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Analysis and Applicability of Mersin Region Wind Speed Data with Artificial Neural Networks[1]

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Abstract

In this study, wind speed data were analyzed in order to provide energy to the heating and electrical systems of a house with renewable energy sources in Mersin-Mut region. Three-year wind speed data is taken from the Turkey General Directorate of Meteorology in the region. Annual estimation was made with artificial neural networks using 28-day wind speed data for the studied area. Some of the wind data were used for training of the neural network, and some were used for testing. In the artificial neural network model, the most successful model was obtained by changing the number of neurons in the hidden layer. In the analysis made using eight neurons in the hidden layer, the lowest MAE and RMSE error values were calculated. While the number of neurons was eight, MAE and RMSE values were obtained as 0.4056 and 0.5403, respectively. In addition, analysis of wind data with WAsP software has been carried out for this region. Thus, the average instantaneous wind speed was determined according to the analysis studies.

Keywords: Renewable Energy Sources, Wind Energy, ANN, RMSE, MAE.

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Mersin Bölgesi Rüzgar Hız Verilerinin Yapay Sinir Ağları ile Analizi ve Uygulanabilirliği

Öz

Bu çalışmada, Mersin-Mut bölgesinde yenilenebilir enerji kaynakları ile bir evin ısıtma ve elektrik sistemlerine enerji sağlanabilmesi için rüzgar hızı verileri analiz edilmiştir. Bölgedeki üç yıllık rüzgar hızı verileri Türkiye Meteoroloji Genel Müdürlüğü'nden alınmıştır. İncelenen bölge için 28 günlük rüzgar hızı verileri kullanılarak yapay sinir ağları ile yıllık tahmin gerçekleştirilmiştir. Rüzgar verilerinin bir kısmı yapay sinir ağının eğitimi için, bir kısmıda test işlemi için kullanılmıştır. Yapay sinir ağı modelinde gizli katmandaki nöron sayıları değiştirilerek en başarılı model elde edilmiştir. Gizli katmanda sekiz nöron kullanılarak yapılan analizde, en düşük MAE ve RMSE hata değerleri hesaplanmıştır. Nöron sayısı sekiz iken, MAE ve RMSE değerleri sırasıyla 0.4056 ve 0.5403 olarak elde edilmiştir. Ayrıca, bu bölge için rüzgar verilerinin WAsP yazılımı ile analiz çalışmaları da gerçekleştirilmiştir. Böylece, analiz çalışmalarına göre ortalama anlık rüzgar hızı belirlenmiştir.

Anahtar Kelimeler: Yenilenebilir Enerji Kaynakları**,** Rüzgar Enerjisi, YSA, RMSE, MAE.

1. Introduction

As the need for energy increases, the energy demand per capita much more increases with each passing day. The majority of this increasing energy need is provided from fossil sources. However, the availability of fossil resources is one of the current debates. Regarding non-renewable energy sources, natural gas and petroleum energy resources constitute the majority of the fossil resources used in Turkey. Due to the use of these resources, our dependence on foreign sources is increasing. We can provide the electricity and heating of a house with wind and solar energy from renewable energy sources which can be used as an alternative to fossil resources [1]. Hence, interest in renewable energy sources such as solar, wind and fuel cell as a clean energy source for energy production is of utmost importance due to the future depletion of fossil fuels from non-renewable energy channels and their damage to the environment. As an environmentally friendly energy source from renewable energy sources, wind energy has never lost its popularity since ancient times. Thus, the use of a considerable increase for electricity generation since the new millennium has gained importance both in Turkey and in other countries [2].

In general, when energy demand is heavily dependent on imported resources rather than national and renewable resources, energy cannot contribute economically and socially. However, the installed wind power capacity in Turkey is much lower than this rate. Turkey's primary energy demand is given in Figure 1, and the share of wind energy is 1% according to these data [3,4].

