and Laser memory boards.
- Engineering Co-op Student** 1986 to 1989
Digital Equipment Corporation, Littleton, MA.
 Software engineer with VAX computer architecture group.

6. Peer Refereed Publications

Chin Yen Tee and Judith B. Cardell, "Market Integration of Distributed Resources through Coordinated Frequency and Price Droop," under revision for *IEEE Transactions on Power Systems*.

C.L. Anderson and J. B. Cardell, "A Decision Framework for Optimal Pairing of Wind and Demand Response Resources," under revision for the *Special Issue in the IEEE Systems Journal*.

C. L. Anderson, **J. B. Cardell**, "The Impact of Wind Energy on Generator Dispatch Profiles and Carbon Dioxide Production," accepted for *Proceedings of Hawaiian International Conference on System Sciences*, Jan. 2012.

Michael Roytman, Uday V. Shanbhag, **Judith Cardell**, Lindsay Anderson, "Packaging Energy and Reserves Bids through Risk Penalties for Enhanced Reliability in Co-optimized Markets," accepted for *Proceedings of Hawaiian International Conference on System Sciences*, Jan. 2012.

J. B. Cardell and C. Y. Tee, "Distributed Energy Resources in Electricity Markets: The Price Droop Mechanism," Allerton 2010, Urbana, IL, October 3, 2010.

J. B. Cardell, C. L. Anderson, "The Effect of Wind and Demand Uncertainty on Electricity Prices and System Parameters," in *Proceedings IEEE PES T&D*, New Orleans, LA, April, 2010.

IEEE PES Climate Change Technology Subcommittee, "Key Technical Challenges for the Electric Power Industry and Climate Change," *IEEE Transactions in Energy Conversion*, June 2010. (**J Cardell** lead author)

C. L. Anderson, **J. B. Cardell**, "Analysis of the System Costs of Wind Variability," in *Proceedings of Hawaiian International Conference on System Sciences*, Jan. 2010.

Stahlhut, J. W., G. T. Heydt, and **J. B. Cardell**, "Power System 'Economic Alarms'," *IEEE Transactions on Power Systems*, Vol. 23, No. 2, May 2008, pages 426-433.

Cardell, J., I. Dobson, W. Jewell, M. Kezunov, T. Overbye, P. Sen, D. Tylavsky, L. Beard, F. Galvin, D. Hawkins, "The Electric Power Industry and Climate Change: U.S. Research Needs," to be presented at *IEEE Power and Energy Society General Meeting*, July 2008.

Cardell, J. B., "Marginal loss pricing for hours with transmission congestion," *IEEE Transactions on Power Systems*, Vol. 22, No. 4, November 2007.

Anderson, C. L., **Cardell, J. B.**, "Reducing the Variability of Wind Power Generation for Participation in Day Ahead Electricity Markets," accepted for presentation at *Hawaii International Conference on System Sciences*, Hawaii, January 2008.

Cardell, J. B., "Price Droop for Microgrid Market Coordination," submitted to *IEEE Transactions on Power Systems*, Aug. 2007.

Cardell, J. B., "Distributed Resource Participation in Local Balancing Energy Markets," in *Proc PowerTech 2007*, IEEE PES, Lausanne, Switzerland, July 3, 2007.

Cardell, J. B., "A Real Time Price Signal for FACTS Devices to Reduce Transmission Congestion," *Hawaii International Conference on System Sciences*, Big Island, Hawaii, January 3-6, 2007.

Cardell, J. B., "Improved Marginal Loss Calculation During Hours of Transmission Congestion" *Hawaii International Conference on System Sciences*, Big Island, Hawaii, January 5-10, 2005.

Cardell, J. B., M. D. Ilic, "Maintaining Stability with Distributed Generation in a Restructured Industry," *IEEE Power Engineering Society General Meeting*, Denver CO, June 2004.

Cardell, J. B., "Defining a Market: Market mitigation by theory versus convenience," *Hawaii International Conference on System Sciences*, Big Island, Hawaii, January 5-10, 2004.

Tabors, R. D., **Cardell, J. B.**, "Ex Ante and Ex Post designs for electric market mitigation: Past and present experience and lessons from California," *Hawaii International Conference on System Sciences*, Big Island, Hawaii, January 6-9, 2003.

Ilic, M. D., P. Skantze, C. N. Yu, L. Fink, **J. Cardell**, "Power Exchange for Frequency Control (PXFC)," in Proc of *Bulk Power Systems Dynamics and Control Conference--IV: Restructuring*, Santorini, Greece, August, 1998; and Proceedings of the IEEE PES Winter Meeting, New York, NY, February, 1999.

