

ASSEF A. ZOBIAN

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SUMMARY

Dr. Zobian is the founder and president of Cambridge Energy Solutions, LLC, a software company with a mission to develop software for the deregulated electric power industry. He is an electrical engineer with over thirty years of experience in power systems technology, economics, and planning. He designed a set of market simulation tools to simulate the economic and engineering operation of electric power markets in the US. These models are being used to forecast locational market clearing prices of electricity and congestion cost, analyze the impact of regulatory policies on stakeholders, analyze market power issues, economics of entry and exit, the technical and economic feasibility of new power plants and transmission lines projects; evaluate alternative market structures and pricing regimes (zonal vs. nodal); define geographic market areas based on transmission constraints; and determine the impact of environmental regulation on electricity prices.

At Tabors Caramanis and Associates, Dr. Zobian was in charge of electric power system modeling, where he developed the software tools and worked on more than thirty different generation and transmission asset and rights valuations with a total value of more than \$20 Billion. Also, he worked on several market power analysis, Regional Transmission Operator cost-benefit studies, market structure and regulatory policy studies. Dr. Zobian led the team on defining the structure and tariff for the first for-profit Transmission System Operator (TransCo) in the US.

Before joining TCA, Dr. Zobian was an associate consultant at Putnam, Hayes & Bartlett, where he worked on developing models for least-cost economic dispatch for secure and economic operation of electric power systems and methods to compute the associated marginal costs of real power. Further, he developed models of *ex post* computation of real and reactive power marginal cost, given a feasible dispatch.

As a research assistant at the MIT Laboratory for Electromagnetic and Electronic Systems, he evaluated alternative organizational structures for the electric power industry after deregulation, and recommended policies for efficient operation in the newly evolving open access environment.

Dr. Zobian has published in the Institute of Electrical and Electronics Engineers (IEEE) Transactions on Power Systems, the International Journal of Modeling & Simulation, and the IEEE Transactions on Industry Applications.

Dr. Zobian earned a BS in Computer and Communication Engineering, and an ME in Electrical Engineering from the American University of Beirut in 1990 and 1992, respectively. He received a Master of Science in Technology & Policy in 1995 and a Doctor of Science in Electrical Engineering & Computer Science from the Massachusetts Institute of Technology in 1996. His doctoral thesis is entitled “A Framework for Cost-Based Pricing of Transmission and Ancillary Services in Competitive Electric Power Markets.”

EDUCATION

- **Doctor of Science (Sc.D.)**, Electrical Engineering & Computer Science, Massachusetts Institute of Technology, June 1996.
- **Master of Science (M.S.)**, Technology & Policy, Massachusetts Institute of Technology, August 1995.
- **Master of Engineering** in Electrical Engineering, American University of Beirut, July 1992
- **Bachelor of Engineering** in Computer and Communication Engineering, American University of Beirut, July 1990.

EXPERIENCE HIGHLIGHTS

Cambridge Energy Solutions, Cambridge, MA, August 2002- current, **President**. Developing software tools to assist market participants in analyzing the electricity markets on a locational basis, forecast and value transmission congestion, and to understand the fundamental drivers of short and long term prices. These tools simulate the operation of the electricity market and replicate the calculations made by the ISOs in solving for the security-constrained, least-cost unit commitment and dispatch in the day-ahead markets incorporating all the security, reliability, economic and engineering constraints on generation units and transmission system components.

Tabor Caramanis & Associates, Cambridge, MA, February 1998 – August 2002, **Vice President**. Advised a major electric power trader on restructuring issues in the Northeast US electric power markets. Analyzed the effects of transmission constraints on the electric power markets, and evaluated the economic and technical feasibility of different transmission planning strategies in the Northeast markets. Developed software models to forecast energy and transmission prices in competitive electric power markets. Helped a small Investor Owned Utility in the New England area to divest its generation assets. Advised a major US bank on financing power plant acquisition deals and quantifying associated risks. Worked with two international power plant developers on analyzing the economics of new generation units in the Northeast markets. Designed the structure and tariff for the first for-profit transmission system operator (TransCo) in the US.

