Robert Zavadil

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ENERGY AND ENVIRONMENTAL ECONOMICS, INC. San Francisco, CA
Senior Director

Robert (Bob) Zavadil is a Senior Director at E3. His career spans over 45 years in the electric power industry, with technical expertise in distribution engineering, transmission planning, and grid modernization. Mr. Zavadil has worked with a variety of clients, including developers, utilities, and government agencies to advance the integration of clean energy technologies into the power system.

ENERNEX Knoxville, TN
Founder, Executive Vice President 2003 – 2022

EnerNex was founded in 2003 by Mr. Zavadil and two partners. The vision for the new company was to apply deep technical understanding of all technical phenomena relevant to the planning, design, and operation of the electric power system to emerging issues and challenges of the time.

Two of those challenges became primary business areas for the next two decades: 1) The interconnection and integration of renewable energy facilities and 2) the application of advanced technologies and increasingly ubiquitous communications to the electric distribution system which was the very beginning of the Grid Modernization movement and its precursor, Smart Grid. Additionally, EnerNex provided technical services not directly related to these primary focus areas, including conventional utility system studies of transients, harmonics, power quality, dynamics, and stability.

From its founding, EnerNex has supported renewable project developers – both wind and solar – with specific studies and investigations relevant to successful interconnection to the grid. Mr. Zavadil's early efforts were pivotable for building this business area, first by personally finding clients and conducting the work, followed by building and training a team of power engineers to meet growing client demand. These engagements involved the development of appropriate models for new technologies such as modern wind turbines and solar inverters, and application of power system engineering principles to what was at the beginning a new type of generation facility. Under his direction, EnerNex has to date supported the grid connection of nearly 100 GW of wind and 50 GW of solar generation for dozens of project developer and EPC (engineering, procurement, and construction) clients.

In the early days of EnerNex, Mr. Zavadil spearheaded the ground-breaking efforts to assess how increasing amounts of variable renewable energy would impact power system operations and control. EnerNex and GE Energy Consulting were pioneers in developing study methodologies for this new problem, and conducted individually and in partnership over two dozen wind and solar integration studies for utilities, ISO/RTO's, and regulatory agencies across the U.S.

EnerNex played a major role from its founding in the broad spectrum of activities that form the foundation of current grid modernization initiatives. Mr. Zavadil and his partners built a highly technical

group of power system engineers and technologists to deliver a wide range of services to utilities looking to move along the modernization path. The custom-built programs defined and architected individual systems and system-of-systems eco-structures based on both practicality and technical standards. Offerings covered a wide range of modernization aspects, including custom roadmaps, smart metering and advanced metering infrastructure, utility communications, advanced distribution management systems (ADMS), distributed energy resource management (DERMS), demand response (DR), enterprise architecture, and microgrid development and integration.

Through his team of power system engineering professionals, Mr. Zavadil provided technical support to EnerNex grid modernization clients, especially in the areas of distribution system analysis, planning, and operations. He directly participated in efforts for certain grid modernization clients, including Southern California Edison (SCE) and Hawaiian Electric Company (HECO).

ELECTROTEK CONCEPTS Knoxville, TV & Mountain View, CA
Senior Power System Consultant 1989 – 2003

At Electrotek, Mr. Zavadil consulted for several Electrotek clients including the Electric Power Research Institute, the National Renewable Energy Laboratory, major U.S. electric utilities, and private corporations in the electric energy industry. His technical responsibilities included distribution system and end-user power quality and power electronics, motor and drive technology and applications, power quality and power quantity measurements, and renewable energy applications.

Mr. Zavadil managed technical operations in Electrotek's Mountain View, California office from late 1992 until his 1996 transfer to sister company BMI. In 1997, he returned to Electrotek. In addition to consulting, his responsibilities included new corporate product development, sales and marketing of Electrotek products and services, and development of new business areas and ventures.