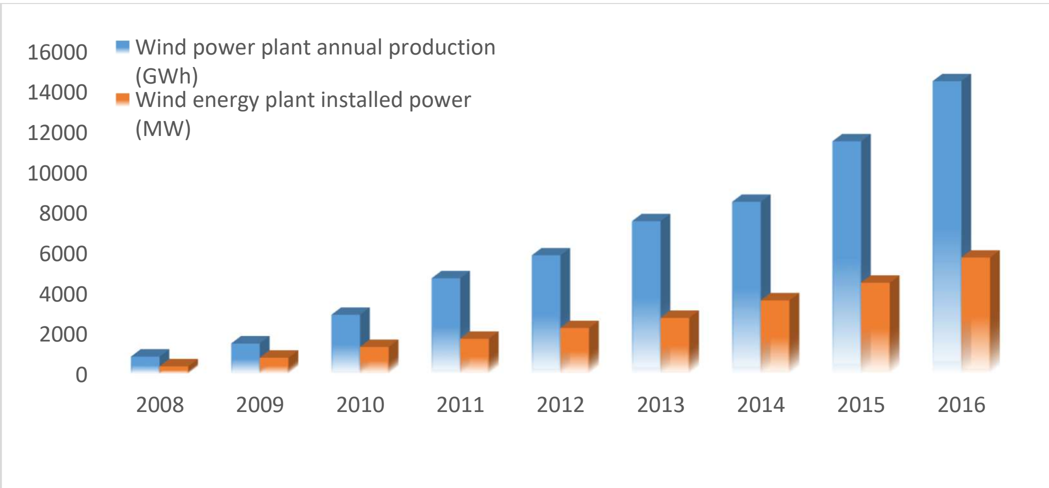

Figure 1. Development of Wind Energy in Turkey(2008-2016) [3,4**]**

On the other hand, solar energy is another energy source that has an important place in renewable resources. There has high solar energy potential due to its geopolitical position in Turkey. Prepared by the Republic of Turkey Ministry of Energy and Natural Resources, Turkey to the Solar Energy Potential Atlas, according to the annual sunshine duration for Turkey was reported to be 2.741 hours. It has also been reported that the annual total incoming solar energy is 1.527 kWh/m^2 per year [3, 4].

Monthly average sunshine duration for Mut region is determined as hour/day by the general directorate of meteorology. Mersin province solar energy potential is shown in Figure 2. When it is looked at global radiation values for Mut region, the highest value was in June and the lowest value was in December [5].

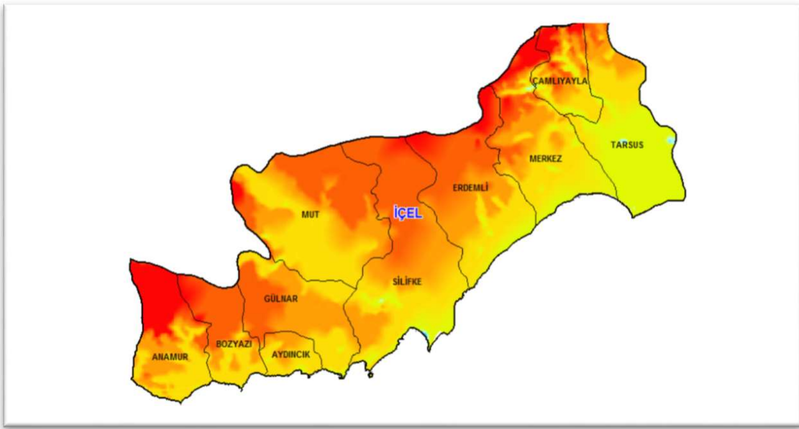

Figure 2. Mersin Province Solar Energy Potential [5]

There are many studies in the literature on statistical and data analysis of the amount of electrical energy obtained from renewable energy sources [6-14]. In a study, Ozay C. and Celiktaş S.M. used Weilbull distribution to make an analysis statistically. Weilbull distribution is one of the methods used to determine wind potential in a specific region. Weibull function is an effective method in determination speed, density and potential of winds. Also, the data obtained from regional data station in Alaçatı province of Izmir city were analysed with this method measures were collected in three different altitudes; (such as: 70m., 50m. and 30m.) in ten minutes intervals for five years. Wind speed having the highest energy is calculated 6.61 m/s and 12.77 m/s respectively [6]. Also, Lange B. and Hojstrup J. compared wind data taken from Baltic Region in Denmark with the results they obtained through the WAsP software. While WAsP software seemingly estimates better for smaller marine space, it estimates a lower calculation for the spaces longer than 30 km [7]. However, Pop L. *et. al.* wanted to develop a certain method to produce maps of the regions taking extreme winds. This method uses the observed data and maps of the general wind climate (GWC). GWC consists of wilbull distribution of wind speed observed eight wind sectors and parameter values for wind speeds of these sectors. By using this method, a map of maximum wind power speed was calculated with 100 m. horizontal resolutiıon for the Czech Republic and its error was also calculated [8].

