Research Article

APPLYING WIND VIOLENCE AND SOLAR RADIATION FORECAST FOR KADIKÖY-GÖZTEPE DISTRICTS[1*]

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ABSTRACT

Although energy topic is one of the most difficult issues in physical sciences, in its simplest definition, each and every one of our surroundings is almost a source. The recent search for energy is increasing day by day and human beings are looking for new energy sources. Since the early 1990s, Turkey has been guiding system energy planning and energy towards the greatest. This latest has a great enthusiasm for new energy and energy technologies. Based on the current record potential in Turkey and Asia, the power has been transferred to 4 Pos. In terms of solar potential, when you compare it with energy potential in Mediterranean Region, it is seen that we have the potential to match the potential in Turkey. In contrast with fossil fuels polluting the atmosphere, an environmentally friendly energy production is gradually increasing. We can realize the potential of the energy resources that we can benefit from the related projects. In this study, the Asian side of Istanbul (Kadıköy-Göztepe) and at the near vicinity, it was analysed time variations of solar radiation and wind speed. The reliability of ANN model for wind speed and solar radiation prediction is better in summer than other seasons. As a conclusion, the relation between ANN model results and observation for solar radiation (r=0,98) is higher than the correlation coefficients (r=0,72) for wind speed modelling. The reason is that the angles of the incoming solar radiation and the wind speed blowing from the sea are high in the coastal areas and high parts of Istanbul.

Keywords: *Artificial Neural Networks (ANN), wind energy potential, solar radiation, solar-wind hybrid/hybrid systems.*

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1. INTRODUCTION

The energy problem continues to take the first place on the agenda of our country. In international relations, energy has an important position in determining either cause or effect in political, commercial and military fields. Wind energy potential is actually one of the oldest sources of energy, used since 2800 BC. This energy has been used mostly for pumping water and obtaining electrical energy in rural areas until recent years. Today, an alternative source of energy generation is taking place in the energy sector [1][2].

Among the renewable energy sources, the wind energy potential is an alternative energy type to the energy obtained with fossil fuels, which has been developing rapidly in our country recently and that about 70 countries in the world benefit from electricity production. At the end of 2007, the total installed wind power potential in the world is 93,864 MW. A total of 57,136 MW of this installed power belongs to the European continent [3][4][5]. In Turkey, the total installed power is only 146 MW [6]. Turkey is the country with high wind energy potential in Europe with 83,000 MW, [7]. Turkey reached a wind energy capacity of 15,000 MW in 2017 and 15,500 MW in 2018 [8]. In this sense, studies and projects are carried out for the establishment of wind power plants, especially on the coasts of the Marmara and Aegean regions, and statistical analyses are carried out by obtaining wind data from suitable places by the Electricity Works Survey Administration (EIE).

In order to analyse the wind potential of the sample region, hourly wind intensity information in that region should be measured for at least one year. In addition, in order to achieve more accurate and sensitive results, attention should be paid to the absence of near-environmental obstacles around the measurement station that will affect the data to be obtained in these measurements [9]. Solar energy is becoming more popular in developed countries because carbon emission is not necessary and other energy sources cause climate change. In recent years, many countries have invested in renewable energy sources. Especially the main countries that use renewable energy sources in the world are Switzerland, Sweden, Costa Rica, and Germany. Brazil, Germany, and Russia are other investor countries investing in renewable energy resources. Bioenergy, geothermal energy, hydroelectricity, ocean sea-wave energy, solar energy, and wind energy are six important renewable energy sources [10]. These energies are clean energy sources. Renewable energy provides new business opportunities apart from its environmental benefits. Hydroelectric technologies are old technologies and have been used for a very long time. On the other hand, studies on wind and solar energy are developing rapidly over time. Solar energy is the most important renewable energy source that has the potential to meet the production need. The popularity of this energy source is constantly increasing due to its various benefits to humans and the environment. Technologies developed to benefit from solar energy not only increase the efficiency of solar energy, but also reduce many infrastructure costs [11] [12].

