WIND POTENTIAL ANALYSIS FOR HAKKARI CENTRAL REGION

Emrah Harmanci[1], Sedat Yayla[1]
[1] Hakkari University Department of Electrical and Automation
[2] Yüzüncü Yıl University Faculty of Engineering Department of Mechanical Engineering

65080 Central, Van, syayla@yyu.edu.tr, emrahharmanci@hakkari.edu.tr

***Abstract**: In this study wind potential investigated for the region to the east of Turkey's Hakkari centers. The wind speed and direction information used in the study were taken from the measurement station belonging to the General Directorate of Meteorology in Hakkari Center. Data sets containing 5 year wind speed and wind direction between 2013 and 2017 taken from this measurement station were analyzed by the WASP program. The NASA SRTM data library in the WASP interface was used to create digital maps for the region. Regional barriers required for areas where wind potentials are searched and roughness maps were created using Google Maps. As a result of these analyzes, annual average wind speed value of 1.96 m / s and average power density of this region in Hakkari Center is calculated as 12 W / m^2. The prevailing wind direction belonging to this region has been identified as Southwest, but it has been found that this dominant wind direction changes with great proximity to the Southeast-Northwest sector interval on the South side.*
Keywords: WASP, WIND ENERGY, RENEWABLE ENERGY, WIND POTENTIAL

1.Introduction

Nowadays, use of natural energy resources has become an area where human beings must rapidly turn due to the rapid depletion of fossil-based energy and the world's inability to carry human population in this direction. In this area, large investments are made in the world, and a large part of the energy needs of the metropolis and the industries are provided within this scope. Many recent studies have been carried out to investigate the sources of renewable energy and to determine the potentials of available resources.

Yayla S. (2005), Van Yüzüncü Yıl University used the WASP program to determine the Campus Area Wind Energy Potential. Şahin B. et al. (2005), wind energy in Turkey's eastern Mediterranean coast have used to determine the potential wasp. The average power density was determined to be 500 W / m2 at 25 m from ground level in many parts of this area. Sharma K. and Ahmed R.M. (2016), Suva and Kadavu in the Fiji Islands have tried to determine the wind energy potential. The dominant wind direction for both regions was found in the Southeast. Data analysis showed that the total wind speed in the region is about 3.5e6.35 m / s. Kazet M. Y. et al. (2016), have prepared a wind source map of Cameroon's Ngaoundere region. Various data types have been used for the study on climate, topography and roughness. Annual energy production for the region is calculated to be 5,985 MWh. Nouri A. et al. (2016), they have prepared a comparative methodology between the wind resources of two different regions in Morocco for the study of the wind farm potential. Himri Y. et al. (2010), using WASP, they performed a statistical analysis of wind speeds in Tindouf in Algeria. It was found that the mean wind speeds of the working area changed between 7.19-7.95 m / s and the annual values of k and c on the field changed between 2.85 and 3.23 and 8.0-8.9 m / s respectively. Bilgili M. et al. (2004), using the hourly wind data observed between 1997 and 2001 at the meteorological stations of Antakya and İskenderun regions, they determined the dominant wind direction, mean values, wind speed, wind potential and frequency distributions. The results are classified according to their height above the ground level. Boudia S.M. et al. (2016), calculated the potential of the wind energy over the Algerian region. Based on the Weibull function, annual mean wind speed was 2.42 m / s and annual mean power density was 49 W / m² in the analysis carried out at a height of 10 m in the meteorological station. Pusat Ş. (2017), has tried to determine the wind energy potential at Sakarya University. In the study, it was determined that the wind energy potential of the zone is generally low. Şahin B. and Bilgili M. (2009), have been studied wind characteristics to using WAsP at Belen Hatay in the south of Turkey. They are calculated as 7.0 m / s and 378 W / m2, respectively, with an average wind speed and power potential of 10 m above sea level. This study concludes that existing regions are suitable for wind power plantation and that building a wind farm in this region may be profitable. Hocaoğlu F.O et al.(2008), by using the WASP, Anadolu University in Eskişehir region has simulated the wind turbine using the data of wind speeds and directions measured and recorded from 2 Eylül Campus in 1 hour intervals. As a result of simulations, the possible energy production of the wind turbine considered was calculated as 849,421 MW/h.