In another paper, Katinas V. *et. al.* studied power density and wind characteristics in the regions having different wind speeds. For two different regions of Latvia, analyses were conducted by taking data from meteorology station. The analysis studies were conducted with weibull distribution. Speed and altitude of wind speed were estimated according to four numeric methods such as maximum probability method, modified maximum probability method, WAsP software and rayleigh distribution methods. Thus, the results were compared with wind speed data observed for both locations. In addition, the proposed simulation method to evaluate wind power density can be used to determine appropriate regions for wind power development [9]. Also, Durisiç Z. and Mikuloviç J. proposed a mathematical model with wind speed data obtained from several altitudes. The model created is based on the least-squares method. The main idea is primarily to calculate measuring data with the method proposed in the estimation process of wind power potential and then to make comparisons by using WAsP software. As a consequence, they are of the opinion that WAsP estimation of electricity generation of wind tribunes could reduce the errors significantly [10]. Baseer M.A. *et.al.* analysed wind properties in seven different regions in Saudi Arabia with five years of wind data for 10 m. altitude. The highest average annual wind speed was determined as 4.52 m/s. Weibull parameters are calculated by using maximum probability, least squares regression method (LSRM) and WAsP software. The most probable wind speed and wind speed carrying maximum energy were calculated using the scales of the coefficient of correlation (R2), root mean square error analysis (RMSE), mean bias error (MBE), mean absolute error (MAE). In at study, the energy output of a 3 MW wind turbine was found as 11136 MWh per year [11]. Amir S. and Marteza A. stated that as a result of the increasing global demand for energy, greenhouse gas emission values and air pollutants increased with fossil fuels. They reported the necessity of the transition to modern energy due to these increases in environmental pollution. They stated that with the use of PV systems, 69-100 million tons of CO_2, 126000-184000 tons of SO_2 and 68000-99000 tons of NO_X could be reduced by 2030. They reported that solar energy technologies have great potential to reduce climate change by reducing energy-induced emissions [12]. Ammar H. E. *et al.* emphasized the necessity of developing solar-based devices in the development of solar energy systems along with rapid energy demand. They stated that the development of solar energy systems could be possible by optimizing the performance of solar-based devices. In the study, they tried artificial neural networks (ANN) applications on different devices such as solar collectors, solar heat pumps [13]. Ali A.*et al.* Portland conducted an energy analysis of a house built according to passive house standards in the USA. They carried out the necessary analyses and investigations for the transformation of this house into a zero energy house and reported that their energy consumption decreased by 3047 kWh per year (64%) by using thermal solar water heating 26 kWh/m^2 energy use density has been achieved. They also stated that 26 kWh/m^2 energy usage density is a good value in converting a house constructed according to passive house standards to a house that meets zero energy standards [14]. Thus, there are different methods for analyzing energy data from wind energy sources and parameter estimation. It is desirable that the error rate is at the lowest values in parameter estimation operations, and in recent years, the most accurate and fastest data processing can be achieved with hardware and software developments in computer technology [15, 16].

In this study, the construction of a two-storey house in the Mut region of Mersin is designed in accordance with the green house standards. Mersin region has a very effective wind energy potential in terms of the use of wind energy. It is inevitable to study and analyze the wind potential. The most important parameters related to wind energy in a region are wind speed and direction. Wind speed and direction data of the Mersin region are taken from Meteorological station, and the necessary analysis studies are performed. For these data, WAsP analysis method is used to test the data. One of the main points that should be considered while analyzing the data is whether the wind is continuous and how long it is in the same direction. For this purpose, it isdesigned to establish a system that will meet the electricity and water needs in order to reduce the energy expenses of a two-storey detached house in Mut region of Mersin. The systems to be used for this house are solar panels and household wind turbines for electrical energy. While analyzing wind energy, error calculations of wind data for the region were made with different algorithms. If wind energy will be utilized in a region, the wind speed and direction data continuity is important for that region.

2. Material Method

2.1. Obtaining Wind Data

In order to determine the wind energy potential, this has an important share in renewable energy sources, more clearly, the analysis of wind speed data with artificial neural networks. Wind direction and speed data for this study are obtained from Turkey General Directorate of Meteorology [17]. It is known that Mersin region has an important wind potential. Unprocessed data from the General Directorate of State Meteorology contains data measured for ten meters. The data received are from 2014-2015 and 2016 for 12 months. In wind turbines used to obtain energy from wind energy, the tower height is on average 80 meters. Then this data for 10 m is analyzed by WAsP for 80 m with formulation.

2.2. Artificial Neural Networks (ANN)

With reference to the superior features of the human brain, a mathematical model is intended to be inspired by inspiring the neurophysical structure of the brain. Thus, a system that works differently from algorithmic computing methods of today's computers, which that called artificial neural networks, has emerged. In artificial neural networks, development is achieved based on the human brain as a model. Artificial neural networks have artificial neural cells as substrate. These artificial nerve cells are called processes. Each process also consists of inputs, weights, addition functions, activation functions and outputs. In artificial neural networks, there is also an input layer, hidden layer and output layer as a general structure. The hidden layer, which is the middle layer, can be more than one [18]. As a general definition, ANN is a mathematical model that processes information. It is a methodogically developed bio-inspired human brain structure. The model is used by providing connections with neurons. MLP is also used as the most common neural network architecture. MLP neural networks are used to solve nonlinear regressions. Function optimization is also applied for optimization processes in artificial neural networks and MSE is shown as the most used performance function [19].

2.3. WAsP Program

WAsP is a computer program to estimate wind power sources. By using this program, analyses could be performed with wind data obtained from the meteorological station and some generalizations could be done with this data. It is important to get the estimated data from the regions having the same weather regimes to make proper analysis with WAsP software. Besides, it is required that the areas should be flatland [20].

