Energy Forecasting in the Smart Grid Era

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Contact Information

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Brief Outline

Chapter 1 Fundamentals of energy forecasting (*2h*)
1.1 Introduction to the tutorial
1.2 Business needs of energy forecasting
1.3 Describing the data
1.4 Regression analysis
1.5 Model selection
1.6 Probabilistic forecasting

Chapter 2 Short-term and long-term electricity demand forecasting (*2h*)
2.1 Introduction
2.2 Short-term load forecasting (STLF)
2.3 Long-term load forecasting (LTLF)
2.4 Challenges for load forecasting in the future smart grid
2.5 Conclusion

Chapter 3 Price forecasting in competitive electricity markets (*2h*)
3.1 Review of markets' pricing mechanism
3.2 What may influence prices
3.3 Simulation models versus time series models
3.4 Characteristics of electricity price time series
3.5 Building conventional models for price forecasting
3.6 Model testing
3.7 Applying price forecasts to operation scheduling
3.8 Non-conventional price prediction models

Chapter 4 Wind power forecasting in theory and practice (*2h*)
4.1 Introduction to the wind and power forecasting problems and applications
4.2 Historical perspective on the wind power forecasting problem
4.3 Data and overall approaches to wind power forecasting
4.4 From point to probabilistic forecasts of wind power generation
4.5 Basics of forecast verification
4.6 Conclusions

Abstract

Wide range deployment of smart grid technologies enables utilities to monitor the power systems and gather data on a much more granular level than ever before. While the utilities can potentially better understand the customers, design the demand response programs, forecast and control the loads, and plan the systems, etc., they are facing analytic issues with making sense and taking advantage of the "big data". This tutorial offers a comprehensive overview of energy forecasting to utility analysts, planners, operators and their managers. The participants will learn the fundamentals and the state-of-the-art of load, price and wind forecasting.

Forecasting electricity demand is crucial for the effective operations and planning of electric power systems. Load forecasts are widely used across all sectors of the utility industry and by many business units of a utility. Such forecasts can be roughly categorized into two groups depending upon the forecasting horizon, short-term forecast, which provides essential information for economic dispatch, unit commitment and electricity market, and long-term forecast, which is an integral process in scheduling the construction of new generation facilities and in the development of transmission and distribution systems. This tutorial will review the technical developments of load forecasting in the last three decades, focusing on the representative forecasting approaches and covering different forms of forecasts, including point forecasts, interval and probabilistic forecasts. Case studies of both long-term and short-term load forecasting for utilities in the US and Australia will be presented, and the opportunities and challenges of load forecasting in the future smart grid environment will also be discussed.

After the introduction of competition in electric power sector in many regions, wholesale electricity prices are determined based on supply and demand. Unlike other commodities, electricity must be produced and consumed at the same time with practically no "warehousing" opportunity. This makes electricity market prices highly volatile, compared to market prices for other commodities, and thus, hard to accurately predict. This part of the tutorial will review the fundamentals, applications, techniques and challenges of short-term electricity market price forecasting. Conventional methods, which focus of forecasting exact price values, as well as non-conventional methods, which are tied to the needs of forecast users, will be discussed. Case studies of applying price forecasts to scheduling problems for both the supply and demand-sides will be presented. The focus will be electric energy prices, while characteristics of reserve and regulation prices will also be reviewed.

With the rapidly increasing penetration of wind energy in power systems and electricity markets, forecasting at time scales of minutes to days is recognized as a necessary input to various operational and decision-making problems. Forecasting of wind power generation is not a trivial problem though, since requiring multi-disciplinary approaches combining expertise in mathematics/statistics, meteorology and power systems engineering. The tutorial will aim at first introducing motivations for prediction by presenting a number of relevant operational problems, also giving it a historical perspective. Research and development in that field can be traced back to the early 1980s, with pioneering work by meteorologists and statisticians. Since then, a wealth of different approaches was proposed for the improvement of wind power forecasts in various forms. Following a presentation of necessary and suggested input data (i.e., different sorts of meteorological forecasts, as well as meteorological and power measurements), an overview of the state of knowledge will be given. The various approaches to the generation of predictions depending upon the lead times of interest will be reviewed. Emphasis will also be placed on the various forms of wind power predictions, including deterministic and probabilistic forecasts, as well as scenarios. Since forecasts are to be seen as a primary product as input to decision-making, it is of utmost interest to evaluate their quality prior to their use. An overview of methods, scores and diagnostic tools will be given for all types of forecasts, also giving hints on the levels of expected forecast skill to be expected today.

