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Wind Potential Map in El Salvador

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Abstract:

The Project for Master Plan for the Development of Renewable Energy in the Republic of El Salvador" was executed by Japan International Cooperation Agency (JICA) in 2012. In the study, master plan for the development of renewable energies such as Geo-thermal, Hydro power, Solar, Biomass and Wind power were prepared.

For the master plan of wind power development, it is necessary to clarify wind potential of the country. Therefore, nationwide wind power potential map was prepared to identify the wind potential area. The map indicates geographical distribution of wind potential over large regions at certain height above ground level. In the study, wind potential map at 30m, 50m and 80m above ground level were prepared respectively. As a result of analysis on the meteorological data and consideration of meteorological influence such as the El Nino phenomenon, meteorological data in 2008 was chosen as suitable annual data for calculation. On the basis of Weather Research and Forecasting Model (WRF Model) wind power potential was simulated by Japan Weather Association. WRF Model is used all over the world as regional weather model. In addition, MASCON model was applied to correct wind velocity using topography data to calculate detailed topography effect. In addition to the map, estimated wind data set was prepared for 10 sites. Based on the wind potential maps, considering with natural and social condition, high potential area (10 sites) were selected. In the selected sites, various data were maintained as a wind characteristics database.

In the result, annual wind characteristics (500 m mesh) of target year (2008) were calculated by a MASCON model and wind potential maps with the resolution of 500 meters mesh were prepared in El Salvador. As a result of wind potential analysis, wind potential areas of El Salvador were identified in the southwest mountainous area, northwest mountainous area and northeast mountainous area.

Wind resource analysis in consideration of wind turbine wake on complex terrain

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Abstract:

In Japan, the government has a plan to boost wind power to 1.7% of total electrical energy by 2030. This means approximately tripling generating wind power, it is expected that many wind turbines will be constructed. However, because flat area suitable for wind farms has been decreasing, wind farms are constructed in complex terrain recently. In this case, it is becoming more and more important for turbine placement evaluation using wind resource analysis. Moreover, in the wind farms comprising multiple wind turbines, we should consider not only topographic effect but also wake effects.

In this paper, we performed validation of wind resource analysis by comparison of measurement data with calculation results to optimize wind turbine placement in wind farms.

Regarding measurement data, we use the data of the wind resource measurement project in real wind farm at Nagashima island in Kagoshima prefecture in Japan. In this project, we prepare ground-based LIDAR to measure vertical wind speed profiles affected by the wake of wind turbines. LIDAR is the measurement device that can obtain wind speed and wind direction data using laser light.

For calculation, we use wind resource analysis software developed by Uchida et.al of Kyushu University. The governing equations of this software are incompressible fluid continuity equation and Navier-Stokes equation, and the mesh type is collocated grid. The turbulence model is LES standard Smagorinsky model. In this paper, wind turbines are assumed to resistance body in calculation. In the resistance body model, the drag forces generated by wind turbine rotor are added to the Navier-Stokes equations as external terms, and the tower and nacelle are reproduced by solid cells.

This paper reports the comparison of vertical wind speed profiles between the measurement and calculation. To evaluate the influence from wind turbine's wake, we use just the measurement data in the leeward of the wind turbine. In order to increase the accuracy of validation of wind turbine model, we use the data that one wind turbine is in upwind of measurement devise. The calculation results show the good agreement with measurement data. Considerable insight has been gained concerning modeling wind turbine using resistance body model.