Highlights of Mr. Zavadil's consulting activities at Electrotek:

- Technical leader on a project for the Electric Reliability Council of Texas focused on developing dynamic models of commercial ERCOT Dynamic Model Development
- Contributor to a series of projects directed at determining the impacts of substantial amounts of intermittent wind generation on the real-time operations and short-term operations planning functions of utility control areas. The basic analytical and simulation methodologies have been extended to cover the full range of possible impacts – from unit governor operations to weekly unit commitment - for application to the Big Island of Hawaii.
- Lead Engineer on multi-year end-use power quality research effort for EPRI that involved numerous on-site studies for participating utility customers. (1990 – 1992)
- Lead Engineer on a multi-year research and development project for EPRI Photovoltaics Program. Member of international technical team for coordination of research, development, and testing activities with Japanese electric utilities and government institutions focused on identifying and resolving distribution system issues related to high penetrations of residential photovoltaic systems. (1990 through 1995).
- Served as secretary of EPRI-sponsored National Motor and Drives Steering Committee (1991 through 1995). This committee was founded by EPRI to provide a forum for electric motor and drive users, researchers, and manufacturers to discuss and exchange information on motor drive market needs, technology, research, and applications. As secretary, Mr. Zavadil was responsible for coordinating all

aspects of the committee's activities, including meetings, technical presentations, and working group activities.

- Primary consultant for EPRI program engaged in development and commercialization of new electric motor drive technologies. Assisted client with technology and market assessments, business planning, and marketing of joint ventures and startup opportunities for bringing EPRI-owned intellectual property to market.
- Member of EPRI-sponsored Technical Review Committee overseeing development of innovative direct-drive wind turbine generation technology using advanced motor and power electronics technology. (1993-1995)
- Expert witness in patent infringement suit (*Kenetech Corporation vs. Enercon Gmb,* United States International Trade Commission, Investigation No. 337-TA-376) for a domestic wind turbine manufacturer (1995-1996).

NEBRASKA PUBLIC POWER DISTRICT Columbus, NE
Senior Power System Consultant 1982 – 1989

At Nebraska Public Power District, Mr. Zavadil worked in the High Voltage Protection and Technical Support Sections of the Transmission and Distribution Engineering Department. His responsibilities included technical studies on specialized protective relaying schemes, substation grounding, irrigation system/power line compatibility, and detailed analysis of transmission system outages. He also performed technical electrical studies associated with the MANDAN 500 kV transmission project, including electromagnetic compatibility, switching surges, and design of series capacitor protection schemes using metal oxide varistors.

He conducted seminars for internal staff and customers on harmonics, grounding, transients, and inductive coordination. Mr. Zavadil worked with commercial and industrial customers on power quality matters related to equipment failure, process interruption, and monitoring.

Other Industry and Professional Activities

Institute of Electrical and Electronics Engineers (IEEE), Senior Member 1982 - 2022

- IEEE Power and Energy Society
- IEEE Power Electronics Society
- IEEE Industrial Applications Society
- Officer, IEEE PES Windpower Coordinating Committee

Registered Professional Engineer – State of Nebraska (1986 -; presently inactive)

Education

South Dakota State University New York, NY
BSEE with Highest Honors 2019

Selected Publications

Smith, C.; Osborn, D.; **Zavadil, R**.; Lasher, W.; Gómez-Lázaro, E.; Estanqueiro, A.; Trotscher, T.; Tande, J.; Korpås, M.; Van Hulle, F.; Holttinen, H.; Orths, A.; Burke, D.; O'Malley, M.; Dobschinski, J.; Rawn, B.; Gibescu, M.; Dale, L. "Transmission Planning for Wind Energy in the United States and Europe: Status and Prospects." *WIREs Energy and Environment*, 2013, 2:1-13,doi:10.1002/wene.8.

Schoene, J.; Walling, R.; Bo, Yang; Niemann, B; Zheglov, V.; Guinn, D.; Peele, S.; Grappe, J.; **Zavadil, B.**; Freeman, L. "Analysis and Mitigation of Excessive Zero-Sequence Harmonic Currents in Distribution Systems." IEEE PES Transmission and Distribution Conference and Exposition (T&D), May 7-10, 2012, Orlando, Florida.