The wind data is taken from the meteorology are statistically graphed in the WAsP software. It can be specified the WAsP software expansion as Wind Atlas Analysis and Application Program. This program is developed by Meteorology in Denmark to create wind atlas with wind speed data. The WAsP software is prepared in the Riso Meteorological laboratory of the Danish Meteorological Organization. Once the program is developed in Europe and Turkey Wind Atlas has been used in the preparation of the Atlas. This developed software performs data analysis by assuming that the wind speed data is distributed according to Weibull distribution with two parameters. WAsP software is basically, because it uses hourly wind data, region roughness information, nearby environmental obstacle information and topography of the analyzed region. The program also uses five computational sub-program directories when performing data analysis. This program block with five calculations, includes analysis of data ordered by time, generation of wind atlas data and estimation of the wind regime. With all these analyzes, the software can also take information about obstacles around the wind measurement station as input [21].

2.4. Root Mean Square Error (RMSE) and Mean Absulate Error (MAE)

Two statistical indicators, root mean square error and mean absolute error methods are used to evaluate the models applied by artificial neural network method. In models where artificial neural network algorithms are applied, RMSE value should also be given with Eq.1. The RMSE value can be defined as an error rate between the normal value and the estimated model when the estimated model is created. In the equation, y(i) and x(i) values can be considered as two vectors. The number of elements included in each of these two vectors is also defined by N [22 and 23].

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(y(i)-x(i))^2}{N}} \qquad (1)$$

MAE value is generally used to measure the degree of similarity between two signal vectors. If the similarity rate is high, it means that the MAE value is that small. Similar to the RMSE equation, y(i) and x(i) values are defined as two vectors. The values of these vectors are defined with N as given in Eq.2 [22, 23].

$$MAE = \frac{1}{N}\sum_{i=1}^{n}|y(i) - x(i)| \quad (2)$$

2.5. Green House Design

This system, which is planned to be built, is modelled with a solid body modelling software (Solidworks 2016). Systems to be used in this house, as need PV panels and domestic wind turbine for electrical energy, and solar collectors for hot water.In addition, in order to minimize energy loss, the materials used in the construction of this house should also be used materials with high insulation value. In the study, the number of collectors required for the heating of the green house is determined. The amount of wind turbine, panels, battery, hybrid inverter and cables required for electricity needs are determined. As a result of all these analyzes, green house design application is examined and the necessary results are obtained. The land where the house is located has been taken as 436 m^2. The house is thought to have dimensions of 130 m^2. The plan of the two-storey house is drawn and the solar panel and solar collector are assembled on the building with 3D modelling. Figures 3 and 4 show drawings of the green house.

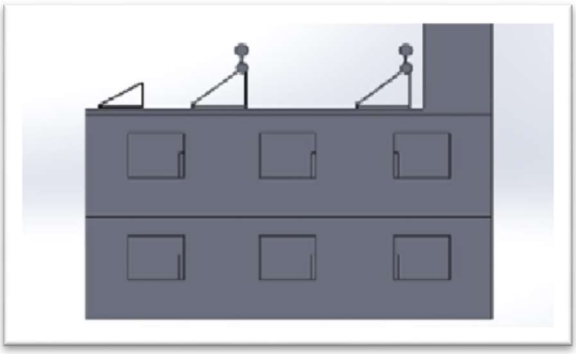

Figure 3. Side View of Green House Drawing**.**

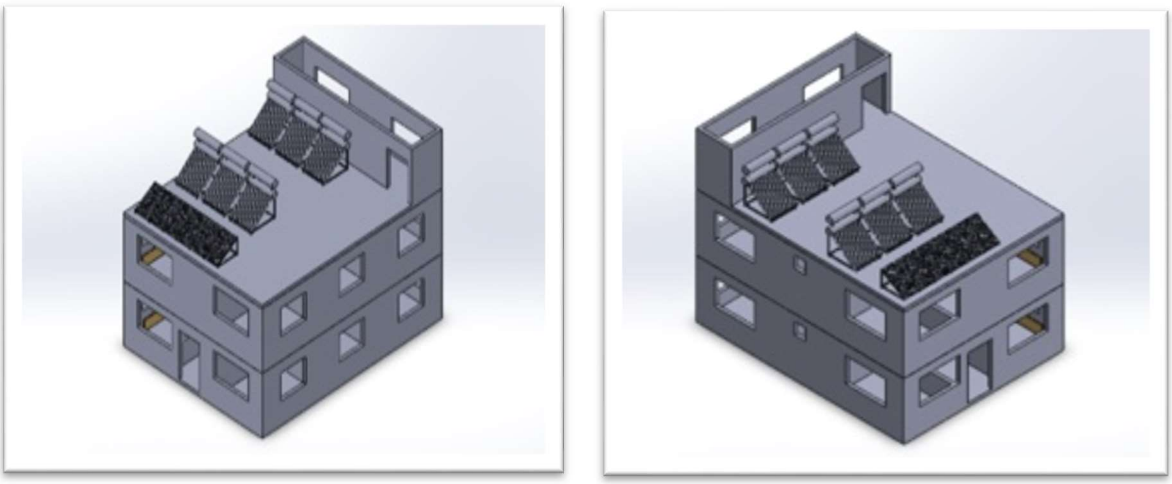

Figure 4. The 3D Perspective View of Green House Drawing.