Cardell, J. B., M. D. Ilic, "The Control and Operation of Distributed Generation in a Competitive Electric Market," in *Power Systems Restructuring: Engineering and Economics*, ed. M. Ilic, et. at., Kluwer Academic Publishers, June, 1998.

Cardell, J. B., S. R. Connors, "Windpower in New England: Modeling and Analysis of Non-Dispatchable Renewable Energy Technologies," *IEEE Transactions on Power Systems*, Volume 13, Number 2, May 1998.

Cardell, J. B., R. D. Tabors, "Operation and Control in a Competitive Market: Distributed Generation in a Restructured Industry," *Energy Journal, Special Issue on Distributed Resources: Toward a New Paradigm of the Electricity Business*, January, 1998.

Cardell, J. B., C. Cullen-Hitt and W. W. Hogan, "Market Power and Strategic Interaction in Electricity Networks," *Resource and Energy Economics*, January, 1997.

7. Research and Consulting Reports

Judith Cardell, Chin Yen Tee, "Integrating Distributed Energy Resources into Electricity Markets: Final Report," Submitted to the National Science Foundation, NSF award number: 0844297, August 31, 2010.

Ray, R. and J. Cardell, "Renewable Energy Prospects in Haiti's Nord-Est Department," Oxfam GB and Smith College College, Northampton, MA, USA, Oct. 2008. Available at <http://www.sustainablefoodlab.org/filemanager/download/14738>

Overbye, T., **J. Cardell**, I. Dobson, W. Jewell, M. Kezunov, P. Sen, D. Tylavsky, "The Electric Power Industry and Climate Change: Power Systems Research Possibilities," Final Project White Paper, PSERC Publication 07-16, June, 2007, Available [Online]: www.pserc.org.

Liu, C., A. Bose, **J. Cardell**, "Agent Modeling for Integrated Power System, Power and Fuel Market Simulation," PSERC Project M-13 Status Report, May 2007.

Timothy J. Browne, Gerald T. Heydt, Jonathan Stahlhut, Radhika Bezwada, Ward T. Jewell, Rajesh Mahadasyam, Piysak Poonpun, O. Ikeako, K. Malmedal, P. K. Sen, **Judith**

Cardell, “Massively Deployed Sensors” final report for PSerc Project T-31, Power Systems Engineering Research Center, July 2008.

Synapse Energy Economics, “Review of Distributed Generation Planning in New York,” for NYSERDA, August, 2006, Available [Online]: <http://www.synapse-energy.com/Downloads/SynapseReport.2006-08.NYSERDA.DG-in-New-York-with-Pace-Law-School.04-37.pdf>.

J. Cardell equal contribution to section on reliability issues (included in dossier), with a minor contribution to the overall report.

Amicus Curiae Of Electrical Engineers, Energy Economists And Physicists In Support Of Respondents In No. 00-568, submitted to the Supreme Court of the United States, May, 2001.

As specialists in electric power, the Amici submitted this brief as an aid to the Supreme Court’s understanding of the scientific and engineering realities of electric power systems, and their relevance to deciding questions of federal jurisdiction, May 2001.

J. Cardell primary author for engineering/power systems material, B. Koukoutchos primary author for legal material.

Rudkevich, A., P. Capozzoli, **J. Cardell**, E. Hausman, R. Hornby, A. Zobian, “Horizontal Market Power in Wisconsin Electricity Markets: A Report to The Public Service Commission of Wisconsin,” Nov. 2000.

Cardell, J., M. Ilic, R. Tabors, “Integrating Small Scale Distributed Generation into a Deregulated Market: Control Strategies and Price Feedback,” MIT Energy Laboratory Technical Report, MIT-EL-98-001, Apr. 1998.

Tabors, R. D., **J. B. Cardell**, “Distributed Storage Systems Within the Utility Grid: Technology Assessment and Evaluation of Market Worth,” LEES Technical Report (for Lincoln Laboratory), MIT, TR95-005, June 1995.

Cardell, J. B., “Renewable Energy Technologies in the New England Electric Sector,” MIT Energy Lab Working Paper, MIT-EL 94-002WP, June 1994.

Cardell, J. B., M. D. Ilic, “Modeling and Stability Analysis for Distributed Generation Systems,” proceedings of the North American Power Symposium, November 1996; and LEES Working Paper, WP96-006, MIT, Oct. 1996.