2.Materials and Methods

In this study, 11 wasp 275,000 population located to the east with Turkey's Hakkari using proğramı of the central district of the province of wind potential has been determined. The data used in this study to make measurements in this region of the Republic of Turkey, which is taken from the General Directorate of Meteorology observation station. The data taken from the measuring station consist of the values of wind speed and wind direction measured at an altitude of 10m from the ground hourly in the interval of 5 years between 2013-2017.

***Figure 1.** General Directorate of Meteorology Hakkari Metering Station.*

There are mountains over 3000 meters in altitude around the area where the measuring station is located. The altitude at which the measuring station is located is 1727 meters. Figure 1 shows a map of Google Earth. Numerical maps of the region used in the WASP program in the study were obtained from the SRTM Importer located in the WASP interface. The SRTM Importer draws data from the SRTM Database, a library of NASA-developed digital maps of all areas of the world. WASP licensing is sufficient for access to this library. Coordinate information of the station worked was taken from the site of General Directorate of Meteorology. When these geographic coordinates are entered in the Map Center Location section in the SRTM Importer section, numerical maps are obtained for a radius of 3 km around this coordinate. Land roughness information of the obtained maps comes with the map by entering Land Roughness value. However, these adjustments have been made using Google Maps in order to more precisely adjust the roughness information in the working regions. Area roughness and obstacle information are obtained by using images from Google Maps as a base in WASP Map Editor section.

The collected MGM data was edited with "WASP Climate Analyst 3" which is included in the WASP 11 version before the main program is transferred. Here, climate data with specific time series are analyzed and the main program is formulated as observed

climate data (.omwc). Crude data with time series were transferred to Climate Analyst 3 module in "csv" format.

Observed station data obtained from the MGM were entered into the program as 3 columns. In the first column, the time slice of the climate data is specified as year, month, day and hour. In the second and third columns, wind speed and direction information related to the measured time are included. After being transferred to the Wind Climate Analyst program, the data sets can be arranged according to the desired category. Here, speed, direction, time series are organized according to the category is organized.

After entering the data as in Figure 2, the "Observed Wind Climate File" (OMWC) was calculated. OMWC calculations have wind charts, statistical reports and wind speed histograms with parameters a and k for all sectors from 0-330 degrees.

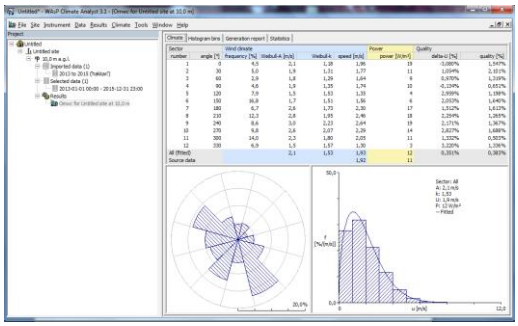

Figure 2. *Creation of OMWC data sets with WAsP.*

The creation of the vector based maps belonging to the region has been done through WASP Map Editor 11. Map Editor allows you to download the topographic maps of the desired region by connecting to the topographic map database of the "SRTM .ver2 Database" created by NASA under the "import" section in the "files" section. In this study, land models belonging to the region were obtained from the SRTM Database by utilizing this feature. In order to obtain the data from the SRTM Database, as shown in Figure 3, the interface opened as DDD from the MGM site was entered as the center of the map and the location was entered in the "Map Center Location" field. Once the projection settings have been made, 2m spacing surface curves are provided with a 30 km area around the selected center. WaSP calculation modules have some limits. For vector maps, the sum of the number of points on the map plus three times the number of lines must not exceed 1,000,000 (Güzel B. 2012).