3. Results and Discussion

3.1. Analysis of Wind Data

The wind speed and direction data in the city of Mersin for the years 2014-2015 and 2016 are obtained from state meteorology station. Using these data, 84 data are obtained monthly with 28-day wind speed values. Using these data, year estimation is made with artificial neural networks. Of these data, 55 are used for the training of ANN, and the remaining 29 were used for testing. By creating a neural network with 12 inputs, the most successful model is obtained by changing the number of neurons in the hidden layer. "1" for 2014, "2" for 2015 and "3" for 2016 are the outputs of ANN. In ANN, Epochs, Learning rate and momentum parameter are taken as 500, 0.3 and 0.2, respectively.

In the ANN, the MAE and RMSE values calculated in the yearly estimate obtained by changing the number of neurons in the hidden layer are given in Table 1.

Table 1. MAE and RMSE Values Obtained by the Number of Neurons in the Hidden Layer

The Number of Neurons in the Hidden Layer	MAE	RMSE
6	0.5198	0.7120
7	0.7219	0.9139
8	**0.4056**	**0.5403**
9	0.7632	1.2196
10	0.5427	0.7597
11	0.7220	1.0726
12	0.4742	0.6949
13	0.6312	0.8699
14	0.7812	1.1111
15	0.4290	0.586
16	0.6134	0.8848

The graph showing the change of MAE and RMSE values according to the number of neurons in the hidden layer is given in Figure 5.

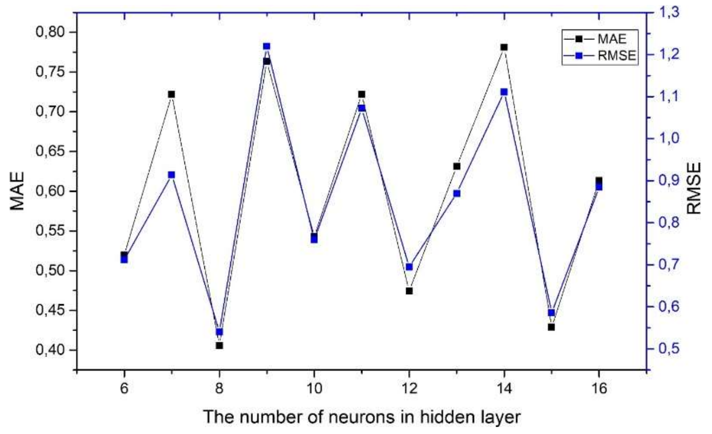

Figure 5. Change of MAE and RMSE Values According to the Number of Neurons in the Hidden Layer

Considering Table 1, the most successful estimate is obtained when the number of neurons in the hidden layer is eight. According to the ANN model with eight neurons in the hidden layer, MAE and RMSE error values are calculated as 0.4056 and 0.5403. The most successful network model for year estimation with 12-month wind data created daily is given in Figure 6. In this network model, the inputs represent 12 months of wind data.

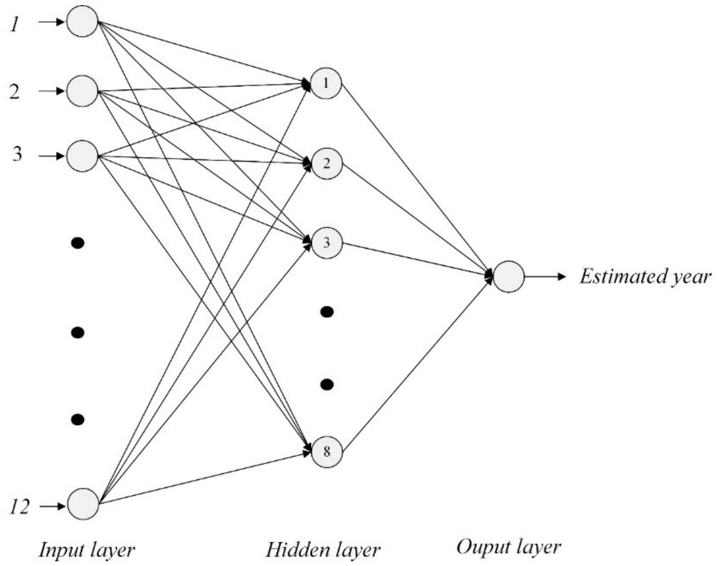

Figure 6. The Structure of ANN

The graph of the real and predicted values of 29 test data obtained with the most successful network model is given in Figure 7. The values of 1, 2 and 3 in the output values in the graph refer to 2014, 2015 and 2016, respectively.