Putnam, Hayes & Bartlett, Cambridge, MA, September 1995 – January 1998, **Associate Consultant**. Developed methodologies to value electric power generation assets in competitive electric power markets. Advised major US independent power producer in bid to acquire the New England System auctioned generation assets. Analyzed the potential for market power in the New York Power Pool (NYPP) electricity generation market after deregulation and recommended possible mitigation strategies. Advised the NYPP and PJM companies on market restructuring as well as on energy and transmission pricing issues, aimed at encouraging highly efficient electricity markets to develop in the Northeast US. Worked on developing simulation models for: 1) least-cost economic dispatch; 2) *ex post* computation of real and reactive power marginal costs from a realizable dispatch; as well as 3) estimation of worldwide market demand and supply curves for the automobile industry. Interacted directly with utility clients and other technical consultants on all assignments.

MIT Lab for Electromagnetic and Electronic Systems (LEES), Cambridge, MA, **Research Assistant**, July 1992 - February 1996. Evaluated alternative organizational structures for the electric power industry after deregulation and recommended policies for efficient operation in the newly evolving open transmission access environment. Also, defined a pricing strategy for electric energy & transmission services to achieve technical and economic efficiency in competitive energy markets. This pricing framework addressed most of the controversial regulatory, contractual, and policy issues, which were the focus of the debate on open transmission access. Other research involved developing a software package for steady state voltage monitoring and control in large-scale electric power systems. Developed the mathematical theory and wrote the software for real-time implementation in control centers.

Rhode Island-Eastern Massachusetts-Vermont Energy Control Center, Westborough, MA, **Software Engineer**, summer 1994. Installed the developed steady state voltage monitoring and control software on the Center computers and tested it on the New England electric power system. Trained center operators to use the software.

FIELDS OF EXPERTISE

- Energy, Transmission and Ancillary Services Pricing
- Electric Power Transmission Planning
- Economic and Technical Policy
- Valuation of Generation Assets
- Competitive Markets Modeling Techniques
- Strategic Analysis
- Market Power Studies
- Restructuring Electric Power Markets

MAJOR PROJECTS

Energy, Transmission and Ancillary Services Pricing

Dr. Zobian, as part of his Doctoral thesis, proposed an electricity market structure with a centralized operator that accepts bilateral trades, charges for transmission use, procures and sells ancillary services, and clears the energy market. A variation of the transmission and energy pricing scheme he proposed is currently used in the Pennsylvania- New Jersey- Maryland (PJM) and New York Power Pool (NYPP) systems, and most of the regional markets in the US. He also worked on developing a conceptual tariff for a TransCo, that includes markets for ancillary services and tradable transmission rights as well as fixed cost allocation mechanism (access fee) to recover transmission system fixed cost.

Electric Power Transmission Planning

Analyzed the economics of building a new transmission project linking the Northeast US and eastern Canada electricity markets. Looked at various alternatives

and identified the market, regulatory and technology risk associated with each alternative.

Identified regulatory rules and business opportunities for use in the development of a transmission business for a major electric power trader.

Analyzed the behavior of transmission constraints and spot prices in the Western Systems Coordinating Council system for a major Investor Owned Utility in the West.

Proposed a transmission and generation expansion plan for the Lebanese electric power system. The plan utilized the least-societal-cost (combined cost of new equipment and unserved energy) approach to determine a set of alternative expansion policies, each with a different level of reliability.

Economic and Technical Policy

Participated in several Federal Energy Regulatory Commission Notice of Policy Rulemakings, and recommended market restructuring policies for the United States electric power markets.

Participated in discussions with North American Electric Reliability Council and FERC on transmission lines congestion management procedures (Transmission Line Relief) and proposing a market-based mechanism to handle congestion and transmission rights.

Participated in several Federal Energy Regulatory Commission technical conferences on improving the efficiency of electric power markets.

Valuation of Generation Assets

Helped a major utility evaluate and purchase nuclear generation assets in the Northeast and Midwest US. Forecasted locational market clearing prices, operating costs and revenues associated with operating nuclear power plants.

Worked with several clients on identifying business opportunities in the US electricity market.

Advised two international power plant developers on the market conditions in the northeastern part of the US and helped them in performing technical and economic feasibility studies for new projects.

Helped a major power marketer in determining the market value of a large coal fired power plant (Homer City) and provided advice on possible means of increasing its value.

