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Editorial: Advanced data-driven methods for monitoring solar and wind energy systems

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Editorial on the Research Topic
Advanced data-driven methods for monitoring solar and wind energy systems

Introduction

Renewable energy systems, specifically wind and solar photovoltaic (PV) systems, play a crucial role in addressing the urgent need for sustainable and reliable energy sources. They reduce dependence on fossil fuels and contribute to the fight against climate change. Additionally, the growth of these systems leads to the creation of jobs and economic growth. They provide a sustainable energy source that can be harnessed for decades to come. Furthermore, by diversifying energy sources they improve energy security, and they help to promote energy access, particularly in rural and remote areas, and reducing poverty.

The integration of renewable energy systems such as wind turbines and PV systems into the power grid requires accurate monitoring and prediction of their power production. This is necessary to ensure that the energy supply matches the demand and to avoid power outages and blackouts. Predictive maintenance and fault detection also play a critical role in ensuring the optimal performance and longevity of these systems, which can reduce costs and minimize the environmental impact.

Advanced data-driven methods can be used for monitoring, modeling, and fault detection, improving the prediction accuracy and overall performance of these renewable energy systems and supporting the integration of renewable energy in the power grid.

Artificial Intelligence (AI) methods such as machine learning and deep learning have a critical role in monitoring and optimizing solar PV and wind energy systems. These methods can analyze large amounts of data from the systems and identify patterns and trends that are not immediately apparent to humans. This can help in monitoring and optimizing the performance, reliability, and efficiency of these systems and also identifying faults and predicting power production. This Research Topic invited contributions that address wind turbine and PV systems faults and power prediction through innovative applications and novel contributions. It covers topics such as fault detection and diagnosis, power prediction, condition monitoring, deep learning, machine learning, and data-based methods for monitoring and optimizing solar PV and wind energy systems.

After rigorous review, four high-quality articles contributed by 16 authors were finally accepted for their contributions to the topic.

In the article *"A Hybrid Forecasting Model Based on CNN and Informer for Short-Term Wind Power"* Wang et al. suggest a forecasting model that combines a convolutional neural network (CNN) and a model named Informer to improve prediction accuracy. The method uses a 2-D CNN to extract additional time features and trend information from the original data, and then applies Informer to predict the average wind power. The proposed model is trained and tested using experimental dataset from a wind farm in China and evaluated by performance metrics for regression (i.e., MAE, MSE, RMSE and MAPE). Results show that the proposed method improves the average wind power prediction accuracy. The authors suggest that in future research, they intend to optimize the model by developing a lightweight network, to achieve a balance between time cost and accuracy.

In the article *"Wind Farm Energy Storage System Based on Cat Swarm Optimization–Backpropagation Neural Network Wind Power Prediction,"* Liu et al. present a method for predicting wind power using a backpropagation neural network (BPNN) optimized by a cat swarm optimization (CSO) algorithm. The goal is to improve the stability of wind farm output power by predicting short-term power output and controlling the operation of an energy storage system. The BPNN is optimized by the CSO algorithm to improve prediction accuracy and prevent local optimal problems. Simulation results show that the proposed CSO-BP algorithm is more accurate than the single BPNN algorithm and can effectively improve the accuracy of wind farm power prediction. The wind farm energy storage system designed on this basis can control the output of the energy storage system in advance and adjust the output power of the wind farm when it is connected to the grid through the predicted output power of the wind farm, providing a reliable solution to the problem of unstable power generation of wind farms.

In the article *"Ultra-Short-Term Wind Power Interval Prediction Based on Fluctuating Process Partitioning and Quantile Regression Forest"* Sun et al. propose an innovative framework for interval forecasting of ultra-short-term wind power that incorporates the power fluctuation process. The method uses a Kalman filter to remove the randomness of the original sequence and to analyze the components at the lower frequencies that reflect the trend of the wind power sequence. It then uses a clustering division of power fluctuation process and a Self-Organizing Map (SOM) to divide the fluctuation process of wind power into several types. The paper also proposes a quantile regression forest interval prediction model for ultra-short-term time scale and considering the clustering division of wave process. The framework is tested using 6 months of data from a wind farm in Jilin, China, and compared with several parametric and non-parametric models at multiple time spans. The results showed that the interval bandwidth is reduced by 0.86% on average, and the interval coverage is increased by 1.4% on average, demonstrating the effectiveness and feasibility of the method. The next step of the study will consider the physical change process of wind power and wind speed, and the physical change process of regional weather in different seasons.

In the article *"A Double-Layer Optimization Maintenance Strategy for Photovoltaic Power Generation Systems Considering Component Correlation and Availability,"* Li et al. propose a new double-layer optimization maintenance strategy for solar PV systems that takes into account component correlation and availability. The authors first analyze the comprehensive correlation of components in the system and model the availability of the system and components using a Markov model. The influence of the failure correlation on the maintenance strategy is checked by introducing the failure-related strength They then introduce the concept of opportunistic maintenance and use it to establish an upper-level optimization model that minimizes maintenance cost while maintaining high availability. They also establish a lower-level optimization model that verifies the proposed strategy. The proposed strategy is tested using a simulated PV power plant, and results show that it can effectively reduce maintenance costs, downtime, and increase system availability. In addition, the maintenance cost saving rate and the system availability reduction rate are greater under low weather accessibility.

This Research Topic focuses on using data-driven techniques, such as machine learning and deep learning, on improving the monitoring and prediction of wind and solar energy systems. These techniques have become increasingly popular due to advancements in sensor technology, high-speed internet, and cloud computing. It is expected that they will play a crucial role in the future development of condition monitoring and performance management for wind turbines and photovoltaic systems.

The guest editors express their appreciation to all the authors for their valuable contributions and to the reviewers for their thorough evaluations. They also want to extend a special thank you to the journal's editor-in-chief and the editorial board for their unwavering support throughout this Research Topic.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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