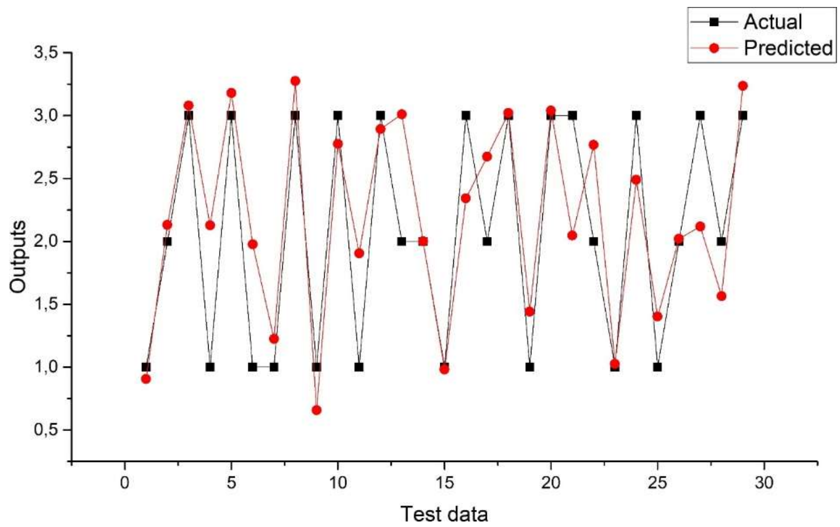

Figure 7. Actual and Predicted Values of Test Data

3.2. WAsP and RETscreen Software Analysis

The wind data taken from the General Directorate of Meteorology can be entered into the program in 2016, and many parameters such as wind potential, average wind speed, velocities at a certain height can be calculated with the help of WAsP software. In this way, both speed and power atlases can be obtained for the desired region. In order for the plant to operate efficiently, the wind speed data should not fall below 7 m/s. The interface basically consists of three different regions. At the top of the interface, there are wind data added to the program and all other data [24].The wind potential of Mersin-Mut region is better than many regions. However, it is not possible to operate a wind turbine with wind speed data from meteorology for a height of 10 meters. In order for wind turbines to work efficiently, the wind speed should be above 7 m/s on average. Turkey also belongs to the employees of the company as we look at the wind turbine when the wind turbine height of the turbine tower height varies between 50 and 80 meters. For this reason, in order to work better with the wind data and obtain an accurate average value, the ten meters wind data has been converted to 80 meters with the following formulation. Wind speed data is not enough to calculate according to the Eq.3. The region that adversely affects the wind speed along with the wind speed should be known for the roughness factor [25]. Depending on the roughness class and table values, the roughness factor is taken from the table considering the agricultural lands and rural areas in Mersin-Mut region [26].

$$v(h) = \frac{u}{k} . ln \frac{h}{z_0} \qquad [3]$$

v = h wind speed

h = wind speed above ground

u = wind speed height factor

k = von karman constant (0.4)

Z_0 = roughness factor caused by ground surface

Another analysis program for renewable energy sources is the RETscreen software. The program makes detailed analysis of the region where wind and solar energy will be used. After selecting the feasibility region within the software, the necessary data must be entered into the software. Then a detailed feasibility report is created by RETscreen. The main factor in making this analysis is ready data by the program. However, we have used raw data from meteorology before modeling with artificial neural network. This section will also include RETscreen analysis. Table 2 also contains data analyzed by the software.

Table 2. Data from RETscreen Software of Mersin-Mut Region

Months	**Air Temperature (^{0}C)**	**Daily Solar Radiation (kWh/m^2/d)**	**Wind Speed (m/s)**
January	8.6	2.27	4.0
February	9.0	3.15	4.0
March	11.6	4.41	3.5
April	15.5	5.39	3.0
May	19.9	6.41	2.7
June	24.5	7.45	2.9
July	27.8	7.55	3.1
August	28.1	6.77	3.1
September	25.3	5.50	3.0
October	20.8	3.85	3.1
November	14.9	2.56	3.5
December	10.3	1.95	3.9
Source	*NASA*	*NASA*	*NASA*

The data are wind speed and solar radiation values in this table. Figure 8 shows the graph of wind speed data for 12 months. Wind speed data reached the maximum in January and February and the maximum wind speed is measured as 4 m/s in these months. The minimum wind speed data is given for May, and it is 2.7 m/s.