Estimation of Probability Distribution Function and Wind Energy Potential

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Abstract:

This paper focuses on analyzing the wind characteristics at Maulana Azad National Institute of Technology (MANIT), which extended up to 650 acres, located in the state capital of Madhya Pradesh, Bhopal, India. The hourly time series wind data of speed and direction at 10m and 25m, measured and recorded. Yearly mean wind speed values for 25m and 10m were determined as 4.26 m/s and 2.90 m/s respectively. Modeling of wind speed probability at this institute is done to estimate wind power density at higher heights of 50m, 80m, 100m, 120m, 140m and 160m. Previous studies state that wind speed is the crucial one that commands the engineering parameters. Distributions appeared in the literature are selected that are Chi – squared, Exponential, Gamma, Gumbel, Inverse gamma, Log normal, Pareto, Rayleigh, Weibull distributions are revisited and a comparison between these methods is carried out. Efficiency and accuracy of these distributions are judged based on outcome of different goodness of fit tests like Root mean square error, variance and chi – square error. Results show that Weibull distribution is superior over other methods. Further six numerical methods namely maximum likelihood method, power density method, standard deviation method, moment method, graphical method and modified maximum likelihood methods are used for evaluation of monthly weibull parameters at 25m and 10m. Fore mentioned statistical tests are performed in order to pick the efficient method. Three methods of modified maximum likelihood, moment method and standard deviation methods present favorable efficiency while the graphical method shows very weak ability of all sections. Further, modified maximum likelihood method has shown better results over other methods. Monthly wind power density values of the region were calculated using the best Weibull parameters. Justus and Mikhail method is used for vertical extrapolation of mean wind speed, weibull parameters and wind power density for higher heights. As a conclusion, the monthly mean value of Weibull shape parameter k is between 3.69 and 2.14; while monthly scale parameter C is between 5.92 and 2.46 m/s at 25 m hub height. The highest wind power density value was found to be in the month of June while the lowest value was encountered in November. It shows a large variation due to change in monthly weather conditions. Extrapolated values of wind power density in June at 50 to 160m vary from 120.73 to 376.76 W/m2; while in November 11.32 to 51.15 W/m2.

Numerical site calibration procedure for power performance testing of wind turbine

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Abstract:

Numerical site calibration procedure for the power performance testing of wind turbine is proposed.

The objective of this work is to provide a methodology that will ensure consistency, accuracy and reproducibility in the calculation flow correction factor, which is specified in IEC16400-12-1, by using numerical simulation.

In order to verify this numerical site calibration procedure, a commercial wind resource assessment CFD software is used and flow simulations at Ubuyama and Ichikikushikino sites are conducted. Measurement campaign was conducted by NEDO at Ubuyama and Ichkikushikino sites. The numerical results are compared to the measurement data obtained by two met masts at each sites.

The conclusion is that, in the case following the proper procedure, the numerical simulation gives acceptable prediction of the flow correction factor for the site calibration.

The wind power potential in low wind speed regions of China

Rong Zhu and Yang Wang

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Abstract:

Along with the technical progress of wind turbine, more and more wind energy resources can be exploited. The richer wind energy resources of China locate in northwest, north, northeast areas which have less population and demand of power. However, in east and south of China, there are more population, developed economy, large power load, but lower wind speed. In recent years, benefited from new wind turbine with long blade and higher power output which can be running under lower wind speed, wind energy resources can be exploited and wind power can be used locally in east and south of China. In this paper, wind power potential with lower wind speed was assessed in order to provide scientific basis for policy making of wind power development in low wind speed regions in China.

Two data bases of wind energy resources were set up by numerical simulation, one has high spatial resolution of 1km*1km in horizontal of mean wind speed of 30 years by simulation of about 500 sample days, and the other has high temporal resolution of 1 hour and horizontal resolution of 15km*15km by simulation of day by day from 1995 to 2014. Based the second data base, the utilization hours of wind turbine in whole year can be estimated by choosing a mainstream wind turbine, and the lowest limit of utilization hours of 1800h is defined. The available areas can be worked out after combining the wind data base with high spatial resolution and setting lowest limit wind speed of 6m/s. For wind resources development in low wind regions, wind turbine with longer blade and higher power output was chosen and lowest limit of wind speed was 5m/s. Finally, the areas not available for wind power development, such as steep slope, water body, cities and nature protection areas, were taken out of the available areas by GIS analysis.