Client Proprietary Study: Study for the Pacific Northwest electric utilities to analyze the regional impacts of combining the transmission system operations of all regional utilities into one regional operator. Final report Feb. 2002.

J. Cardell equal contribution to report, with other TCA associates.

Client Proprietary Study: Study for the Government of El Salvador to analyze the present and future potential for the exercise of market power in the Salvadoran wholesale electricity market and provide recommendations for mitigation. Funding from the Inter-American Development Bank. Oct. 2000.

J. Cardell equal contribution to report, with other TCA associates.

8. Expert Testimony to the U. S. Federal Government

(Note: J. Cardell is sole witness, except where noted as “joint testimony.”)

Submitted testimony to the Federal Energy Regulatory Commission on behalf of FPL Energy, LLC, proposing an alternative method for calculating marginal transmission losses in New England, Docket EL03-216, Nov. 2003.

Expert witness before the Federal Energy Regulatory Commission on behalf of Powerex Corporation, British Columbia, providing testimony and analysis on market flaws and the determination of competitive electricity prices in the California ISO markets, FERC Docket EL00-95, September 2001 to 2003.

Expert witness before the Federal Energy Regulatory Commission on behalf of Portland General Electric, providing testimony and analysis on power flows between the Pacific Northwest and California, FERC Dockets EL03-113 and EL03-180, Oct. 2002.

Submitted joint testimony with Aleksandr Rudkevich to the Federal Energy Regulatory Commission on behalf of Duke Energy North America analyzing the potential market power consequences of a generating plant purchase, Docket EC01-128, July 2001.

Submitted testimony to the Federal Energy Regulatory Commission analyzing the physical interdependence of the power systems of the three proposed Southeast RTOs, FERC Docket RT01-100, August 2001.

Submitted testimony to the Federal Energy Regulatory Commission analyzing the market power impact of a power plant purchase, FERC Docket EC01-128, July 2001.

Submitted testimony to the Federal Energy Regulatory Commission analyzing the three Northeast ISOs and their proposed Scope and Configuration, FERC Dockets RT01-2, RT01-86, RT01-95, February 2001.

Submitted testimony to the Federal Energy Regulatory Commission commenting on the Scope and Configuration of the Alliance RTO proposal (regional transmission organization proposal from Midwestern utilities), FERC Docket ER99-3144, October 2000.

Submitted joint testimony with Richard Tabors to the Federal Energy Regulatory Commission analyzing market flaws in the wholesale electricity markets on the Delmarva Peninsula, FERC Docket EL00-96, August 3, 2000.

9. Scholarly Lectures and Other Professional Presentations

J.B. Cardell and C.L. Anderson, “Optimal Balancing of Wind Resources with Responsive Demand on a Network,” to be presented at INFORMS Annual Meeting, 2001, Charlotte NC, Nov 13-16, 2001.

J.B. Cardell and C. L. Anderson. “Power System Performance with 30% Wind Penetration”. Presented at the 7th Annual Carnegie Mellon Conference on the Electricity Industry. Pittsburgh, PA. March 8, 2011.

C. L. Anderson and J. B. Cardell, “Assessing the Cost and Reliability Impacts of Stochastic Wind Power Through Network Simulation,” *Inform*s 2010, Austin, TX, Nov. 7, 2010.

C. L. Anderson, J. B. Cardell, "Analysis Of Wind Penetration And Network Reliability Through Monte Carlo Simulation" *accepted for publication in Proceedings of the 2009 Winter Simulation Conference*, Dec. 2009.

J. B. Cardell, C. L. Anderson, "Simulating the System Costs of Wind Power Uncertainty," *Proceedings of the IEEE Power and Energy Society General Meeting*, Calgary, Alberta, July 2009.

C. L. Anderson, J. Cardell, "Simulating the System Costs of Wind Power," Institute for Operations Research and Management Sciences (INFORMS) Annual Meeting, Washington DC, Oct 15, 2008.

Coalton Bennett, Judith Cardell, Stephen Wicker. "Residential Demand Response Wireless Sensor Network". Fourth Annual Carnegie Mellon Conference on the Electricity Industry, Carnegie Mellon University Department of Electrical Engineering, March 5, 2008.

C. L. Anderson, J. B. Cardell, "Characterizing the Cost of Wind Power Uncertainty on a Network," Canadian Operations Research Society/ Institute for Operations Research and Management Sciences, (CORS/INFORMS) Joint Meeting, Toronto, Ontario, June 14, 2009.