Advised US Generation Company in assessing the market value of the New England Electric Power generation assets. The assets were evaluated under the proposed New England Pool (NEPOOL) market regulatory structure and under different market conditions, demand growth, and supply scenarios. The interactions with energy markets outside the NEPOOL system were also incorporated into the analysis.

Participated in stranded cost studies for several electric power utilities in the Northeast and Western parts of the United States.

Competitive Markets Modeling Techniques and Software Development

Developed software applications to demonstrate the operation of the Pennsylvania-New Jersey- Maryland (PJM) market under locational market clearing prices (largest electric power market in the United States). This software was later used to implement the ex-post LMP Price calculator in PJM for the real-time market. The first nodal power market in the world

Helped in developing a software algorithm for the operation of the Italian electric power market. The software is currently running the Italian zonal power market.

Developed a calculator for the zonal flowgates shadow prices on the ERCOT system using the published shift factors by the ERCOT ISO. This tool was used to help clients evaluate the market rules for transmission congestion and valuation of the auctioned transmission rights and determine a strategy to hedge their contracts against zonal price volatility.

Developed steady state voltage monitoring and control software and tested it on the New England electric power system. CES-US staff installed the software on the Rhode Island-Eastern Massachusetts-Vermont Energy Control Center at Westborough, Massachusetts and trained the center operators on using the software.

Developed optimization models to analyze the behavior of electric power generators in a competitive market under spot pricing, and to solve for the associated energy spot prices, and transmission congestion cost. Also, analyzed the behavior of market participants under oligopolistic competition, and simulated the market under various equilibrium conditions such as Cournot and Bertrand.

Strategic Analysis

Analyzed the optimal behavior of generation owners in a competitive market, from the cost-reduction side to the optimal bidding strategy side in the short-term and optimal location and expansion decisions in the long-term.

Worked for two clients on interpreting the ERCOT market rules for transmission congestion and valuation of the auctioned transmission rights. Helped one client determine a strategy to hedge their contracts against zonal price volatility in ERCOT.

Worked with major electricity trader on buying a portfolio of transmission rights in New York and PJM markets. Looked at maximizing returns while minimizing the risks associated with owning these transmission rights.

Providing assistance on entry decisions into the electric power generation market and possible operational strategies after entry for many power plant developers, traders and investors.

Market Power Studies

Worked with the Government of El Salvador, the Ministry of Economics, on analyzing the potential for market power in the Salvadorian electricity market and recommended various mitigation measures.

Performed analyses to test for the potential of exercising market power in the Pennsylvania- New Jersey- Maryland market after a proposed merger of two investor owned utilities (Constellation). The analysis focused on the effects of transmission constraints in limiting the ability of the proposed entity from exercising market power in the wholesale energy market.

Helped Consolidated Edison of New York in divesting its generation assets into separate bundles such that none of the bundles can exercise market power in the heavily constrained New York City wholesale energy market.

Worked with New Century Energies on analyzing market power in the Colorado and southern Texas electricity markets. Reviewed and criticized studies that concluded regulation is better for consumers than competitive markets.

Restructuring Electric Power Markets

Worked with RTO West on proposing and analyzing the impact of implementing a regional transmission operator (RTO) in the Western part of the US and Canada. **Met with and briefed US senators and congressmen and their staff** on the expected costs and benefits associated with implementing RTO West.

Worked with the Government of El Salvador, the Ministry of Economics, on analyzing the alternative transmission congestion management systems and associated pricing structures for the Salvadorian electricity market.

Assisted in designing the rules for the operation of the NYPP, and PJM Independent System Operators.

Worked with San Diego Gas & Electric during the early stages of the California market restructuring, and analyzed the energy markets in the Western Systems Coordinating Council region.

Worked with Northern States Power on developing the conceptual Tariff for the first proposed TransCo in the US.

Helped TransLink design their proposed transmission management congestion system and their balancing market and alternatives to integrate that with the Midwest ISO systems.

Helped Commonwealth Edison evaluate various electricity market and pricing structures.