Instructors' Biographies

Dr. Tao Hong, SAS Institute, USA

Dr. Tao Hong is an Industry Consultant at SAS Institute, where he leads the forecasting vertical of the utilities business unit. His major areas of expertise are in forecasting and optimization. He has applied various statistical and optimization techniques to the development of algorithms and tools for utility applications of analytics, such as energy forecasting, power system planning, renewable integration, reliability planning and risk management, etc. He has been providing consulting services to numerous large and medium utilities in Americas, EMEA and AP. The long term spatial load forecasting methodology implemented in his MS thesis and the short term forecasting methodology proposed in his PhD dissertation has been commercialized and deployed to many utilities worldwide.
Dr. Hong currently serves as the Founding Chair of the IEEE Working Group on Energy Forecasting, where he leads the efforts of improving the forecasting practice of the utility industry. He has organized, chaired, and participated in many forecasting related sessions in several major conferences sponsored by IEEE Power and Energy Society and INFORMS. He is the General Chair of Global Energy Forecasting Competition and the Guest Editor in Chief of IEEE Transactions on Smart Grid – Special Issue on Analytics for Energy Forecasting with Applications to Smart Grid. Dr. Hong is an adjunct instructor at NC State University teaching load forecasting and demand response related topics at both Electrical & Computer Engineering department and Advanced Analytics Institute. He is also an instructor at SAS Institute teaching the Business Knowledge Series course "Electric Load Forecasting: Fundamentals and Best Practices".
Dr. Hong received his B.Eng. in Automation from Tsinghua University, Beijing, a M.S. in EE, a M.S. with co-majors in OR and IE, and a Ph.D. with co-majors in OR and EE from North Carolina State University.

Dr. Shu Fan, Monash University, Australia

Shu Fan received the B.S., M.S. and Ph.D. degrees in electrical engineering from Huazhong University of Science & Technology (HUST), Wuhan, China. From 2004 to 2006, he was doing postdoctoral research work sponsored by Japanese Government in Osaka Sangyo University. He was a visiting assistant professor at the Energy Systems Research Center of The University of Texas at Arlington from 2006 to 2007. Presently, he is a senior research fellow at Business and Economic Forecasting Unit, Monash University. His research interests include energy system forecasting, power system control, stability analysis, and power electronics. In the past years, he has published extensively in the prestigious academic journals, including IEEE Transaction on Power Systems, IEEE Transaction on Industry Application, IEEE Transaction on Energy Conversion, Energy Conversion and Management, IET Generation, Transmission & Distribution, etc. He has engaged in forecasting practice with electric regulators and utilities worldwide in developing load forecasts and wind generation forecasts. Currently he is providing short-term and long-term load forecasting advice for Australian Energy Market Operator (AEMO) for all the regions of the National Electricity Market (NEM). As an international recognized researcher, he is invited as referees for major academic journals in electrical engineering and forecasting. Dr. Shu Fan is a senior member of Institute of Electrical and Electronics Engineers (IEEE) and a member of International Institute of Forecasters (IIF).

Dr. Hamidreza (Hamid) Zareipour, University of Calgary, Canada

Dr. Hamidreza (Hamid) Zareipour received his Bachelor and Master degrees in Electrical Engineering in 1995 and 1997 from K.N. Toosi and Tabriz universities, Iran, respectively. He was a university lecturer at Persian Gulf University, Iran, from 1997 to 2002, where he also served as the Manager of IT and Director

of Research. During this period, he was also an independent consulting engineer in the area of power systems. He then joined the University of Waterloo, Ontario, Canada, in 2003, where he received his PhD degree in 2006. He has been with the University of Calgary from 2007, where he is an Associate Professor of Electrical and Computer Engineering. He is also a Research Fellow of the University of Calgary's Institute for Sustainable Energy, Environment and Economy, and a Research Fellow of University of Calgary's School of Public Policy.

Dr. Zareipour's research is generally concerned with the operation, management, and planning of electric energy systems in a deregulated electricity market environment. In particular, his research interests include optimal power system operation and planning under uncertainty in competitive markets, electricity price/demand forecasting, wind/solar power modeling and forecasting, impact of renewable inflexible generation (RIG) on power markets, energy storage for mitigating variability of RIG, operation scheduling of carbon capture and storage power plants, and energy management under uncertainty,

Dr. Zareipour is the recipient of several teaching and research awards within the University of Calgary's Department of Electrical and Computer Engineering, including: Award for Excellence in Supervision of Graduate Students, Teaching Excellence Award, Professor of the Year Award, and Excellence in Early Career Research Award.

Dr. Zareipour is an active volunteer with IEEE's Power and Energy Society (PES) and has served as: Technical Activities Organizer for the Power Engineering/Industrial Applications Chapter, Southern Alberta Section (SAS), IEEE; SAS Vice-chair, the Co-chair of 2008 North American Power Symposium in Calgary, and Member of Local Organizing Committee for the 2009 IEEE PES General Meeting in Calgary. Further, he currently serves in a number of IEEE PES technical activities including: he is the Secretary of Working Group on Energy Storage, he is the Secretary of Working Group on Energy Forecasting, and he chairs Electricity Market Economics Subcommittee. Dr. Zareipour is a senior member of the IEEE.

Dr. Pierre Pinson, Technical University of Denmark, Denmark

Pierre Pinson holds a M.Sc. In Applied Mathematics, as well as Ph.D. in Energy from Ecole des Mines de Paris, France. He is the Associate Professor in Stochastic Energy Systems at the Technical University of Denmark, having also been a visiting researcher at University of Washington (Seattle), University of Oxford, as well as a consultant at the European Centre for Medium-range Weather Forecasts (ECMWF – the world-leading research and operational weather forecasting center). He is involved as principal scientist and workpackage leader in several Danish (eg. Radar@Sea) and European projects (eg. SafeWind) related to the optimal management and integration of renewable energy in power systems and electricity markets. He acts as editor for Wind Energy and for IEEE Transactions on Power Systems. He has a published numerous articles in international peer-reviewed journals and is a regular speaker at international conferences. With co-authors, he is working on 2 books focusing on wind power prediction, and on integration of renewable energy in electricity markets, to be published in 2013-2014.