Smith, J. C., Osborn, D., Piwko, R., **Zavadil, R.**, Parsons, B., Coles, L., Hawkins, D., Lasher, W. and Nickell, B. (2012) Transmission Planning for Wind Energy in the USA: Status and Prospects, in Wind Power in Power Systems, Second Edition (ed T. Ackermann), John Wiley & Sons, Ltd, Chichester, UK. doi: 10.1002/9781119941842.ch19

Zavadil, R.; Miller, N.; Ellis, A.; Muljadi, E.; Pourbeik, P.; Saylors, S.; Nelson, R.; Irwin, G.; Sahni, M.S.; Muthumuni, D. "Models for Change." *Power and Energy Magazine, IEEE* Nov - Dec 2011: 86-96.

Henderson, M.; Henson, W.; Norden, J.; Coste, W.; **Zavadil, R.**; Piwko, R.; Jordan, G.; Hinkle, G.; Miller, N. "ISO New England Wind Integration Study." IEEE Power and Energy Society General Meeting, July 24-29, 2011, Detroit, Michigan.

Schoene, J.; McDermott, T.E.; Smith, C.; **Zavadil, R.**; Lamoree, J. "Flicker from Distributed Wind Generation." IEEE Power and Energy Society General Meeting, July 24-29, 2011, Detroit, Michigan.

Ela, E.; Kirby, B.; Lannoye, E.; Milligan, M.; Flynn, D.; **Zavadil, B.**; O''Malley, M. "Evolution of Operating Reserve Determination in Wind Power Integration Studies." IEEE Power and Energy Society General Meeting, July 25-29, 2010, Minneapolis, Minnesota.

Piwko, R.; Camm, E.; Ellis, A.; Muljadi, E.; **Zavadil, R.**; Walling, R.; O'Malley, M.; Irwin, G.; Saylors, S. "A Whirl of Activity." *Power and Energy Magazine, IEEE* Nov - Dec 2009: 26-35.

Corbus, D.; Lew, D.; Jordan, G.; Winters, W.; Van Hull, F.; Manobianco, J.; **Zavadil, B.** "Up with Wind." *Power and Energy Magazine, IEEE* Nov - Dec 2009: 36-46.

Smith, J.C.; Ahlstrom, M.L.; **Zavadil, R.M.**; Sadjadpour, A.; Philbrick, C.R. "The Role of Wind Forecasting in Utility System Operation." IEEE Power & Energy Society General Meeting, July 26-30, 2009, Calgary, AB, Canada.

Smith, J.C.; Thresher, R.; **Zavadil, R.**; DeMeo, E.; Piwko, R.; Ernst, B.; Ackermann, T. "A Mighty Wind." *Power and Energy Magazine, IEEE* March-April 2009: 41-51.

Samaan, N.; **Zavadil, R.**; Smith, J.C.; Conto, J. "Modeling of Wind Power Plants for Short Circuit Analysis in the Transmission Network." IEEE Transmission and Distribution Conference and Exposition, April 21-24, 2008, Chicago, Illinois.

Zavadil, R.; Miller, N.; Ellis, A.; Muljadi, E.; Camm, E.; Kirby, B. "Queuing Up." *Power and Energy Magazine, IEEE* Nov - Dec 2007: 47-58.

Muljadi, E.; Butterfield, C.P.; Ellis, A.; Mechenbier, J.; Hochheimer, J.; Young, R.; Miller, N.; Delmerico, R.; **Zavadil, R.**; Smith, J.C. "Equivalencing the Collector System of a Large Wind Power Plant." IEEE Power Engineering Society General Meeting, June 18-22, 2006, Montreal, Quebec, Canada.

Ahlstrom, M.; Jones, L.; **Zavadil, R.**; Grant, W. "The Future of Wind Forecasting and Utility Operations." *Power and Energy Magazine, IEEE* Nov - Dec 2005: 57-64.