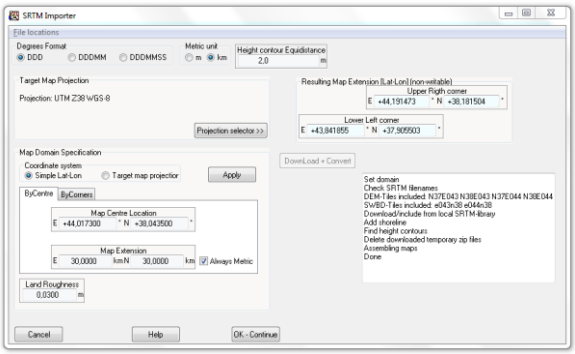

Figure 3. *Topographic data generation from the SRTM Database.*

The surface roughness limits for the maps obtained for the regions were obtained using images obtained from Google Earth. The borders of areas with roughness values in the Google Earth interface are surrounded by road lines, which are then transferred to the WASP Map Editor in ".kmz" format. Roughness values are defined in the line properties and areas with different roughness values are defined in the program.

The vector map and roughness boundaries were merged into a single Map file and then saved in the ".map" format to be transferred to WASP 11. Observed climate data (.omwc) and surface map (.map) files were transferred to WASP 11 program.
When the observed climate data is transferred to the WASP, the UTM coordinate information of the station from which the measured values are received is being sought. Geographic coordinates obtained from stations belonging to the MGM were converted to UTM format, and then the coordinates of the metering station were entered.

After the transfer operations were completed, "Vestas V52 850 kW" was selected from the ready turbine models that came with the WASP program and the wind fields belonging to the region were created. Coordinate information of the wind field in UTM format should be entered when the turbine site is created as it is in the transfer of Observed Climate Data. After these operations are completed, the measurement station and the wind field are formed on the Vector Map.

After these processes are completed, a potential map has been created that allows us to read the potential distribution of the region with the aid of the color scale. The potential distributions of the region in the potential map show the power density of the regions in each sector. This map provides the most advantageous points for establishing a turbine site according to the potential density of the zone.

3.Result and Discussion

In the study, wind atlases and potential maps were created using the WASP program to determine the wind potential of the region. For this, the data from the MGM measurement stations belonging to the studied regions were transferred to the WASP Climate Analyst module to obtain the wind skip and wind gauge graphs. The resulting omwc file was then transferred to WASP11 with surface maps from the SRTM Database and environmental barrier information was added. All zone environmental obstacles have been obtained using Google Maps. The graph of the wind skip obtained by transferring the data from the MGM to the WASP Climate Analyst program is shown in the following figure x. In this graph, mean wind speed value, weibull parameters and wind power values calculated for the square meter area are observed.

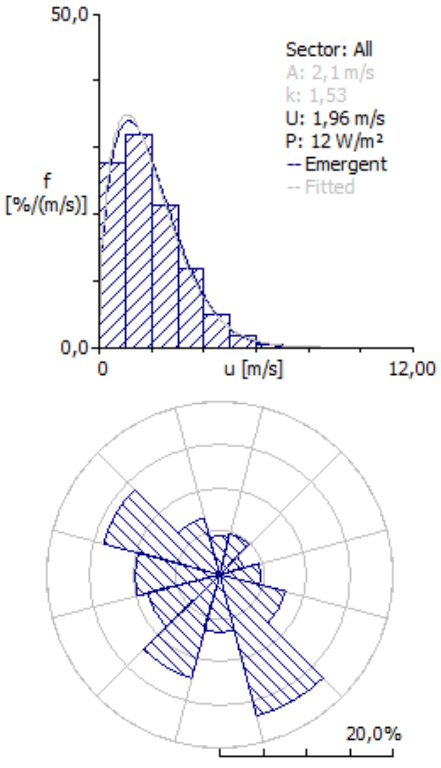

***Figure** Грешка! В документа няма текст със зададения стил.. Observed wind climate data and wind velocity histogram of Hakkari central station.*

The graphics are arranged to determine the wind potential of the 3 km area around the metering station. This does not cover the whole of the region studied. It is to create a system that can analyze the whole region that needs to be done. For the MGM station obtained in the study with data from the MGM and the area within 3 km of the coverage area, the wind is very low as seen from the graphs of potential. At the same time, as seen in the graph of wind gusts, the direction of the wind in the region varies from south to south in the clockwise Southeast and Northwest sectors, with very close violence. This indicates that the region has a turbulent wind blowing structure. The active dominant wind direction in this region can be seen in the wind rose in the graph of Sector 5 at 150 ° in the southeast direction. The average speed value, mean power density, wind speed frequency and wind frequency frequency belonging to this region are shown in the table below.