Assessment of this paper shows that China has the available area of 1730000 km2 and wind power potential of 880.5X106 kWh for wind power development. If the wind turbines with long blade and high power output are used in whole China and lowest limit of wind speed is 5m/s, the wind resource assessment shows that the available areas will increase 73% and the wind power potential will increase 70%. For 18 provinces in east and south of China, the assessment shows that the available areas will increase 1.94 times and the wind power potential will increase 1.9 times. The numerical simulation indicated that, in east plain of China, the wind speed increases rapidly with the height, so wind power potential would increase obviously if using wind turbines with higher hub height.

Applicability of k-ε model and LES model on prediction of turbulent flow field over transition region of trees

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Abstract:

Prediction of turbulent flow field over transition region of trees is important for the design of wind turbine which is installed in the clearing of forest or close to a patch of trees. The wind energy production is proportional to the cubic of mean wind speed, and fluctuating wind component accounts for fluctuating wind load, which is required in fatigue analysis of wind turbine.

Therefore, accurate prediction of both mean wind speed and fluctuating wind component is necessary according to different consideration.

In order to achieve accurate prediction of turbulent flow fields, accurate modelling of the effect of trees is required. The canopy model, in which the effect of the obstacles is considered as external force, is widely used to modelling the effect of trees and many versions are available. Enoki and Ishihara (2012) proposed a generalized canopy model, by which the effect of the distributed buildings and trees can be considered simultaneously, for simulation with k-ε model. It is found that the mean wind speed in the wake of tree can be well predicted, but the turbulent kinetic energy is underestimated and the reason is not clear. It is worth to study the applicability of combination of canopy model and LES (large eddy simulation) model, by which the turbulence motion can be understand even though it requires much more calculation cost compared with simulation with k-ε model.

In this study, the generalized canopy model proposed by Enoki and Ishihara is used to modelling the effect of trees. Simulations on prediction of turbulent flow fields over a row of trees are carried out using both k-ε model and LES model. In case k-ε model is applied, the turbulent wind component generated and dissipated by canopy layer is explicitly modelled as a source term in k and ε equations. On the other hand, in case LES model is used, the turbulent wind component generated and dissipated by canopy layer is simulated by resolving all eddies without introducing any model. Quadrant analysis, based on the results from simulation with LES model, is then carried out to clarify the mechanism of turbulence motion in the wake of tree.

The assessment of offshore extreme wind speeds on the western coast in Taiwan

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Abstract:

It is of great importance and urgency for Taiwan to develop offshore wind power. However, several damage surveys indicated many failures of offshore structures due to extreme wind force, and typhoons occurred frequently surrounding Taiwan. Thus, it is important to analyze the characteristics of extreme wind speeds on offshore wind turbines under extreme wind conditions. In this research, a long-term 10-min average wind speed in used, and the annual maxima method (i.e. AMM) and method of independent storm (i.e. MIS) are applied to assess the characteristics of extreme wind speeds. The results show that extreme 10-min average wind speeds at 90 m in 50-yr return period are approximately 45-55 m/s.

Mitigation of crossover phenomena of wind speed scaling analysis based on season division

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Abstract:

Abstract:As a natural signal, wind is affected by many other natural factors and shows natural features, such as diurnal and seasonal alternation. Considering the crossover phenomena (CP) of wind speed time series (WSTS) occurs at seasonal time scaling and WSTS shows different features among seasons, the seasonal scaling analysis of WSTS is carried out. Seasonal WSTS is extracted by 3 methods that contains solar terms method, gregorian calendar method and multi-index method. The multi-index method proposed in this paper combines gregorian calendar method with natural indices, such as temperature, wind speed and its standard deviation. Compared with chronological order WSTS which is not divided into seasons, the CP of seasonal WSTS is mitigated, especially by multi-index method. These illustrate effect of season division and existence of different scaling features among seasons. Further analysis that includes more factors is required in order to improve the multi-index method. A new scaling analysis technique, adaptive fractal analysis, is applied.

Keywords: seasonal scaling analysis, wind speed time series, multi-index method, adaptive fractal analysis