Mining SCADA Data Offers a New Roadmap of Wind Farm Operations and Management

Zijun Zhang[1] **and Zhe Song**[2*]

[1]Department of Systems Engineering and Engineering Management, P6600, 6F, Academic 1, City University of Hong Kong, Hong Kong, P R China

[2]School of Business, Nanjing University, Nanjing, P R China

*Corresponding author: Zhe Song, School of Business, Nanjing University, Nanjing, P R China, Tel: +86-152-95511-856; E-mail: zsong1@nju.edu.cn

Data-driven Wind Farm Operations and Management

Compared with traditional power plants, commercial wind farms contain dozens of power generation units, wind turbines, which are exposed to the harsh working environment and distributed over a broad region. Uncertainties in wind speeds, system failures, and grid loads introduce extra complexities in operating wind farms more efficiently. Hence, traditional knowledge of operating and managing power plants cannot be directly applied and a new mind of wind farm management is highly desired to advance the competitiveness of the wind power in the power market.

Emerging research problems prioritized by considering industrial needs of enhancing wind farm operations and management functions can cover: 1) Improve the reliability of wind power production through optimizing the operational schedule of wind turbines and their control 2) Develop efficient and effective systems for monitoring wind turbine conditions so that unexpected downtime of wind turbines can be controlled 3) Optimize the maintenance schedule by considering various factors to guarantee an efficient wind power production performance 4) Predict the failure of wind turbine major components including the gearbox, blade, and generator as well as offer meaningful information for better managing wind turbine spare items.

It is challenging to directly apply analytical approaches to generate deterministic solutions for formerly introduced problems due to their complexities. The development of information system and data-driven methods offer another direction for addressing those problems. Supervisory Control and Data Acquisition (SCADA) systems have been widely installed in commercial wind farms for continuously collecting conditional data of wind turbines. Collected SCADA data convey useful information for extracting novel knowledge of improving wind farm operations and management. Data-driven methods are powerful knowledge discovery tools applicable to handle such task.

Data-driven approaches in recent wind energy researches follow a similar framework as illustrated in Figure 1 [1,2]. The framework principle can be briefly illustrated by following four steps: 1) Data collection and processing 2) Parameter analysis and selection 3) Model development and verification 4) Model utilization and knowledge generation. Based on characteristics of considered problems, related wind farm SCADA data are extracted and processed to form datasets with desired formats for further data-driven analyses. The parameter selection is typically performed by considering statistical analyses and domain knowledge to determine useful parameters for developing data-driven models. In the model development, well-known data-driven methods will be compared to determine the most suitable one for accurately modeling different wind turbine processes based on

SCADA data. Developed data-driven models can be applied into studies of optimization, condition monitoring, and simulation to generate effective solutions for wind energy problems.
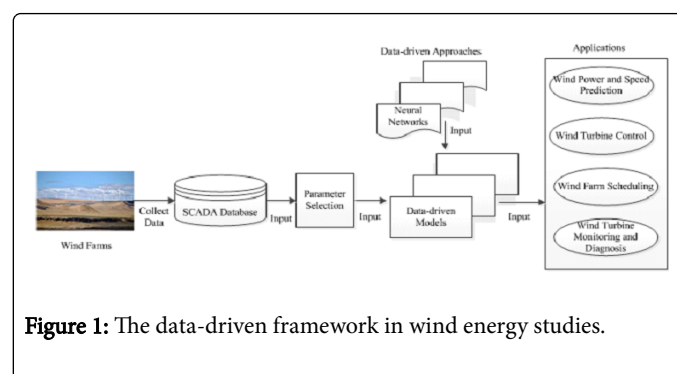

Figure 1: The data-driven framework in wind energy studies.

Successful applications of data-driven frameworks for solving problems related to the wind farm operations and management have been presented in recent pioneering studies. Long et al. [1] integrated data-driven modeling methods and statistical monitoring approaches to provide the online monitoring of wind power profiles. Jiang et al. [2] proposed a Bayesian structural break model to realize the interval and point prediction of future wind speeds. Kusiak et al. [3] introduced a data-driven framework for optimizing the operational schedule of wind turbines in a wind farm so that the overall cost could be minimized. Long and Zhang [4] developed a two-echelon planning model for optimizing the wind farm layout according to the statistical analysis results of wind speed data. Kusiak et al. [5] reported an anticipatory wind turbine control approach developed based on data-driven methods. Zhang et al. [6] presented the study of wind turbine gearbox condition monitoring with data-driven approaches. Results of [1-6] exposed that data-driven approaches are capable to tackle uncertainties involved in daily wind farm operations and generate customized solutions for facilitating the decision-making of wind farm operators. The self-learning ability of data-driven approaches could easily maintain their effectiveness and accuracy in various wind energy applications.

Reported studies [1-6] offered the initial taste of the feasibility of applying data-driven approaches for addressing different research problems in wind energy. Generated results provided a solid support of conducting more rigorous data-driven studies to discover novel knowledge for advancing functions in wind farm operations and management. The ultimate goal is to build up a comprehensive knowledge driven system for optimizing the cost and efficiency of wind farm operations and management.

References

1. Long H, Wang L, Zhang Z, Song Z, Xu J (2015) Data-Driven Wind Turbine Power Generation Performance Monitoring. IEEE Transactions on Industrial Electronics 62: 6627-6635.

2. Jiang Y, Song Z, Kusiak A (2013) Very short-term wind speed forecasting with Bayesian structural break model. Renewable Energy 50: 637-647.

3. Kusiak A, Zhang Z, Xu G (2013) Minimization of Wind Farm Operational Cost Based on Data-Driven Models. IEEE Transactions on Sustainable Energy 4: 756-764.

4. Long H, Zhang Z (2015) A Two-Echelon Wind Farm Layout Planning Model. IEEE Transactions on Sustainable Energy 6: 863-871.

5. Kusiak A, Song Z, Zheng H (2009) Anticipatory control of wind turbines with data-driven predictive models. IEEE Transactions on Energy Conversion 24: 766-774.

6. Zhang Z, Verma A, Kusiak A (2012) Fault Analysis and Condition Monitoring of the Wind Turbine Gearbox. IEEE Transactions on Energy Conversion 27: 526-535.