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Editorial

Advances in Floating Wind Energy Converters

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During the last decades, wind energy has been developed from an emerging technique of yielding sustainable energy into a robustly established technology due to its renewable, sustainable, and clean features. The respective economic and environmental benefits gained great importance in the global energy industry in the fight against climate change. It is of great interest to just follow certain sporadic recent achievements: during the last year 17 GW of wind power capacity were installed in Europe, bringing its total wind power capacity to 236 GW [1]. In 2019, wind energy saved 118 million tonnes of CO_2 in Europe, and at the end of this decade, 270 million tonnes of CO_2 are expected to be saved annually [2,3].

Among the various onshore and offshore wind energy systems, floating wind power technology plays a leading role nowadays, being considered as an utmost promising way to yield energy from the wind in oceans and deep seas, e.g., in the Mediterranean Sea [1,2]. According to last year's data, floating wind energy contributes a total capacity of 73.33 MW, from which almost half is contributed be the UK [1–3]. Floating wind turbines are usually of large size and located in areas of high wind potential in deep waters. Therefore, a plethora of challenges and difficulties arise during the construction of their floating and mooring system along with the operation due to frequent extreme environmental actions (winds, waves and currents).

The present Editorial on the Special Issue "Advances in Floating Wind Energy Converters" discusses six papers on different technological aspects of floating wind energy technology that range from the dynamic response analysis of semi-submersible floating wind turbines in combined wave and current conditions [4], the drivers for and barriers to the take up of floating offshore wind technology [5] and a multi-criteria approach to evaluate floating offshore wind farms [6] to the technical definition of the TetraSpar demonstrator floating wind turbine foundation [7] and the concept, design and extreme response in survival conditions of a floating wind—solar—aquaculture system [8].

A brief summary of the content associated with each of the selected papers belonging to this Special Issue is presented below:

In the first paper, Ishihara and Liu [4] propose an advanced hydrodynamic model to predict the dynamic response of a floating offshore wind turbine in combined wave and current conditions. This model is validated by laboratory and full-scale, semi-submersible platforms. By introducing a hydrodynamic model, the added mass and drag coefficients in a wide range of Reynolds numbers are evaluated. Then, an advanced hydrodynamic model is proposed to calculate the drag force of a cylinder under combined wave and current conditions. The model at hand is validated by water tank tests in current-only, wave-only and current–wave conditions and is also used to investigate the effect of current on the dynamic response of the floating offshore wind turbine. Within this framework, the full-scale, semi-submersible platform used in the Fukushima demonstration project is investigated. The authors conclude that the predictions of the dynamic responses of the platform by the proposed hydrodynamic model can be improved by means of the application of the directional spreading function of the sea wave spectrum, showing favourable agreement with the field measurements.

In the second paper by Umoh and Lemon [5], a systems approach is adopted to investigate the viability of floating offshore wind power generation, focusing on Scotland

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and South Africa, by means of a content analysis of relevant secondary documentation such as policy documents, industry reports, press releases, online publications and databases to determine the drivers and barriers of floating wind energy. The four key findings are the following: (1) substantial technical potential is required to attract floating wind investments; (2) political support is necessary in order to scale up; (3) a strong offshore wind supply chain could cushion the high-cost effects of floating wind projects; (4) and more innovative business models such as corporate Power Purchasing Agreements could serve as social drivers for such projects. The authors conclude that the first floating wind project in Scotland benefitted from the Renewable Obligation scheme of local government; however, its discontinuation threatens the prospects of future projects. Alternatively, South African technical potential coupled with the support of the local government for renewable energy development could lead to a strong take-up of this technology soon, with corresponding benefits for more sustainable energy in densely populated areas.

The third paper by Diaz and Guedes Soares [6] proposes a multi-criteria optimisation method applied to evaluate floating wind farms. In particular, the study presents a methodology for floating wind farm site selection with a Canary Islands case study combining geographical information systems (GIS) and multiple criteria decision methods (MCDMs). The problematic areas for the installation of the turbines are identified through a GIS database application that generates thematic layers representing exclusion criteria. Available maritime locations are analysed and ranked using the analytical hierarchy process based on technical, economic and environmental aspects that guarantee the elimination of subjectivity. The study compares the solutions of the proposed technique with those of others, and in particular with PROMETHEE, ELECTRE III, TOPSIS and WSA. This investigation concludes with the creation of a realistic and objective overview of floating offshore wind farm site selection and the contribution to minimize the environmental impacts and reduce the social conflicts between stakeholders.

The fourth paper by Borg et al. [7] focuses on the TetraSpar floating wind turbine foundation being a milestone in floating wind and bringing a significant cost-reduction in these projects. In particular, the paper aims to give a description of the design in order to enable a thorough discussion of different design philosophies and their influence on the usage of materials and production time. The description of the different subcomponents of the system should allow any entity to build a model for comparison and benchmarking versus this concept. The authors expect that this open approach to this technological discussion is paramount to obtaining continued cost-reduction in the area of floating offshore wind.

In the fifth paper by Cottura et al. [9], an offshore floating wind turbine is comprehensively modelled, and the response of the system is examined as it results from a wide spectrum of sea and wind states being typical in the Mediterranean Sea. The flexible and accessible in-house, in-purpose model developed is compared with the reference model FAST v8.16, so that its reliability is verified. In addition, a systematic simulation campaign is carried out to estimate the wind turbine Levelized Cost of Energy and then, based on this, the best substructure is chosen and the convenience of the investment is evaluated.

The last paper by Zheng et al. [8] proposes a design concept for offshore floating wind–solar–aquaculture systems and studies its extreme response in survivability conditions. This new design concept combines multiple-megawatt, vertical-axis wind turbines and a solar array with a floating steel fish-farming cage that intends to utilize the ocean space and water resources more effectively and more economically, while greatly shortening the payback period of investment in offshore power generation. Having employed the WAMIT program based on potential-flow theory to obtain the response amplitude operators in sinusoidal waves of varying periods, the proposed concept possesses better hydrodynamic seakeeping performances than its OC3Hywind spar and OC4DeepCwind semi-submersible counterparts. After the selection of a potential site, the proposed WSA system is studied, and its feasibility is examined in terms of hydrodynamic motions and structural dynamic response driven by wind, waves, and current. Fully coupled time-domain simulations have been carried out for 50-year survival conditions and the overall structural system exhibits outstanding performance for its small motions in random wind and seas, whilst top accelerations and tower base stresses and mooring line tensions meet the design requirements. As a conclusion, the authors claim that the WSA has strong competitiveness and wide prospects in floating wind for both power exploitation and marine aquaculture in intermediate and deep waters.

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