***Table 1.** Observed climate data for measurement stations.*

Station	A (m/sn)	k	U(m/sn)	P (W/m^2)
Hakkari Station	2,1	1,53	1,96	12

The ".omwc" file created after the calculation of the observed climate data in the Wasp Climate Analyst program has been transferred to the WASP 11 program. In the WASP 11 program, environmental obstacles, turbine selection and potential mapping of the region have also been carried out. The environmental barrier was created using Google Maps.

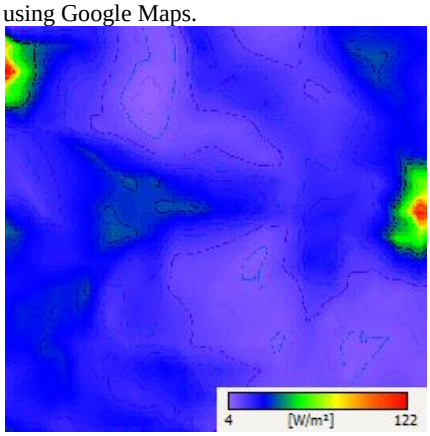

***Figure 5.** Wind potential distribution maps of MGM Hakkari Central Station.*

Turbine selections were calculated in accordance with the calculated wind force power density and the selections were concluded accordingly. Finally, wind simulation is performed on the vector maps obtained from SRTM Databese under WASP Map Editor, and wind potential maps of the regions shown in the following figure x are created. In these maps, the area around the station can be observed with the aid of the color scale. As can be seen from the maps, some areas in the eastern and southeastern regions of the Hakkari metering station are estimated to have wind potentials of around 152 W / m2.

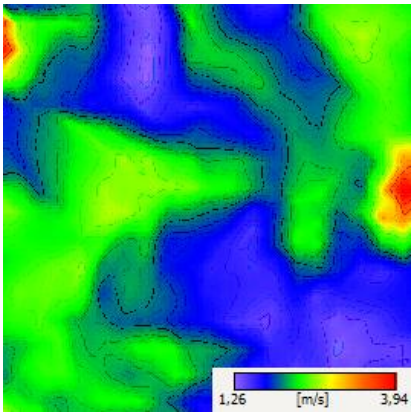

***Figure 5.** Wind speed distribution maps of MGM Hakkari Central Station.*

When the obtained potential maps and wind rose graphs are examined, the results obtained from the wind potential and wind roses are obtained for the Hakkari Central Station, which is shown in Table 2. According to this, it is seen that the area where Hakkari Central Station is located is in a medium level in terms of wind potential. When the theoretical results obtained in the analysis with WASP showed conformity to the Weibull distribution (Yayla S. 2005), it was tried to determine the wind speed potentials at various altitudes for Hakkari Central Station. The mean wind speed for this study and the mean and maximum wind potential results are shown in the table below for 10, 30, 50, 80 and 100 meter heights.

***Table 2.** The results of wind gulness and potential atlas of Hakkari Central Station.*

Station	Mean Wind Speed (m/s)	Wind Potential (W/m^2)		Dominant Wind Directions
		Mean	Maximum	
Hakkari Center 10m	2.07	19	122	Southeast
Hakkari Center 30m	3.00	50	177	
Hakkari Center 50m	3.39	64	197	
Hakkari Center 80m	3.88	90	241	
Hakkari Center 100m	4.11	105	262	

The wind parameters obtained in the sectors according to the selected turbine are shown in Table 4 below. According to this, it is understood that the most successful sector in terms of annual wind production is the ninth sector with 240°.

Table 2. The results of wind gulness and potential atlas of Hakkari Central Station.

