applied sciences

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Editorial

Special Issue on 'Large Grid-Connected Wind Turbines'

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Received: 25 February 2019; Accepted: 26 February 2019; Published: 6 March 2019

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1. Introduction

The renewable energy penetration rate to the power grid is rapidly increasing these days. As per the statistics available in 2018 [1], the total renewable power capacity is 1,081 GW, excluding hydropower. Wind, solar, biomass, tidal and geothermal are considered as the prime renewable sources in generating electric power, while wind energy is the most attractive one dominating the energy market. In 2017, 52 GW of wind power was added globally, making a total of 539 GW, which is more than 50% of the total power generated from various renewable resources. China, the United States, Germany, India and Spain are the top five countries investing most in the wind energy sector. Among many wind turbine manufacturers, Vestas, Siemens-Gamesa and GE have captured the majority of the wind market in 2017, having a market share of 16.7%, 16.6%, and 7.6%, respectively [1].

Because of the growing nature of wind energy penetration, large scale wind turbines are getting popular, especially in offshore wind farms. In June 2017, MHI Vestas, a joint venture between Vestas and Mitsubishi Heavy Industries, launched a 9.5 MW offshore turbine, which is currently the world's largest wind turbine as of today, and it has been scheduled for 10 MW. Standing 187 meters tall and with 80-meter blades, this wind turbine is an upgraded version of MHI Vestas' 8 MW V164 turbine, which is already in operation at the Burbo Bank Extension and Blyth offshore wind farms in Britain. Seeing the bright future of the large scale wind turbine, GE has recently introduced the Haliade-X 12 MW, which will be the most powerful offshore wind turbine in the world to date, featuring a 12 MW capacity, 220-meter rotor, and a 107-meter blade. The Haliade-X will also be the most efficient of wind turbines in the ocean having a capacity factor of 63%—which of course will be dependent on wind conditions. This turbine is expected to be commissioned for trial by the middle of 2019 [2].

2. Challenges and Opportunities of Large Wind Turbines

Considering the growing nature of large wind turbines, many technological challenges are to be resolved. Wind power intermittency is a well-known problem. To address this issue, it is important to exercise well how to predict the wind speed, and only then can this intermittency problem be handled precisely. The smoothing of the variable wind power is the next step in which the energy storage system and other advanced control approaches may play vital roles [3,4]. The intermittency of wind power may also lead to voltage and frequency instabilities. Many FACTS devices and energy storage systems can help in augmenting these stabilities. A modern approach to address the frequency dip problem is to use the synthetic inertial [5]. Grid Interfacing, fault ride through and power electronic converters' reliability are other important issues to be addressed [6] in order to get a reliable grid operation.

The wind energy sector is blessed by the contribution from many engineering and science disciplines in the last few decades, mainly from mechanical, electrical, electronic, computer and aerospace. The individual and joint efforts from scientists within different disciplines are prime drivers for the wind industry to reach maturity. In this special issue, the present and future development schemes of wind turbine generator systems are depicted based on the contribution from many renowned scientists and engineers in different disciplines. To make this special issue collection useful for students and researchers, a wide variety of research outcomes are merged together, putting focus on the variability, stability and scalability issues of wind energy conversion systems. To address the challenges mentioned above, 10 different articles are included in this special issue collection, selected from many submissions, and a brief description for each article is given below.

The first paper [7], authored by Arman Oshnoei, Rahmat Khezri, SM Muyeen and Frede Blaabjerg, presents a pure technical review on Wind Farm Automatic Generation Control (AGC), focusing on frequency regulation. In this article, the contribution of wind farms in the supplementary/load frequency control of AGC is overviewed first. Then the authors proposed a fractional order proportional-integral-differential (FOPID) controller to regulate the speed of the turbine rotor in the participating AGC. The second paper [8] provides another review on Fault Current Limiting Devices to augment the fault ride through the capability of large wind turbines using doubly fed induction generators, authored by Seyed Behzad Naderi, Pooya Davari, Dao Zhou, Michael Negnevitsky and Frede Blaabjerg, giving a focus mainly on fault current limiters and series dynamic braking resistors. This is indeed a timely reporting.

There are three papers addressing wind power variability and intermittency issues. In the first paper [9], authored by Yanxia Shen, Xu Wang and Jie Chen computed the potential uncertainties of wind power in constructing prediction intervals (PIs) and prediction models using a wavelet neural network (WNN). In order to optimize the forecasting model, the authors have proposed a multi-objective artificial bee colony (MOABC) algorithm combining multi-objective evolutionary knowledge, called EKMOABC. It appears that in this way, a better short-time wind power forecasting is very much possible. In the second paper [10], the novel output power smoothing control strategy for a wind farm based on the allocation of wind turbines is proposed by the Authors Ying Zhu, Haixiang Zang, Lexiang Cheng and Shengyu Gao. The wind turbines in the wind farm are divided into control wind turbines (CWT) and power wind turbines (PWT), separately. The rotor inertia based power smoothing method is adopted in that study for the sake of better performance. This is another timely reporting in addressing wind power variability problem. In the third paper [11], authored by Andrzej Tomczewski and Leszek Kasprzyk, the wind power intermittency problem is addressed by using Flywheel Energy Storage System (FESS).

In paper [12], authored by Abdullah Bubshait and Marcelo G. Simões, is presented a new control approach for wind turbines in regulating system frequency. The prime focus was to design a control method to maintain the reserved power of the wind turbine, by simultaneously controlling the blade pitch angle and rotor speed. The transient stability augmentation method of a wind farm populated with both fixed and variable speed wind generators is presented in [13], by Md. Rifat Hazari, Mohammad Abdul Mannan, S. M. Muyeen, Atsushi Umemura, Rion Takahashi and Junji Tamura. In that work, it has been shown that a fuzzy based control approach works well to stabilize the squirrel cage induction generators of a wind farm through the use of doubly fed induction generators.

Condition monitoring of equipment and accessories including sensors are very important tasks for large wind turbines to reduce any downtime. This is critical because the shutdown of a megawatt class wind turbine causes considerable revenue loss. The current sensor fault diagnosis and isolation problem for a permanent magnet synchronous generator (PMSG) based wind system is presented in [14], by Zhimin Yang, Yi Chai, Hongpeng Yin and Songbing Tao. In [15], Bin Li, Junyu Liu, Xin Wang and Lili Zhao discussed the protection issues of wind turbines using the doubly fed induction generator. Feasibility and economic studies of wind farm using FACTS devices in a distribution network have been conducted in [16] by Lina Wang, Kamel Djamel Eddine Kerrouche, Abdelkader Mezouar, Alex Van Den Bossche, Azzedine Draou and Larbi Boumediene.

3. Concluding Remarks

It is obvious that although wind energy technology has reached a stage of maturity, more in-depth research should be carried out in this area to welcome 10+ MW class wind turbines onto the market. The main problems identified so far are the intermittency, stability and reliability issues of large scale wind turbines. This requires further improvements in existing control and protection mechanisms and hence, combined efforts from scientists and researchers from multiple disciplines are very much essential and most appreciated, in order to drive down the cost of energy.

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