Guest Editorial
Special Section on Emerging Informatics for Risk Hedging and Decision Making in Smart Grids

THE development of smart grids worldwide aims at tackling various challenges facing power system operation and planning due to increased penetration of many new technologies of diversified properties. On the one hand, system operators and many other participants have to deal with increased uncertainties and risks involved in daily operation and planning activities. On the other hand, applications of many new metering and measurement devices, capable of closely monitoring and sensing grid operation in real time, result in overwhelming amount of measurement data of high precision and resolution. By far, how to make the best use of the massive data remains quite a challenging task facing power system researchers and practitioners [1].

It is recently realized that the availability of the high-quality data could potentially facilitate risk hedging and decision making in system operation and planning, of which the prerequisite calls for innovative informatics approaches that are intelligent, data driven, and capable of handling various complex problems. For instance, the application of advanced data mining techniques has enabled better prognosis of renewable generations that are highly uncertain and intermittent. Specially, recent trend has seen a revolutionary change of forecasting paradigm moving from the point-based forecasting approaches toward the probabilistic interval based ones by utilizing advanced data analytic techniques such as extreme learning machine (ELM) and granule computing [2]–[4], in order to achieve better prognosis and representation of the uncertainties and intermittencies involved in renewable energies. Another example is the wide area measurement systems data measured by widely deployed phasor measurement units has been exploited to develop advanced online power system security surveillance and visualization tools by many utilities [5]–[7]. Recently, there are also industrial applications of intelligent and data-oriented approaches dedicated for resolving complex control and operation problems in transmission or distribution grids with high renewable energy penetration [8]–[10]. In terms of electricity market operation, applications of advanced data analytic techniques have been popular to construct optimal bidding strategies for generators or electric vehicle aggregators, as well as short load forecasting and electricity market price forecasting, etc. [11], [12]. There are also many applications of risk-based techniques to counterbalance the uncertainties facing construction/expansion planning, as well as operation planning in context of deregulated electricity markets.

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The aim of this Special Section is to attract and report the latest advances toward the trend of applying advanced informatics techniques resolving complex problems facing power system operation and planning in the new era of smart grids. Special interests are given to the new methods that can handle various tasks of risk hedging and decision making appeared in eleven system operation and planning, though the scope has been slightly expanded to other topical issues in smart grids as well. The accepted eleven high-quality papers represent how the new advances and solutions toward resolving complex problems facing power system operation and planning can be brought forward by continuously leveraging emerging techniques in the field of data analytics and informatics. It should be highlighted that with the increased penetration of various emerging technologies such as renewables and electric vehicles (EVs), secure and economic system operation and planning deserve continuous research efforts in producing the most up-to-date methods and solutions dealing with issues of diversified natures and complexities in future power grids.

Specifically, the covered topics in this Special Section are topical and broad, concerning mainly power system security analysis and electricity market planning and operation under risks and uncertainties, which are briefly summarized in the following.

With respect to system security analysis, several new methods dealing with dynamic security, short-term voltage stability and frequency restoration have been reported. Zhang *et al.* investigate an intelligent early warning framework against dynamic insecurity risk that is developed based on ELM and a decision-making process under a multiobjective programming framework. The ensemble learning can ensure the robust performances in training individual ELMs, while the optimal tradeoff between the accuracy and earliness can be well handled through the multiobjective programming framework. In the same line, also applies machine learning technique in studying the voltage stability issue in power systems, where an imbalance learning machine based short-term voltage stability assessment method is proposed in Zhu *et al.* Considering the scarcity of voltage instability cases that would lead to class imbalance problem in training conventional learning machines, the proposed method actually combines a time series shapelet classification based method for sequential transient feature mining, a nonlinear synthetic oversampling technique, and a cost-sensitive learning method to enhance the adaptability and reliability of its online implementation. To enable renewable energy participation in power system frequency regulation, a new dynamic state estimation (DSE) based framework for frequency restoration is proposed in Yu *et al.*, where the DSE algorithm is introduced to tackle noises and uncertainties involved in state estimation of traditional and photovoltaic (PV) generators.

With respect to electricity market planning and operation, different methods and approaches for risk-averse biding and system planning as well as electricity demand forecasting, etc., have been reported. A novel optimal biding strategy for electric vehicles aggregators in electricity markets have been proposed in H. Yang *et al.* Distinguished from most existing methods, the proposed biding strategy innovatively forms the biding offers for both day-ahead and real-time markets in one holistic approach, so that the expected total electricity purchase cost can be significantly minimized given various constraints including the conditional value-at-risk ones, etc. Furthermore, the effectiveness of the method is confirmed based on case studies using practical electricity market data. Similarly, the risk-based approach is also adopted in studying renewable energy development in Xiao *et al.* Considering the risks attributed to electricity market and national energy policies, a modified computable general equilibrium (CGE) model that can analyze potential risks of various development plans for renewable energy and national economy in China is developed. The effectiveness of the proposed CGE model is validated through case studies using practical data, where sensitivity analysis of key model parameters is also performed to obtain insights into model characteristics. The paper by C. J. Li *et al.* deals with optimal multienergy trading considering the risk from uncertain energy supply and demand of a group of microgrids. Based on a novel two-stage stochastic game model with Cournot Nash pricing mechanism and the conditional value at-risk criterion, a new optimal energy strategy for the microgrid aggregator has been developed to maximize each microgrid's profit while minimizing the risk of overbidding by microgrids with high renewable energy penetration. To validate the effectiveness of the proposed method, numerical simulations have been successfully conducted using real-world data from Australia power grids. In view of the important role of battery in both spot and frequency regulation markets with high renewable penetration, a novel co-optimization model is proposed in Zhai *et al.* to maximize the financial return considering the tradeoff between the lifespan and economic benefit. The estimation methods for lithium battery operation cost and lifespan have been developed taking into account the battery discharging depth and state of charge, etc., and Australian National Electricity Market framework is specially considered in this study. In the research in Jia *et al.*, battery storage is also focused for effective energy management in microgrids based on historical system operation data, where a novel adaptive intelligence technique based variable charging/discharging threshold method is developed to manage the battery-ultracapacitor based hybrid energy storage system for optimal scheduling of microgrid operation. To facilitate electricity market operation, an accurate and fast converging short-term load forecasting method is proposed in Ahmad *et al.* based on mutual information based feature selection, artificial neural network and enhanced differential evolution algorithm. Case studies using practical data demonstrate the superior convergence and accuracy of the proposed model over traditional ones. L. Yang *et al.* investigate a risk-averse operational planning method for regional energy providers to pursue maximal profits while tackling the uncertainties of electricity market price. Since the proposed model forms a mixed-integer quadratically constrained programming problem, a global optimization method, named as multiple perspective-cuts outer approximation method (MPC-OAM) is developed to solve this model efficiently. Case studies demonstrate the proposed MPC-OAM can outperform other state-of-the-art solution methods in both computing efficiency and solution quality. Lastly, an interesting work on system planning has been reported to address the complexities and uncertainties facing future power systems. A novel probabilistic wind and PV power hosting capacity assessment method for active distribution networks is proposed in Al-Saadi *et al.* The system deterioration risk indices with respect to power quality and over loading due to system demand, PV and wind power variations have been developed and computed using the likelihood approximation approach. Sparse grid based technique is adopted for implanting the proposed hosting capacity assessment method, which shows superior efficiency and acceptable accuracy in comparison to traditional Monte Carlo simulation based approach.

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