Renewable energy-based generation facilities in the Turkish electricity system especially supported solar and wind energies. Turkey has high wind and solar energy potential. Central parts of Turkey in general have high solar energy potential, while high wind energy potential is observed in the western parts of Turkey. As of the end of 2010, Turkey was in the 17th place in the worldwide wind energy ranking with its 1274 MW production. Turkey showed a great growth rate at the end of 2009 and made itself known in the

European wind market [13]. The growth rate in 2009 was recorded as 138.9%. Growth continued in 2010, but a lower growth rate was observed compared to 2009. At the end of 2010, a growth of 59.9% was realized. Despite this, Turkey entered the top 10 in the world in terms of growth rate and took its place in the 5th place [14]. In the global energy crisis triggered by the COVID-19 pandemic, which put pressure on the whole universe in 2020, alternative ways were preferred in electricity generation methods, and this option increased solar energy and electricity production. In 2020, approximately 90% of the additional electricity generation capacity will be realized in renewable energy. Less than 10% will come from gas and coal. The trend is that green electricity is expected to be the largest source of power by 2025, surpassing electricity from renewable energy and coal for electricity by 2024.

The share of solar energy in meeting the electricity supply, which will increase in the next 10 years, is expected to increase by 12% on an annual basis starting from 2023. Solar and wind energy, which has a market share of 8% in 2019, is expected to reach 30% in 2030. In 2025, the 275 GW coal power plant will be decommissioned and replaced with renewable solar and wind power plants. This figure corresponds to 13% of the global coal production capacity. This increase will reduce the solar energy investment cost rates to 42% below the 2019 data, to 3.9 cents/kW/hour, and will make it 80% less costly than coal investments. The report from the US Department of Energy, dated Tuesday, August 17, 2021, estimates that the current status of the tax relief plan for renewable projects and utilities will exceed 40% by 2035, while the current status of the new energy plan will exceed 40% by 2035. It is 3%. This action plan is expected to create 1.5 million new jobs in the US and the manufacturing and industrial sectors are expected to be a nasty force.

According to the International Energy Agency, offshore wind power is capable of meeting all of the world's electricity needs and uses it as a "game" for energy systems. The Paris sales energy agency aims to compete with fossil energy within the year after overseas sales plummet. The IEA estimates that the global average power consumption generated by offshore wind will fall by 40% by 2030. At the same time, major cities in France are working to reduce their use in major cities to net zero by 2050.

2. DATA AND WORKING AREA

Wind speed and solar radiation data records at 2016 were analysed. The wind speed and solar radiation for the following year were estimated after it was obtained from the Ministry of Environment, Urbanization and Climate Change, Turkish State Meteorological Serice.

2.1. WORKING AREA

Göztepe has been selected as the study area.

2.2. DATA

The data sampling rate is for every ten minutes. Variables measured at Göztepe Kadıköy station; the air temperature is 2m (^{o}C), solar radiation (W/m^{2}), UV radiation, wind speed

(km/h) and 5 cm above surface temperature (°C). The data covers the period between January 1, 2016 and December 31, 2016. Meteorological variables at the station are shown in Table 1 below.

Table 1. Sampling Data Set

Station Name	Date	Air Temperature 2m °C	Solar Radiation W/m2	UV Radiation indis	Wind speed km/saat	Wind direction	Surface temperature 5cm °C
Kadıköy-Gözdetepe	2016-06-01 00:00:00.000	18.9	7	0.1	3.2	1	16.1
	2016-06-01 00:10:00.000	18.3	15	0.3	1.6	3	15.6
	2016-06-01 00:20:00.000	18.3	23	0.2	0	3	16.7
	2016-06-01 00:30:00.000	18.3	34	0.1	1.6	0	17.2

It is observed at regular intervals at Göztepe-Kadıköy Station. The missing data is completed by compiling the arithmetic mean of the neighbour values. The data to be obtained in this article are given in ten-minute intervals. Seasonal data was calculated by collecting all the data of the months of that season. At the Göztepe Kadıköy Meteorology Station of the study area, the air temperature at 2 m above the mean average ground level is calculated as ab °C, the value of solar radiation is W/m^2, UV radiation, wind speed is calculated as km/h and the temperature at 5 cm above the ground is °C.

3. METHODOLOGY

In this part of the research, the ANN method that was used to predict the potential of solar radiation and wind speed analyses will be presented. Moreover, the open source WEKA application will be introduced to identify attractive variables.

3.1. ARTIFICIAL NEURAL NETWORKS

In this section, information about the diagnosis, general structure and elements, architecture and training of ANN will be given.