EXPERT TESTIMONY

Provided expert testimony on behalf of a natural gas producer in Canada in an arbitration case with a power plant in Rhode Island. Analyzed the pricing arbitration

standard of a long-term natural gas contract under the Standard Market Design rules implemented in New England. **The arbitration Panel decided in favor of the gas producer. The total value of the contract exceeded \$10 Billion.**

Provided Affidavit on behalf of NRG Energy to report on the results of a quantitative analysis of the potential impact of the temporary bidding rules in the ISO- New England (ISO-NE) market on the ability of some NRG Energy generating units to recover their fixed costs.

PAPERS AND PUBLICATIONS

Journal Articles

“A Global Planning Methodology for Uncertain Environments: Application to the Lebanese Electric Power System,” *IEEE Transactions on Power Systems*, Vol. 10, No. 1, pp. 332-8, Feb. 1995, (with M. Yehia, R. Chedid, M. Ilić, R. Tabors and J. Lacalle-Melero).

“A Steady State Voltage Monitoring and Control Algorithm Using Localized Least Square Minimization of Load Voltage Deviations,” presented at the IEEE Power Engineering Society Summer Meeting, Portland, Oregon, July 1995. *IEEE Transactions on Power Systems*, Vol. 11, No. 2, pp. 929-38, May 1996 (with M. Ilić).

“Available Transmission Capacity (ATC) and Its Value Under Open Access,” presented at the IEEE Power Engineering Society Winter Meeting, January 1996, Baltimore, MD, 96WM349-1 PWRs. *IEEE Transactions on Power Systems*, Vol. 12, No. 2, pp. 636-45, May 1997 (with M. Ilić and Y. Yoon).

“Unbundling of Transmission and Ancillary Services, Part I: Technical Issues,” presented at the IEEE Power Engineering Society Winter Meeting, January 1996, Baltimore, MD, 96WM319-4 PWRs. *IEEE Transactions on Power Systems*, Vol. 12, No. 2, pp. 539-48, May 1997 (with M. Ilić).

“Unbundling of Transmission and Ancillary Services, Part II: Cost-Based Pricing Framework,” presented at the IEEE Power Engineering Society Winter Meeting, January 1996, Baltimore, MD, 96WM320-2 PWRs. *IEEE Transactions on Power Systems*, Vol. 12, No. 2, pp. 549-58, May 1997 (with M. Ilić).

“Toward Regional Transmission Provision and Its Pricing in New England,” *Utilities Policies*, Vol. 6, No. 3, pp. 245-56, Sept. 1997

“An Improved Dynamically Allocated Data Structure Scheme for Power System Problems,” *Proceedings of the International Association of Science and Technology for Development (LASTED) International Conference on Reliability, Quality Control & Risk Assessment*, Cambridge, MA, October 1993. *International Journal of Modelling & Simulation*, Vol. 17, No. 2, pp. 61-5, 1997 (with M. Yehia, R. Chedid, Z. Jaber and M. Ilić).

“The Importance of Marginal Loss Pricing in an RTO Environment”, *The Electricity Journal*, Vol. 15, No. 8, pp. 40- 45, October 2002 (with Leslie Liu).

Conference Papers and Presentations

“An Improved Algorithm for Fast Decoupled Load Flow,” *Proceedings of the International Society for Mini and Microcomputers (ISMM) Conference on Computer Applications in Design, Simulation and Analysis*, Orlando, Florida, March 1992 (with M. Yehia)

“Computation of Static Stability Margins in Power Systems Using Monotonicity,” *Proceedings of IEEE International Symposium on Circuits and Systems*, Vol. 4, pp. 2196-9, May 1993 (with M. Hasler, C. Wang and M. Ilić).

“Dynamics and Control of the Existing and Planned Lebanese Electric Power System,” An AUB/MIT Collaborative Research Program, Progress Report, Oct. 1993 (with M. Ilić, F. Karamch, J. Lacalle-Mellero, M. Yehia).

“Improved Dynamically Allocated Data Structure Scheme for Power Systems Problems,” presented at IASTED International Conference on Reliability, Quality Control and Risk Assessment, Cambridge, MA, Oct. 15, 1993.

“Alternative Organizational Structure for the Electric Power Industry After Deregulation,” presented at New England Electric, August 4, 1994.

