World Academy of Science, Engineering and Technology
International Journal of Energy and Environmental Engineering
Vol:9, No:07, 2015

Mapping the Turbulence Intensity and Excess Energy Available to Small Wind Systems over 4 Major UK Cities

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Abstract : Due to the highly turbulent nature of urban air flows, and by virtue of the fact that turbines are likely to be located within the roughness sublayer of the urban boundary layer, proposed urban wind installations are faced with major challenges compared to rural installations. The challenge of operating within turbulent winds can however, be counteracted by the development of suitable gust tracking solutions. In order to assess the cost effectiveness of such controls, a detailed understanding of the urban wind resource, including its turbulent characteristics, is required. Estimating the ambient turbulence and total kinetic energy available at different control response times is essential in evaluating the potential performance of wind systems within the urban environment should effective control solutions be employed. However, high resolution wind measurements within the urban roughness sub-layer are uncommon, and detailed CFD modelling approaches are too computationally expensive to apply routinely on a city wide scale. This paper therefore presents an alternative semi-empirical methodology for estimating the excess energy content (EEC) present in the complex and gusty urban wind. An analytical methodology for predicting the total wind energy available at a potential turbine site is proposed by assessing the relationship between turbulence intensities and EEC, for different control response times. The semi-empirical model is then incorporated with an analytical methodology that was initially developed to predict mean wind speeds at various heights within the built environment based on detailed mapping of its aerodynamic characteristics. Based on the current methodology, additional estimates of turbulence intensities and EEC allow a more complete assessment of the available wind resource. The methodology is applied to 4 UK cities with results showing the potential of mapping turbulence intensities and the total wind energy available at different heights within each city. Considering the effect of ambient turbulence and choice of wind system, the wind resource over neighbourhood regions (of 250 m uniform resolution) and building rooftops within the 4 cities were assessed with results highlighting the promise of mapping potential turbine sites within each city.

Keywords : excess energy content, small-scale wind, turbulence intensity, urban wind energy, wind resource assessment
Conference Title : ICRERA 2015 : International Conference on Renewable Energy Resources and Applications
Conference Location : Paris, France
Conference Dates : July 20-21, 2015