Zavadil, R.; Miller, N.; Ellis, A.; Muljadi, E. "Making Connections [Wind Generation Facilities]." *Power and Energy Magazine, IEEE* Nov - Dec 2005: 26-37.

Zavadil, R.M.; Smith, J.C. "Status of Wind-Related US National and Regional Grid Code Activities." IEEE Power Engineering Society General Meeting, Vol.2, (2005) 1258-1261.

Kazachkov, Y.A.; Feltes, J.W. and **Zavadil, R.M.** "Modeling Wind Farms for Power System Stability Studies," IEEE Power Engineering Society General Meeting, July 13-17, 2003, Toronto, Canada.

Zavadil, R.M. "High Neutral-to-Earth Potentials on Rural Distribution Feeders Sharing Right-of-Way with Windplant Collector Lines," Windpower 2003, May 18-21, 2003, Austin, Texas.

Zavadil, R.M. "Dynamic Models for Wind Turbines and Wind Plants," Windpower 2003, May 18-21, 2003, Austin, Texas.

Ahlstrom, M.L.; **Zavadil, R.M.** "The Role of Wind Forecasting in Grid Operations & Amp; Reliability" IEEE PES Transmission and Distribution Conference and Exhibition: Asia and Pacific, Oct. 6-10, 2002.

Zavadil, R.M.; Banerjee, B.; Pileggi, D.; Divan, D. and Atwood, D. "Design of an Active Series/Passive Parallel Harmonic Filter for ASD Loads at a Wastewater Treatment Plant," 2000, PQA 92, Atlanta, Georgia.

Smith, J.W. and **Zavadil, R.M.** "Electric Utility Study Requirements and Needs for Interconnecting Large Wind Plants to the Transmission Network," Windpower 2000, Palm Springs, California.

Zavadil, R.M. "EPRI Power Quality Business Unit: Research & Development Plan for Advanced Motors and Drives," EPRI TR101828, July 1996.

Zavadil, R.M. "Utility Integration of Photovoltaic Systems," EPRI TR-106406, November 1996.

Goodman, F.R.; DeMeo, E.A.; **Zavadil, R.M.** "Residential Photovoltaics in the United States: Status and Outlook." *Solar Energy Materials and Solar Cells,* Volume 35, September 11, 1994: 375-386.

Zavadil, R.M. "Assessment of Active Power Line Conditioning Technologies," EPRI TR-102026, April 1993.
Tang. L. and **Zavadil, R.M.** "Shunt Capacitor Failures due to Windfarm Induction Generator Self-Excitation Phenomenon," 1992 IEEE PES Summer Meeting, Seattle, Washington.

Johnson, K.F. and **Zavadil, R.M.** "Assessing the Impacts of Nonlinear Loads on Power Quality in Commercial Buildings - An Overview," 1991 IEEE Industry Applications Society Annual Meeting, September 28 - October 4, 1991, Dearborn, Michigan.

M.F. McGranaghan; **Zavadil, R.M.**; Hensley, G.; Singh, T.; and Samotyj, M. "Impact of Utility-Switched Capacitors on Customer Systems: Magnification by Low Voltage Capacitors," 1991 IEEE PES Transmission and Distribution Exposition, September 22 -27, 1991, Dallas, Texas.

Tang. L.; **Zavadil, R.M.**; Smith, J.C.; and Childs, S. "Parametric Study of the Performance of a Passive Dynamic Brake," In *Proc. Windpower '91*, September 24-27, 1991, Palm Springs, California.

Pinneo, C.M. and **Zavadil, R.M.** "Analysis of Distribution System Harmonics with High Nonlinear Load Concentration," IEEE PES Summer Meeting, July 1990, Minneapolis, Minnesota.

Johnson, K.F.; Hensley, G.; McGranaghan, M.F.; and **Zavadil, R.M.** "Analysis of Harmonic Distortion Levels in Commercial Buildings," First International Conference on Power Quality for End-Use Applications, Paris, France.