“A Steady State Voltage Monitoring and Control Algorithm Using Least Square Minimization of Load Voltage Deviation,” *Proceedings of the 26th North American Power Symposium*, Kansas State University, Manhattan, Kansas, September 1994 (with M. Ilić).

“Hierarchical Control and Pricing of Frequency Quality and Network Security Under Open Transmission Access,” *Proceedings of the National Science Foundation Workshop on Infrastructure of Power Systems*, Washington, DC, National Science Foundation, October 1994 (with M. Ilić, F. Graves and P. Carpenter).

“Towards Performance-Based Pricing of Unbundled Services (Transmission and Generation Under Competition),” presented at Workshop on Transmission and Distribution Operational Strategies for a Restructured Electric Industry, Cambridge, MA, October 18, 1994.

“Nonlinear Tracking Control of Small Electrical Machines,” *Proceedings of the 33rd IEEE Conference on Decision and Control* (Cat. No. 94CH3460-3), Vol. 1, pp. 211-12, New York, NY, 1994, (with K. Chin, S. Huang and M. Ilić).

“A Framework for Pricing Transmission Services in Competitive Electric Power Markets,” presented at MIT/GAPP Meeting, Cambridge, MA, Feb 7, 1995.

“A Framework for Cost-Based Pricing of Transmission and Ancillary Services in Competitive Electric Power Markets,” *Proceedings of the American Power Conference, 57th Annual Meeting, Technology for a Competitive World, Illinois Inst. Technol.* Vol. 2, pp. 1445-53, Chicago, Illinois, April 1995 (with M. Ilić).

“Allocation of Power Imbalance Caused by Economic Transactions,” *Proceedings of the 27th North American Power Symposium*, Montana State University, Bozeman, Montana, October 1995 (with M. Ilić).

“Unbundling of Transmission and Ancillary Services, Part I: Technical Issues, Part II: Cost-Based Pricing Framework,” presented at IEEE 1996 Winter Meeting, Power Engineering Society, Baltimore, MD, Jan 21-25, 1996.

“A Three Part Tariff for Scheduled Transmission and Ancillary Services,” presented at Innovative Electricity Pricing Conference, Electric Power Research Institute, San Diego, CA, March 27-29, 1996.

“Market Power Analysis Using MAPS,” presented at GE MAPS User’s Conference, Schenectady, NY, May 20-21, 1999.

“Modeling NO_x Emissions Trading in Competitive Electricity Markets,” Stanford Energy Modeling Forum, Washington DC, November 4-5, 1999.

“Least Cost Strategies for Complying with New NO_x Emissions Limits,” 21st USAEE/IAEE North American Conference, Philadelphia, Pennsylvania, Sep. 24-27, 2000

“Market Power Analysis in the Presence of Transmission Constraints,” Institute for Operations Research and the Management Sciences, INFORMS Fall 1999 Meeting, Philadelphia, PA, November 7-9, 1999.

“Using GE MAPS to Perform Cost/Benefit Analysis of Establishing Regional Transmission Operators (RTOs) in the US”, presented at GE MAPS User’s Conference, Baltimore, MD, October 17, 2001.

“Locational Price Forecasting and Transmission Rights Evaluation”, InfoCast Conference, Congestion Forecasting and Pricing, Chicago, IL, June 22, 2000.

“Congestion Pricing Mechanisms Tutorial: From LMP to Zonal,” InfoCast Conference, Congestion Forecasting and Pricing, Chicago, IL, June 21, 2000.

“Switching from Standard Offer Service to Competitive Service – Where is the Added Value?” UTECH 2000, St. Petersburg, FL, November 30, 2000 (with R. Hornby).

“Congestion Pricing Tutorial: From LMP to Flow-Based”, InfoCast Conference, Large Regional RTOs: The FERC Initiative and Its Consequences, Washington, DC, November 12-13, 2001.

“Evaluating the Benefits and Costs of RTOs and Membership in RTOs”, InfoCast Conference, RTO Formation: The business Issues in RTO Participation, Chicago IL, June 20-21, 2002.

