# Judith B. Cardell

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Education

**Ph.D. in Technology Management and Policy** 1997

*Department of Electrical Engineering and Computer Science,*
*Massachusetts Institute of Technology, Cambridge, MA.*
Coursework emphasized operation and control of power systems, policy analysis, economics.
Thesis: "Control Strategies and Dynamic Pricing for Small Scale Distributed Generation in a Deregulated Market," Awarded Best Thesis on Technology and Policy, MIT, 1998.

Research assistant in the MIT Laboratory for Electromagnetic and Electronic Systems. Developed dynamic models for small-scale, distributed dispatchable and non-dispatchable generators responding to both physical and economic control signals. Developed system models to demonstrate the evolution of the electric power system toward a fully distributed system, as driven by both market forces and the characteristics of fossil based and renewable energy technologies.

**Masters of Science in Technology and Policy** 1994

*Department of Electrical Engineering and Computer Science,*
*Massachusetts Institute of Technology, Cambridge, MA.*
Coursework included energy systems, energy economics and law.
Thesis: "Renewable Energy Technologies: Analysis and Policy Tools for Utility Integration."

Research assistant in the MIT Energy Laboratory. Utilized a production-cost model to perform scenario-based, multi-attribute trade-off analysis. Designed and developed a methodology to analyze large-scale integration of renewable energy technologies into the electric utility system. Quantified the potential impacts of wind power and photovoltaic technologies on the New England power system in terms of cost, emissions and reliability.

**Bachelor of Science in Electrical Engineering** 1989
**Bachelor of Arts in Government**

*Cornell University, Ithaca, NY.*
Concentrations in electromagnetic theory, political theory and Latin American studies.
Engineering co-op student with Digital Equipment Corporation, Littleton, MA.
Semester in Buenos Aires, Argentina studying political and economic institutions.
Teaching assistant for computer programming courses.

Academic Appointments

**Clare Boothe Luce Assistant Professor of Computer Engineering** present

*Smith College, Northampton, MA.*
Joint appointment in the Picker Engineering Program and Department of Computer Science. Courses include introduction to engineering design, computer programming, digital circuits, circuit theory and dynamic system modeling.

**Lecturer in Technology and Policy** 2002

*Massachusetts Institute of Technology, Cambridge, MA.*
Lead a graduate level seminar on Energy Systems and Economic Policy Development. Topics include electric power system operation, industry restructuring and government regulation. Course

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combines formal lectures with student led discussions on case studies and current developments in the industry.

### Graduate Instructor in Energy Systems and Economic Development

*Massachusetts Institute of Technology, Cambridge, MA.* 1994 to 1996

Developed curriculum for masters level seminar course. Lectured on electric power system operation and planning and economic development. Course concluded in a group design project of an energy system for selected developing countries. Awarded MIT Graduate Student Council Teaching Award.

### Teaching Assistant in Regulation and Electricity Economics

Summer 1995

*University of Strathclyde, Scotland*

Developed curriculum modules for the University of Strathclyde, Scotland, MS Program in Energy Management.

### Teaching Assistant in Technology and Policy

1993 to 1994

*Massachusetts Institute of Technology, Cambridge, MA.*

Assisted with core-curriculum seminar course for masters students.

Professional Experience

### Senior Associate

2000 to present

*Tabors Caramanis & Associates, Cambridge, MA.*

Consultant analyzing electric power systems, electricity policy and market issues.

Testified as an expert witness before the Federal Energy Regulatory Commission on issues relating to the California wholesale electricity markets. Submitted expert testimony on power system operations throughout the Eastern United States, energy market operation in the Mid-Atlantic region, and local market power in the Southeast.

Reports include:

- 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 February, 2002.
- Coauthor of *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. 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.
- 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. October/November 2000.
- Study for the Public Service Commission of Wisconsin to analyze horizontal market power in the state's wholesale electricity market and recommend mitigation. Final report October 31, 2000.

Reports and testimony available at www.tca-us.com.

### Electrical Engineer and Policy Analyst

1997 to 2000

*Federal Energy Regulatory Commission, Washington, DC.*

Developed and provided internal training courses on control area operations, transmission system gaming and competitive market design. Developed an optimization model of the power grid to test and analyze the competitive and reliability effects of power company mergers. Model was used to represent both competitive and strategic market behavior, and incorporates representations for both

actual power flows and financial, contract path power transactions. Member of the Regional Transmission Organization Rulemaking team (FERC Order 2000). Helped develop Commission policy for industry restructuring, corporate mergers and regional transmission organizations.

### Research Assistant

Summer 1995

*Harvard Electricity Policy Group, Cambridge, MA*.
Researched issues of potential market power in the restructured electric power industry. Emphasized the role of the transmission network in facilitating market power. Developed linear program models to demonstrate the ability of power generators to exercise market power in energy markets.

### Policy Analyst

Summer 1994

*Union of Concerned Scientists, Cambridge, MA.*
Researched and documented the technical and economic potential for a wide range of renewable, distributed generation and storage technologies in the Boston Edison service territory.

### Signal Integrity Engineer

*Digital Equipment Corporation, Boxboro, MA.* 1989 to 1991
Analog design engineer for the Alpha processor module. Developed SPICE model simulations to perform timing analysis for and assist in design of the Alpha processor and Laser memory boards. Designed, built and tested prototypes of both modules to ensure the signal integrity of the final design. Completed internal training courses on electromagnetic modeling and simulation of hi-speed digital circuits, computer architecture I and II, and signal integrity.

### Engineering Co-op Student

*Digital Equipment Corporation, Littleton, MA.* 1986 to 1989.
Software engineer with VAX computer architecture group. Member of a team designing the VAX architecture exerciser (AXE). Final project was to design a program in Bliss to randomly generate realistic assembly code sequences in Macro32. These code sequences were used to test new and existing VAX instructions, with the resulting code segments able to be executed at any desired address.

Publications

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., 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, April, 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.

Tabors, R. D., J. B. Cardell, "Distributed Storage Systems Within the Utility Grid: Technology Assessment and Evaluation of Market Worth," LEES Technical Report, 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.

Testimony

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 present.

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.

Refereed Conferences

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.

"*Defining a Market: Market mitigation by theory versus convenience* " Hawaii International Conference on System Sciences, Hilton Waikoloa Village, 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, Hilton Waikoloa Village, 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)," Proceedings of the 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, "Modeling and Stability Analysis for Distributed Generation Systems," proceedings of the North American Power Symposium, November 1996; and LEES Working Paper, WP96-006, MIT, October 1996.

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.

Invited Talks "Are We Entitled to Low Priced Power? – Pricing Imports in California Energy Markets" IEEE Power Engineering Society: 2004 Power Systems Conference & Exposition, October 10-13, New York, NY.

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

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

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

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

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

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

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

"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.

Refereed Papers for
International Journal of Power and Energy Systems
Operations Research, Informs Publishers, through the Wharton School of Business
Energy Journal, Journal of the International Association for Energy Economics

Memberships
The Institute of Electrical and Electronics Engineers
IEEE Energy Policy Committee
Tau Beta Pi and Eta Kappa Nu, honor societies
Sigma Xi, honorary scientific research society

Awards
Best Thesis on Technology and Policy, MIT, 1998
Alfred Keil Fellowship for the Wiser Uses of Science and Technology, MIT, 1994
MIT Graduate Student Council Teaching Award, 1994
Bernard Rabinowitz Fellowship for Leadership and Service, MIT, 1994