Sayı (Number): 4

SU VAKFI

Wind Farm Energy Production Assessment in Balikesir Ömerli Location

Balıkesir Ömerli Mevkiinde Rüzgâr Çiftliği Enerji Üretimi Değerlendirmesi

Zekâi Şen

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YENİLENEBİLİR ENERJİ KÜLLİYESİ

TURKISH WATER FOUNDATION

RENEWABLE ENERGY FACULTY

YENİLENEBİLİR ENERJİ BÜLTENİ : SAYI 4

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Abstract

Turkish Water Foundation through its Renewable Energy Research and Development Center has also a consultant company, which specializes in various topics such as water resources, renewable energy (solar, wind, hydro-electric), climate change and environment natural hazards (flood, drought, and earthquake) and related areas in engineering domain.

All the calculations and suggestions in this bulletin abide by the international standards of wind energy and turbine calculations. In addition to average wind velocity different useful statistical parameters such as the standard deviation of the wind velocity records are also presented in this report. The final calculations take into consideration uncertainty that may arise from the power curve, wind data and model.

Claimer

Although wind velocity and turbine calculations are directly related to fluctuations and temporal variations including turbulence component in wind velocity, all of the calculations are performed in the best possible scientific expertise of **Turkish Water Foundation** staff and the client may reliably depend on these calculations for 5-year period with updated measurements and calculations then onwards. The **Turkish Water Foundation** is not responsible for any feasibility study beyond the stipulated time duration which is 5 years from the date of this report. Additionally, any long term predictions based on the available wind data are not given in this bulletin and hence **Turkish Water Foundation** is not responsible for such predictions in the future. This is due to the availability of more than one year 10-min wind velocity average data at this site.

PLEASE NOTE: Actual wind turbine sitting in the field is not considered in this bulletin

Uncertainty

During the calculations in this report three different kinds of individual uncertainty sources are considered. These are

1. Wind data uncertainty,
2. Turbine uncertainty, and
3. Model uncertainty

The total uncertainty is defined as the square root of the summation of square errors. In this report, individual uncertainties are taken as 5%, 10% and 3%, respectively. Hence, the total uncertainty is 11.57%, which may be taken rounded to 10%.

Purpose

This report provides an independent expert view about the wind energy generation possibility at the specified site and all the calculations are undertaken by **HYDROSEN** company expert staff. It is of prime importance for the **Turkish Water Foundation** company staff to visit the study area in order to appreciate possible wing energy generation feasibility and turbine sitting in the field, if necessary, in the future. There was a measuring post at Ömerköy location, which recorded wind velocity measurements in years 2001-2002. **Turkish Water Foundation** company staff was provided with the following items for calculations in this report.

1. A simple topographic map with rough details and the scale of this may was 1:25000.
2. A field trip facility for one day.
3. Wind velocity measurements at every 10-min interval starting from 2001 and 2002.
4. NordexS70/1500 type of wind turbine power curve (1500 kW).

Location of the study area

The city of Balıkesir is in the Eastern Province of Turkey (Aegean Sea region). Its location is in the transition zone between the Marmara and Agean geographical regions.

Wind speed data

On the basis of the given documents **Turkish Water Foundation** experts started to evaluate the most long-term mean wind energy and the following steps are among the essentials for a successful accomplishment.

1. Unfortunately, the raw data were not reliable and there were many mis-recordings, recording error and others. Hence the first step was to establish a reliable data.
2. After the elimination of unreliable data the raw data were transferred to Microsoft Excel software.
3. The reliable data is adjusted for long-term wind fluctuations

The raw data of 10-min measured averages are used for the present calculations after the reliability corrections. Table 1 includes the wind speed averages and standard deviations with coefficient of variation and the Weibull model parameters at field measurement height of 30 m with extrapolations to 70 m.

Table 1 Wind speed characteristics

Height (m)	Average speed (m/s)	Standard deviation (m/s)	Variation coefficient	Weibull PDF parameters	
				A	k
30	8.80	4.69	0.61	9.41	1.93
70	9.07	5.30	0.58	10.63	1.93

In any wind power calculation, it is necessary to know the theoretical wind speed probability distribution function (PDF), which appeared as Weibull PDF with parameters given in Table 1 and in the graphical form in terms of exceedance probabilities in Figure 1.

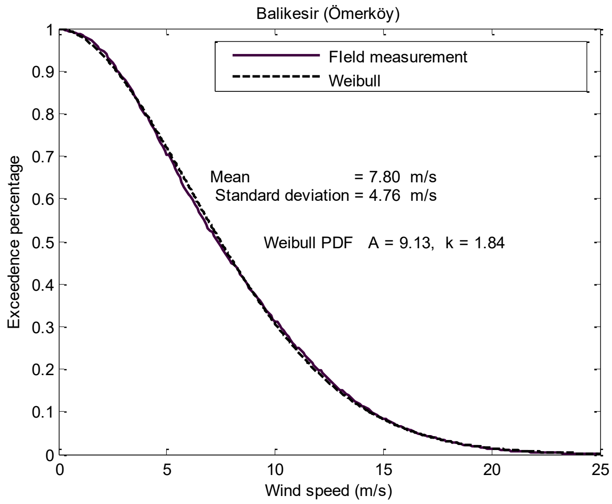

Figure 1. Wind speed relative frequency

Turbine calculation

The used turbine is of NordexS70/1500 type, which may be used at Balıkesir, Ömerköy location. The characteristics of such a turbine are given in the following with power curve values in Table 2.