“Efficient and Reliable Generation Asset Valuation”, GE MAPS users' conference, October 24-25, 2002

“Valuation of Transmission Assets and Projects,” INFOCAST Conference on Transmission Investment: Opportunities in Asset Sales, Recapitalization and Enhancements, Washington, DC, May 19-21, 2003

“Fundamentals-based models for Day-Ahead Power Markets”, EUCI FTR conference, Houston, TX, July 25, 2011,

“SCUC and SCD Software for Fully Coordinated Regional Power Markets, FERC Technical Conference on Increasing Real-Time and Day-Ahead Market Efficiency through Improved Software”, Washington, DC, June 23-25, 2014

“A Corrective Approach to Security Constrained Unit Commitment and Dispatch, FERC Technical Conference on Increasing Real-Time and Day-Ahead Market Efficiency through Improved Software”, Washington, DC, June 22-24, 2015

“Are Technical or System Limitations Reducing the Efficiency or Performance of the FTR auction(s)? If so, What Are Those Problems and How Can They Be Addressed?”, Baltimore, MD, January 29, 2019

“EUCI Financial Transmission Rights Conference Pre Conference Workshop”, Washington, DC, January 29, 2018

Reports

“Reconstruction of the Lebanese Electric Power System,” AUB/MIT Collaborative Research Program, final report, February 1993 (with N. Al-Nakhl, A. El-Irani, M. Ilić, Z. Jaber, J. Lacalle-Melero, P. Shawcross, R. Tabors and M. Yehia).

“Pricing of Electricity Network Services to Preserve Network Security and Quality of Frequency Under Transmission Access,” Response to the Federal Energy Regulatory Commission's Request for Comments on its Notice of Technical Conference, Docket No. RM93-19-000, November 1993 (with F. Graves, P. Carpenter and M. Ilić).

“Contingency Analysis Based Transmission Expansion: Application to the Lebanese Electric Power System,” 1994 (with M. Ilić, J. Lacalle-Melero, M. Yehia and Z. Jaber).

“A Simple Solution to the Loop Flow Problem in Pricing Transmission Services,” MIT Laboratory for Electromagnetic and Electronic Systems Technical Report, TR95-002, January 1995 (with M. Ilić).

“An Alternative Institutional Structure for Preserving System Reliability and Facilitating Competitive Power Markets,” Response to the Federal Energy Regulatory Commission's Inquiry Concerning Alternative Power Pooling Institutions Under the Federal Power Act, Docket No. RM94-20-000, March 1995 (with M. Ilić).

“Steady State Voltage Monitoring and Control,” EPRI TR-105393, Research Project No. 2473-70, Final Report, Nov. 1995. Also MIT Laboratory for Electromagnetic and Electronic Systems Technical Report, TR94-002, May 1994 (with M. Ilić).

“Comparison of Transmission Cost Allocation Methods on the New England System,” August 1996 (with M. Ilić, Y. Yoon, M. Paravalos, M. Rosenqist and A. Turner).

“PJM and NYPP: A Briefing on Market Structure and Approaches,” Tabors Caramanis and Associates, Sept. 1998.

“Conceptual Tariff Structure for an Independent Transmission Company,” Tabors Caramanis and Associates, March 1999 (with R. Tabors and R. Fagan).

“Modeling the Impact of NOx Regulations and Generation Competition on Electric Power Markets in the Northeast and Midwest United States,” Tabors Caramanis & Associates, Working Paper no. 108-1099-0233, October 1999.

“Prices and Emissions in Restructured Electricity Market”, Energy Modeling Forum, Report #17, Stanford University, Stanford, CA 94305, May 2001.

“Duke Energy Carolinas and Progress Energy Carolinas Analysis of Economic Efficiencies under Joint Dispatch”, Duke Energy Progress Energy merger, January 09, 2011

“Economic Impact Analysis of NRG Dunkirk Repowering Project”, Final report prepared for NRG Energy, March 20, 2013

“Economic Impact Analysis of NRG Astoria Repowering Project”, Final report prepared for NRG Energy, May 17, 2013

“The Impact of Energy Policies, Environmental Regulations, and Market Trends on the Power Sector”, Cambridge Energy Solutions, July 2013

“The Case For Distributed Renewable Energy In Developing Countries (Case Study Lebanon)”. (with Asser Zobian, Sean Meany and Thomas Conner), Cambridge MA, July, 4 2020