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天氣預報模式在風場開發之應用

An Application of the Weather Prediction Model in Wind Farm Development

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摘要

近年來，離岸風能於再生能源中扮演舉足輕重的角色。開發離岸風場時，利用數值天氣預報(NWP)進行區域風能模擬是不可或缺，因為 NWP 相較於氣象塔提供更密集的空間與更精細的時間解析度。另一方面，為了產生較多電能，風機的體積隨之增大，意味對大氣邊界層與環境影響將更顯著。基於以上，本研究以 WRF 模擬與福海氣象塔資料比對，再利用 Fitch 參數化，進行福海風力發電股份有限公司於彰濱外海預訂 30 台 SWT-4.0-120 風機(第一、二期)之模擬，並發現風場後方有顯著且接近 2(m/s)損失的尾流。為了探討尾流特徵，以一維動量理論做基本驗證，並藉由 Jensen 尾流模型概念，推廣出改良式風場尾流模型，以提供風場開發初步建議。比較模型與 WRF 參數化之結果，發現在這樣的風場佈置下，風場的尾流衰變常數(wake decay constant)與單一風機之離岸建議數值有相當的關聯性，間接證明風場尾流的影響能以單一風機來比擬。總結，希望能夠以此研究首次呈現數值天氣預報模式在台灣風場開發之應用，並嘗試整合工程觀點評估風場尾流影響，以進一步了解彰濱離岸風力資源與風場佈署。

關鍵詞：WRF 模式，福海氣象塔，Fitch 參數化，Jensen 尾流模型，尾流衰變常數

Abstract

Offshore wind energy has been playing an important role in sustainable energy recently. In the development of the offshore wind farm, the regional wind simulation conducted by numerical weather predictions (NWP) is becoming indispensable because it can provide much wider coverage of spatial and finer temporal resolution than the meteorological mast. In addition, in order to generate more electrical power, the size of the wind turbines has been enlarged. This tendency implies that the interaction between the wind turbines, the atmospheric boundary layer, and the environment are becoming increasingly significant. To address the interaction, we conduct simulation using the WRF model and compare to the data recorded by the Fuhai met mast. To cope with the increasing operational wind farms, the WRF model has been incorporated with a wind turbine parameterization model, proposed by Fitch et al. The model is applied to simulate the Fuhai wind farm with 30 SWT-4.0-120 wind turbines (Phase I, II), designed by the Fuhai Wind Farm Corporation. Results show a distinct wake formed with a nearly 2 (m/s) velocity deficit behind the Fuhai wind farm. To discuss the characteristics of the wake, a 1D momentum theory is developed and a modified wake model similar to Jensen's approaches is proposed. Interestingly, comparing the result of the modified wake model and the simulation, it is found that the wake decay constant of the wind farm has a substantial connection to the suggestion of a single wind turbine in this deployment, as if the influence of the entire wind farm on the wake can be imitated by a single wind turbine. To conclude, this study is an initial attempt in Taiwan to illustrate the importance of applying the NWP model to wind farm development, as well as to explain the wake effect of the wind farm from the engineering perspectives to the better understanding of the wind resources and wind farm deployments of Changhua offshore.

Keywords: WRF model, Fuhai met mast, Fitch scheme, Jensen's wake model, wake decay constant