Nominal Power : 1500 kW

Rotor diameter : 70 m

Cut-in speed : 3 m/s

Cut-out speed : 20 m/s

Table 2 Power curve values

Speed (m/s)	Power (kW)
1	0
2	0
3	0
4	25
5	87
6	214
7	377
8	589
9	855
10	1162
11	1453
12	1500
13	1500
14	1500
15	1500
16	1500
17	1500
18	1500
19	1500
20	1500
21	0
22	0
23	0
24	0
25	0

The first step in any turbine calculation is to obtain the wind speed PDF curve, which is Weibull PDF at this site. The theoretical relative frequency distribution of wind speed is presented in Figure 2.

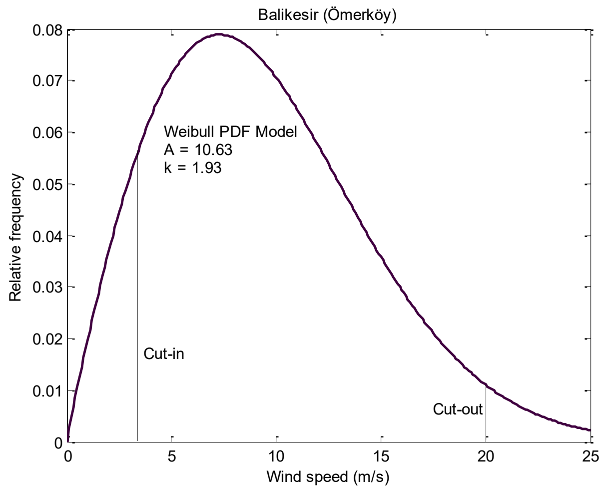

Figure 2. Wind speed distribution function

The wind energy calculations are made according to power curve values in Table 2 by considering aerodynamic principles. The results are presented in Figure 3. This figure tells how much wind energy can be produced annually for a given wind speed?

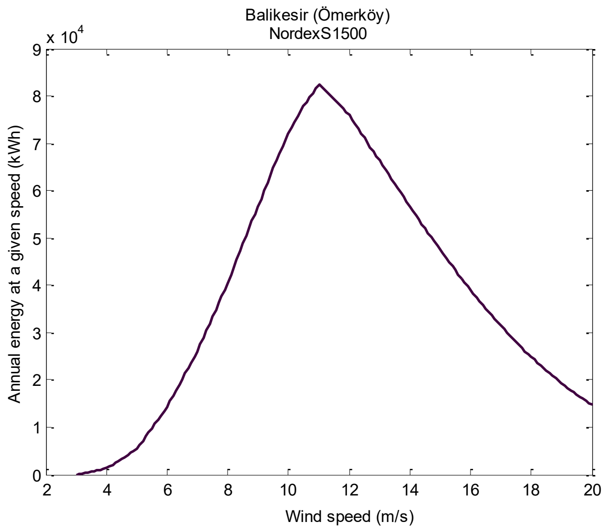

Figure 3. Wind energy for a given velocity value

The integration of the curve in Figure 3 by numerical analysis yields the annual total wind energy as given in Figure 4.

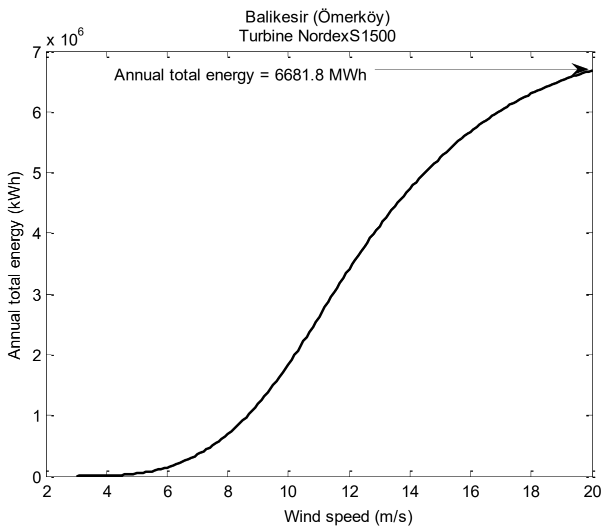

Figure 4. Annual total wind energy

Conclusions

The wind energy of a single turbine of type NordexS1500 yields at Ömerköy, Balikesir, the following values as in Table 3.

Table 3. Single turbine energy generation characteristics

WEC type	Power (kW)	Rotor (m)	Hub Height (m)	Single turbine (MWh)	Parking Efficiency (%)	Single turbine in wind farm (MWh)
NordexS1500	1500	70	70	6681.8	90	6013.6

Consideration of 10% total uncertainty as explained above the wind energy output of a turbine in a wind farm becomes

6013.6×0.9 = 5412.2 MWh

At Balikesir, Ömerköy location the total wind energy generation is considered as 45 MW, and therefore, the number of NordexS1500 turbines is 45/1.5 = 30 turbines.

Establishment of a wind farm at Ömerköy location in Balikesir can generate annually the following energy amount.

30×5412.2 = 162366.0 MWh/year

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