3.1.1 ARTIFICIAL NEURAL NETWORK DEFINITION

In this part of the research, the artificial neural network method will be used to predict solar radiation and wind speed.

ANN is an artificial system that tries to imitate the working structure of the human brain. Artificial neural networks look at the examples of events, make generalizations about the event using these examples, collect information, and then make decisions using the information they have learned when they encounter examples that they have never seen.

ANN is inspired by the human brain. It is based on mathematical modelling of the human learning process. ANN studies first with the modelling of neurons, biological units of the brain. ANN consists of initiated connecting with each other in various ways and is usually arranged in layers. In accordance with the brain's learning process, ANN is a parallel distributed processor capable of collecting information after a learning process, storing and generalizing this information with the weight of the connection between cells [15].

The learning process includes learning algorithms that renew the ANN hidden a year to achieve the desired goal. ANNs' perform automatically with their abilities (ratio, performance, accuracy) such as obtaining, creating and discovering new information by training [16].

Contrary to methods based on traditional models, even when the relationships between variables are unknown or very difficult to understand, they can capture the relationships between these variable data and learn from examples. ANN is widely used in applied studies to solve real world problems, [17].

ANN uses previously obtained data samples to make predictions about the future. It creates a mathematical function (model) for the problem by training the existing historical data [18].

3.1.2 FEEDBACK NEURAL NETWORKS

In the network, one or more processor element outputs are given on their own or as inputs of other processor elements. Generally, these networks are located on a delay element. It is the element that is responsible for carrying the activation value in the intermediate or output layer to the iteration of the other stage. Feedback networks can be between processor elements in a layer, or there may be processor elements between all layers. Because of this feature, feedback networks show a dynamic feature. These networks do not show a linear feature. Thanks to these functions of feedback networks, artificial neural networks with different structures and behaviors are available. The working principles of these networks have

a complex structure. Because they are only capable of dynamic memory, they give good results in predictions.

Figure 1. Symbolic representation of the neural network model

The neural networks simulation in the figure above collects and works on the accumulation from each cell. It now forwards to different elements. There are separate algorithms and attitudes based on the transaction. Artificial Neural Networks do not have accumulation aggregation problems in other professional systems. It gains experience by training sample data from old periods and begins to learn. It is necessary for the selected values to represent the ties desired to be learned without any problems.[19][20] Table 2 shows, results of comparison between model outputs and real world data. To predict wind speed and solar radiation based on ANN Modelling, error analyses and success ratio of the model have been presented in Table 2.

Table 2. Results of artificial neural network model

Comparison Model Results and Observation	**Winter**	**Spring**	**Summer**	**Autumn**
R, Wind speed	0.63	0.62	0.72	0.48
R, Solar Radiation	0.92	0.97	0.98	0.90
Absolute Error **Wind Speed**	0.077	0.093	0.079	0.094
MSE **Wind Speed**	0.010	0.044	0.010	0.016
RMSE **Wind Speed**	0.100	0.129	0.101	0.127

NRMS Wind Speed	0.152	0.166	0.167	0.215
Absolute Error Solar Radiation	0.036	0.032	0.033	0.035
MSE Solar Radiation	0.004	0.002	0.003	0.004
RMSE Solar Radiation	0.065	0.053	0.056	0.869
NRMS Solar Radiation	0.063	0.063	0.060	0.085

4. CONCLUSION

Energy is the process of producing the possibilities in nature to meet the needs of people. In this thesis, the Kadıköy-Göztepe Region and its vicinity, which was selected as a pilot, were at and the wind intensity and solar energy potential for the region were area wisped and solar radiation were analysed estimated by using Artificial Neural Networks (ANN) and MATLAB programs. Wind speed (km/h) and solar radiation (W/m^2) speed were estimated seasonally. Parameters and data for the estimations of wind and solar energy potential in the sample region were obtained at Kadıköy - Göztepe Meteorology station. In order to estimate wind speed and solar radiation, 2m air temperature (^oC), 5 cm above ground temperature (^oC), solar radiation (W/m^2) and wind speed (km/h) parameters were selected as 10-minute averages. These parameters were normalized and processed.

The model was created with the help of the MATLAB program. With the help of the ANN model, the wind speed and solar radiation statistics, which will create input data for both wind and solar energy potential studies, were obtained by using the back propagation artificial neural network.