Sektor	Angle	Frequency	Weibull-A [m/s]	Weibull-k	Speed [m/s]
1	0	4.02	3.3	1.44	2.96
2	30	5.56	4.2	1.55	3.78
3	60	5.67	3.7	1.56	3.35
4	90	6.86	2.6	1.60	2.36
5	120	7.35	1.8	1.88	1.62
6	150	9.21	1.9	1.82	1.65
7	180	7.87	2.1	1.79	1.91
8	210	12.29	5.0	2.19	4.41
9	240	14.04	6.4	2.48	5.64
10	270	13.87	5.3	2.28	4.70
11	300	8.89	3.8	2.18	3.36
12	330	4.38	3.3	1.75	2.96

4. Results

As a result of this work, it has been determined that this measuring station in the center of Hakkari and the area of 3 km radius around it are not suitable for wind farm installation. As can be seen from the wind turbine belonging to the region, the dominant wind direction is determined as Southeast. The wind speed in the region is 1.96 m / s and the power density is 12 W / m2. The area is very mountainous and there is a pitched area between the mountains and peaks that cut the wind speed of the metering station. The potential to be investigated in the higher parts of the hilly and mountainous areas surrounding the center of the Hakkari Center, which is outside the coverage area of this measurement station that needs to be done, and where the wind speed is not exposed to high obstacles. Since there is no metering station in these regions, the wind could not be calculated for the center of the potential center of the province. In order to be able to determine the general potential of the zone at every point, it is necessary to be able to determine the wind speed and direction at the points to be determined before being dependent on the measurement stations.

5. Acknowledgement

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6. Resources

Bilgili, M., Şahin, B., Şimşek, E., 2010. Ege Bölgesindeki Toprak Sıcaklıklarının Yapay Sinir Ağları Yöntemi İle Belirlenmesi, Isı Bilimi Ve Tekniği Dergisi 30(1): 121-132.

Boudia, S.M., Berrached, S., Bouri, S., 2016. On the use of wind energy at Tlemcen, North-western region of Algeria, Energy Procedia 93: 141-145.

Güzel B., 2012. Açik Deniz Rüzgar Enerjisi, Fizibilite Adimlari Ile Bozcaada Ve Gökçeada Örnek Çalişmasi (Yüksek Lisans Tezi), İTÜ, Enerji Enstitüsü, Sarıyer, İstanbul.

Himri, Y., Himri, S., Stambouli, A.B., 2010. Wind power resource in the south-western region of Algeria, Renewable and Sustainable Energy Reviews 14: 554–556.

Hocaoğlu F.O., Kurban M., Filik, Ü.B., 2008. WAsP Yazılımı İle Rüzgar Potansiyeli Analizi Ve Uygulama, Anadolu Üniversitesi İki Eylül Kampüsü Mühendislik-Mimarlık Fakültesi 26555, Eskişehir.

Kazet, M.Y., Mouangue, R., Kuitche, A., Ndjaka, J.M., 2016. Wind energy resource assessment in Ngaoundere locality, Energy Procedia 93: 74 – 81.

Nouri, A., Babram, M.A., Elwarraki, E., Enzili, M., 2016. Moroccan wind farm potential feasibility. Case study, Energy Conversion and Management 122: 39–51

Pusat, Ş., 2017. Sakarya Üniversitesi için rüzgâr enerjisi potansiyel belirleme çalışması, Pamukkale Universitesi Mühendislik Bilim Dergisi 23 (4): 352-357.

Sahin, B., Bilgili, M., Akilli, H., 2005. The wind power potential of the eastern Mediterranean region of Turkey, Journal of Wind Engineering and Industrial Aerodynamics 93: 171–183.

Sahin, B., Bilgili, M., 2009. Wind Characteristics and Energy Potential in Belen-Hatay, Turkey, International Journal of Green Energy, 6: 157–172.

Sharma, K., Ahmed, M.R., 2016. Wind energy resource assessment for the Fiji Islands: Kadavu Island and Suva Peninsula, Renewable Energy 89: 168-180.

Yayla, S., 2005. Van Gölü Kıyısının Rüzgar Enerjisi Potansiyelinin Belirlenmesi (Yüksek Lisans Tezi), YYÜ, Fen Bilimleri Enstitüsü, Merkez, Van.