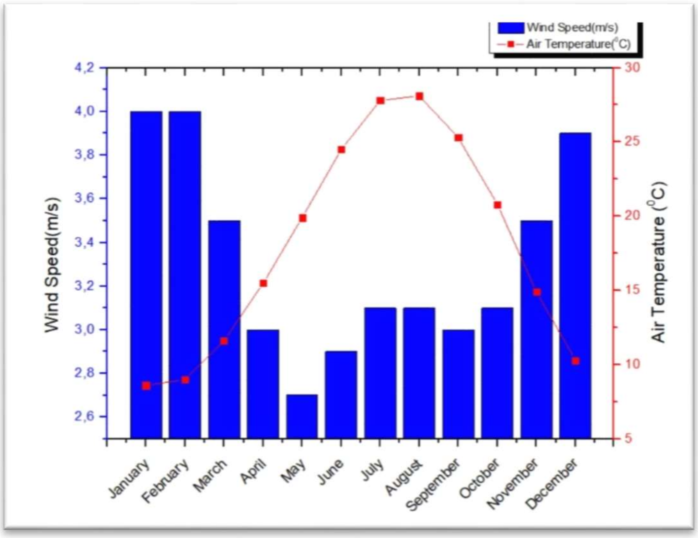

Figure 8. Wind Speed Data for Mersin-Mut Region According to RETscreen Software

In Figure 9, solar radiation data taken from the RETscreen software for Mersin-Mut region and analyzed data are shown. The highest solar radiation value was given in July according to the program data. Our solar radiation value for the month of July is 7.55 kWh/m^2/d. The lowest solar radiation value is measured in December and solar radiation value is measured as 1.95 kWh/m^2/d for December.

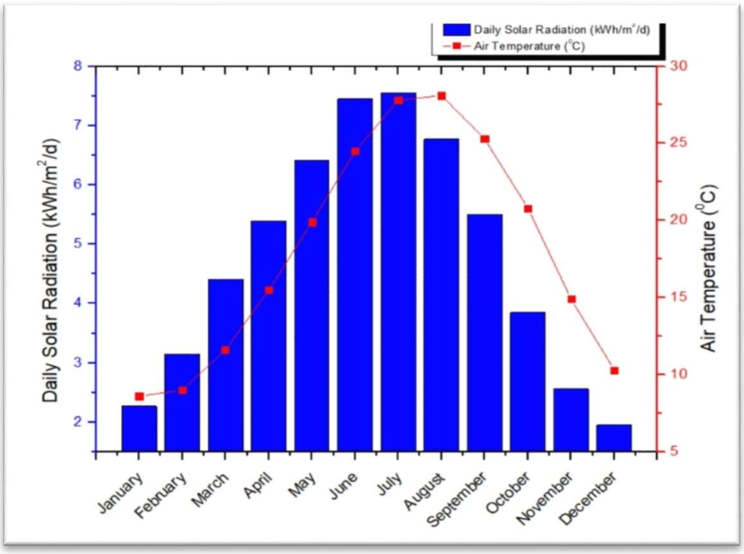

Figure 9. Solar Radiation Data for Mersin-Mut Region According to RETscreen Software

4.Conclusions

Mersin-Mut is one of the renewable energy sources in a region favorable for solar and wind energy. In this context, an artificial neural network model is created with the data received for 12 months, and wind data are classified in order to investigate the continuity of wind data. Thus, the electricity and heat energy need of a two-story house are listed the below factors to provide them from renewable energy sources.

- One of the most important parameters for wind energy is whether the wind is continuous for the region. As a result of this study made for the region, it is concluded that the continuity of the wind is suitable for use.
- RMSE and MAE values are determined for the multi-layer sensor algorithm for wind data. Success percentages and error margin values are calculated. According to these results. When the neural network model is modeled with eight neurons in the hidden layer. MAE and RMSE values are determined as 0.4056 and 0.5403, respectively. The lowest MAE and RMSE values for these models are these values.
- The average wind speed available for the region has been determined with the WAsP software for 80 m altitudes. These values are suitable for the use of wind energy. In addition, wind speed and solar radiation values were determined for the region examined with the help of RETscreen software.
- After the calculations made in terms of solar energy usage, it is concluded that six solar panels would be sufficient.
- Finally, 1.5 kW domestic wind turbine will be sufficient for the project.
-

5. Acknowledgment

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6. References

[1] Lightning U., Gungor A., “Green Home and Applications in Turkey”, Tmmob chamber Of Mechanical Engineers 5th Solar Energy Systems Symposium and Exhibition Proceedings Book. Mersin. Ankara: ***Tmmob Chamber of Mechanical Engineers,*** (M / 2011/562). 66-67, 2011.

[2] Akin M. and Balci S., ”The Electromagnetic Modeling and the Co-Simulation of a Direct Drive Axial Flux Permanent Magnet Synchronous Generator”, ***Journal of Energy Systems,*** 2020 4(2), DOI: 10.30521/jes.690997, 2020.

[3] Yılmaz Ş., “Natıonal Renewable Energy Action Plan.” *MMO,* 2018.