Tim Mount, Lindsay Anderson, Judy Cardell, Alberto Lamadrid, Surin Maneevitjit, Bob Thomas and Ray Zimmerman, "The Economic Implications of Adding Wind Capacity to a Bulk Power Transmission Network," presented at Rutgers Center for Research on Regulated Industries Annual Eastern Conference, Skytop, PA, May 14-16, 2008.

Anderson, L., J. Cardell, "Assessing System Reliability Costs of Wind Power: A Framework," <http://w1.cirrelt.umontreal.ca/scrojopt2008/en/program/index.php>, Canadian Operational Research Society, CORS 2008, Quebec City, QB, May 13, 2008.

Bennett, Coalton, Steven B. Wicker, and Judith Cardell. "Residential Demand Response Wireless Sensor Network," Pittsburgh, PA, March 10-11, 2008, [Online]. Available: <http://www.ece.cmu.edu/~electricconf/papers.html>

Zhang, D., U. Shanbagh, J. Cardell, "Reliability Impacts of Increased Wind Penetration in Electricity Markets," to be presented at INFORMS Annual Meeting 2007, Nov. 4-7, 2007, Washington State Convention & Trade Center & Sheraton Seattle, Seattle, WA, www.informs.org/Conf/Seattle07

Cardell, J., T.Overbye, "The Electric Power Industry and Climate Change: Power Systems Research Possibilities," Research Tele-seminar, June 5, 2007, Available [Online]: www.pserc.org.

Cardell, J. B., "The Distributed Utility: A Future for Electric Power," Jones Seminar on Science, Technology and Society, Thayer School of Engineering, Dartmouth College, April 20, 2007, Available [Online]: <http://engineering.dartmouth.edu/news-events/lecture-series/jones/2007/JudithCardell.html>

Cardell, J. B., "A Distributed Utility with a Closed-loop Price Signal for FACTS Devices" IEEE Power Engineering Society: 2006 Transmission and Distribution Conference & Exposition, Dallas, TX, May 21-24, 2006.

Cardell, J., "Competitive Distributed Generation," research seminar, Department of Electrical Engineering, University of Wisconsin – Madison, Mar. 10, 2005.

Cardell, J., "Market Clearing Mechanisms in Incomplete Markets: Excluding Importers from Competitive Electricity Pricing," IEEE Power Systems Conference and Exposition (PSCE04), New York, NY, October 2004.

Cardell, J., "The operation of distributed generation in the restructured power industry," Carnegie Mellon University, Spring 2004 and Spring 2005.

Cardell, J., "Data and Information Requirements for a Distributed Utility," MIT's Program on Emerging Technologies, POET, 5th Annual Symposium, Apr. 11, 2005.

Cardell, J., "A Distributed Utility: System Stability and Operation," research seminar, Department of Electrical and Computer Engineering, Cornell University, Apr. 15, 2004.

Cardell, J., "Standard Market Design: Is Cloning the Answer?," Large RTOs, The FERC Initiative and its Consequences, Washington DC, November 11, 2001.

Cardell, J., E. Hausman, "Horizontal Market Power Study for the Public Service Commission of Wisconsin," presentation to the Wisconsin PSC, Oct. 31, 2000.

Cardell, J., "Hybrid Congestion Management Systems: Flow-Based versus Point-to-Point Transmission Rights," Energy Information Administration, US Department of Energy, March 13, 2001.

Cardell, J., "Strategic Use of Transmission Assets," Transmission Expansion and Reliability, Infocast Conference, Alexandria, VA, September 20, 2000.

Cardell, J., "Performance-Based Transmission Pricing: Alternatives and Incentives," Designing Transmission Pricing Under FERC Order 2000, Infocast Conference, Chicago, IL, May 3, 2000.

Cardell, J., "Creating Competitive Energy Markets" Federal Energy Regulatory Commission, Apr. 4, 2000.

Cardell, J., "RTOs and Electric Industry Restructuring," School of Advanced International Study, Johns Hopkins University, Washington, DC, Feb. 24, 2000.

Cardell, J., "Transmission Constraints, Market Power and Modeling at FERC," Energy Information Administration, US Department of Energy, Dec. 7, 1999.

Cardell, J., "What is a Control Area: Historically and Today?" Federal Energy Regulatory Commission, Oct. 28, 1999.

Cardell, J., "Understanding Transmission Constraints and Their Influence on Market Power" Federal Energy Regulatory Commission, Sep. 21, 1999.

Cardell, J., "Understanding Transmission Constraints and Their Influence on Market Power," The Impact of Market Power in Competitive Energy Markets, Infocast, Washington, DC, July 16, 1999.

Cardell, J., "Markets and Reliability: Policy Issues at FERC," The Power of Choice, Cornell University, April 16, 1999.

Cardell, J., "Frameworks for Energy Services Markets," New Concepts and Software for Competitive Power Systems, Massachusetts Institute of Technology, Thursday, February 4, 1999.

Cardell, J., "Designing Competitive Energy Markets," Robert H. Smith School of Business, University of Maryland, College Park, MD, Oct. 14, 1999.

Cardell, J., "The Control and Operation of Distributed Generation in a Competitive Electric Market," Vision 21: Environmental Electric Energy Opportunities for the Next Century, National Science Foundation, April 27, 1998.

Cardell, J. B., S. R. Connors, "Integrating Renewables into Resource Planning," RENEW'94, Stamford, CT, April 1994.

Connors, S. R., J. B. Cardell, "Integrating Renewables into Integrated Resource Planning: Emissions Reduction Potential from Wind and Solar Generated Electricity in New England," NARUC Conference, Savannah, GA, October 1993.

10. Other Professional Activities

Invited Participant / Peer Review Panel

- Panel participant for the National Science Board to review the National Science Board and National Academy of Engineering report on "Educating the Engineer of 2020," Cambridge, MA, October 20, 2005.
- Panel participant on "Diversity in the Engineering Workforce," National Academy of Engineering, Washington, DC, September 23, 2004.
- Peer review meeting for US Department of Energy Transmission Reliability Program, Washington, DC, May 20-21, 2002.

Journal and Conference Articles Reviewed for:

- IEEE Power Engineering Society Transactions on Power Systems
- International Journal of Power and Energy Systems
- The Energy Journal, Journal of the International Association for Energy Economics
- Energy Policy
- European Transactions on Electric Power
- Hawaii International Conference on System Sciences.
- IEEE Transmission and Distribution Conference and Exposition.
- IEEE Power Systems Conference and Exposition, PSCE.
- IEEE Power Systems Computation Conference, PSCC.
- Carnegie Mellon conference on Electric Power Systems.

Research Grant Proposals Reviewed for:

- National Science Foundation
- Power Systems Engineering Research Center research solicitation

Grants

National Science Foundation:

- SGER: Integrating Distributed Energy Resources into Electricity Markets, 2009 to 2011, \$70,000.
- Improved reliability and congestion management with closed-loop control strategies for FACTS devices, 2004 – 2006, \$50,000.

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- Educating 21st Century Power Engineers, co-PI with Carnegie Mellon University, MIT, University of Pittsburg, 2003 – 2005, \$20,000.

Power Systems Engineering Research Center, PSERC

- Multidimensional Market Design: Renewable and Distributed Energy Resources: Economic Incentives and the Reliability of Supply, co-PI with Cornell University, 2008 to present, \$50,000.
- Facilitating Environmental Initiatives While Maintaining Efficient Markets and Electric System Reliability, co-PI with Iowa State University (lead), Washington State University, 2007, \$35,000.
- The Electric Power Industry and Climate Change Discussion Paper, co-PI with Arizona State University, Colorado School of Mines, Texas A&M University, University of Illinois-Urbana Champaign (lead), University of Wisconsin-Madison, Wichita State University, 2007, \$8000.
- Agent Modeling for Integrated Power System, Power and Fuel Market Simulation, co-PI with Cornell University (lead), 2005-2007, \$40,000.
- Hybrid MicroGrid System, co-PI with University of Wisconsin-Madison (lead), Georgia Tech, 2005, \$30,000.

Team for Research in Ubiquitous Secure Technology, NSF Science and Technology Center

- Secure Sensor Networks: Next Generation SCADA, co-PI with Cornell University and UC Berkeley, \$90,000.

Department of Energy / Consortium for Electric Reliability Technology Solutions

- Coupling Wind Generation with Controllable Load and Storage: A Time-Series Application of the SuperOPF, co-PI with Cornell University, 2008 to present, \$85,000.
- Analysis of Economic and Technical Feasibility of Wind Farm Participation in Electricity Markets, co-PI with Cornell University, 2006 to 2008, \$45,000.

11. Professional Memberships

The Institute of Electrical and Electronics Engineers, IEEE

Research consortia:

- Adjunct researcher with PSERC (Power Systems Engineering Research Center) www.pserc.org