[4] “Republic of Turkey Ministry of Energy and Natural Resource”
URL 1: http://www.enerji.gov.tr/En-Us/mainpage, Last Access: 09.11.2019

[5] “Energy Efficiency and Environment Department”
URL 2: http://www.yegm.gov.tr/mycalculator/pages/33.Aspx, Last Access: 09.11.2019

[6] Ozay C. and Celiktas M.S., "Statistical Analysis of Wind Speed Using Two-Parameter Weibull Distribution in Alaçatı Region", ***Energy Conversion and Management*** **,** 121:49-54, 2016

[7] Lange B. and Højstrup J., "Evaluation of the Wind-Resource Estimation Program WasP for Offshore Applications", ***Journal of Wind Engineering and Industrial Aerodynamics,*** 89.3-4: 271-291, 2001.

[8] Pop L., Zbyněk S. and David H., "A New Method for Estimating Maximum Wind Gust Speed with a Given Return Period and a High Areal Resolution", ***Journal of Wind Engineering and Industrial Aerodynamics,*** 158:51-60, 2016.

[9] Katinas V., Giedrius G. and Mantas M., (2018)."An Investigation of Wind Power Density Distribution at Location with Low and High Wind Speeds Using Statistical Model", ***Applied Energy,*** 218:442-451.

[10] Đurišić Ž. and Jovan M., "A Model for Vertical Wind Speed Data Extrapolation for Improving Wind Resource Assessment Using WaSP", ***Renewable Energy,*** 41: 407-411, 2012.

[11] Baseer Mohammed A. et al., "Wind Power Characteristics of Seven Data Collection Sites in Jubail. Saudi Arabia Using Weibull Parameters", ***Renewable Energy,*** 102: 35-49, 2017.

[12] Shahsavari A. and Morteza A.,"Potential of Solar Energy in Developing Countries for Reducing Energy-Related Emissions", ***Renewable and Sustainable Energy Reviews,*** 90: 275-291, 2018.

[13] Elsheikh Ammar H. et al., "Modeling of Solar Energy Systems Using Artificial Neural Network: A Comprehensive Review", ***Solar Energy***, 180: 622-639, 2019.

[14] Ali A, Rodríguez S. and Sailor D.,"Transforming a Passive House a Net-Zero Energy House: A Case Study in The Pacific Northwest of the Us", ***Energy Conversion and Management,*** 172: 39-49, 2018.

[15] Sabancı K., Balcı S. and Aslan M.F.,"Estimation of the Switching Losses in Dc-Dc Boost Converters by Various Machine Learning Methods", ***Journal of Energy Systems,*** 4(1). 1-11. Doı: 10.30521/Jes.635582, 2020

[16] Balci S. and Helvaci O., "A Comparative Simulation on the Grounding Grid System of a Wind Turbine with FEA Software", ***Journal of Energy Systems,*** 3(4), 148-157, DOI: 10.30521/jes.613724, 2019.

[17] Republic of Turkey General Directorate of Meteorology, Ankara (Turkey).

[18] Ataseven B., "Yapay Sinir Ağları ile Öngörü Modellemesi", *Öneri Dergisi, 10.39: 101-115,* 2013

[19] Bomin K. et al.,"Effect of Surfactant on Wetting Due to Fouling in Membrane Distillation Membrane: Application of Response Surface Methodology (RSM) and Artificial Neural Networks (ANN)", ***Korean Journal of Chemical Engineering***, 37.1:1-10, 2020.

[20] "Republic of Turkey Ministry of Agriculture and Forestry General Directorate of Meteorology"
URL 3: https://www.mgm.gov.tr/files/genel/sss/ruzgaratlasi.pdf, Last Access: 09.10.2019

[21] Bowen A. J.and Niels G. Mortensen.,"Exploring the Limits Ff WAsP: The Wind Atlas Analysis and Application Program", ***Proceedings of the 1996 European Union Wind Energy Conference,*** Göteborg. Sweden, 1996.

[22] Hande K. and Ercan E.,"Forecasting Study on the Comparative Performance of Back Propagation Neural Network Algorithms", ***Animal Production***, 56(1): 22-27, 2015.

[23] Maroufpoor S., Ahmad Fakheri-Fard and Jalal S., "Study of the Spatial Distribution of Groundwater Quality Using Soft Computing and Geostatistical Models", ***Journal of Hydraulic Engineering,*** 25.2: 232-238, 2019.

[24] Semih G., "Rüzgar Enerjisi Potansiyel Hesaplamasında Kullanılan Bilgisayar Programlarının Karşılaştırılması", ***Diss. Enerji Enstitüsü,*** 2014.

[25] Dinçer F., Rüstemli S., Yılmaz Ş.and Çıngı A., "Kilis İli için Farklı Yüksekliklerdeki Rüzgâr Potansiyelinin Belirlenmesi", ***Bitlis Eren Üniversitesi Fen Bilimleri Dergisi,*** 6(1). 12-20, 2017.

[26] Vardar A., "Wind Turbine Types and Determination of Energy to Be Obtained From Wind" URL 4: http://slideplayer.biz.tr/slide/2335624/., (Last Access: 11.11.2019), 2013.