As a result of the model, it was determined that the highest wind energy potential is observed in summer (June, July, and August). The correlation coefficient between the observed and predicted values by ANN in this season is r=0.72, and it was determined that there is a significant relationship at $\alpha<0.01$ confidence level. The lowest success ratio in the estimation of wind speed values was obtained in the autumn season (September, October and November). The correlation coefficient between the observed and estimated values by ANN in autumn is r=0.48,

and it was concluded that there was a significant relationship at the $\alpha<0.10$ confidence level.

In the summer season (in June, July, August) solar radiation, accordingly, the highest performance was achieved in the estimation of solar radiation energy potential. The correlation coefficient between the values observed and estimated by ANN in this season was r=0.98, and a significant relationship was defined with $\alpha<0.01$ confidence level. The season in which wind speed and related wind energy potential are estimated with the lowest success ratio was determined in autumn (September, October, and November). The correlation coefficient between the values observed and estimated by ANN in this season is r==0.90, and it was concluded that there is a significant relationship at the $\alpha<0.01$ confidence level.

In the model study conducted for the study area, it was determined that the solar energy estimations were more successful than the wind energy estimations. Based on the outputs of the paper, it can be emphasized that the applied ANN model will make a significant contribution on to the energy estimation studies of both wind and solar hybrid systems with a confidence level of 0.05. This contribution can be obtained at most in the summer season.

The model improvement study for the wind energy potential in the region for the autumn season can be selected the next research topic. The results of the paper are primarily important at Turkey's wind-solar hybrid energy sector, determining new energy resources and strategies, (agriculture, irrigation, lightening, heating/cooling systems, traffic signalling, transportation, etc.,) due to its environmentally friendly structure. It is expected that it will contribute to the development of new technologies in many areas.

Based on these outputs, new research would be directed towards analyses of the performance of other models at different seasons.

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REFERENCES

[1] Pamir, N. "Enerji Arz Güvenliği ve Türkiye "Stratejik Analiz, /Energy Demand in Turkey, Strategic Analyses, March, 83, 2007.

[2] IEA, 2007, World Energy Outlook,1-6, 2007, Paris, http://www.mobildepo.com/arsiv-konu-31517.0 , (Accessed Date: 2018).

[3] Bilgili, M., A Global Review of Wind Power Installations and their Development in Turkey, Clean-Soil, Air, Water, 37, 195-202, 2009.

[4] GWEC, Global Wind Energy Council, Global Wind 2007 Report, 2008. http://www.gwec.net , (Accessed Date: Mart 2018).

[5] Ali, S., Lee, S.-M., & Jang, C.-M. Techno-Economic Assessment of Wind Energy Potential at Three Locations in South Korea Using Long-Term Measured Wind Data. Energies, 10, 1442-1465, 2017.

[6] EPDK, Energy Market Regulatory Authority, Electricity Market, 2008. http://www.epdk.gov.tr , (Accessed Date: October, 2018).

[7] Hepbaşlı, A. ve Özgener Ö., A Review on the Development of Wind Energy in Turkey, Renewable and Sustainable Energy Reviews, 8, 257-276, 2004.

[8] https://www.mgm.gov.tr/FILES/haberler/2010/retsseminer/2_Mustafa_CALISKAN_RITM.pdf/ , (Accessed Date: September, 2018).

[9] Bilgili, M. ve Şahin, B., Yönlere ve Pürüzlülük Değerlerine Göre Rüzgâr Enerji Potansiyelinin Belirlenmesi, / Definition of Wind Energy Potential, by considering wind direction and roughness, 15. Ulusal Isı Bilimi ve Tekniği Kongresi, /15th. National Conference of Heat Sciences and Techniques, Trabzon, 107-113, 2005.

[10] Annual Reporting of Renewables: Ten years of excellence (2015). Renewables 2015 Global Status Report. 19-20.

[11] F. Barbieri, S. Rajakaruna and A. Ghosh, "Very short-term photovoltaic power forecasting with cloud modeling: A review," Renewable and Sustainable Energy Reviews, vol. 75, pp. 242-263, 2017.

[12] A. Bugałaa, M. Zaborowiczb, P. Bonieckib, D. Janczakb, K. Koszelab, W. Czekałab and A. Lewickib, "Short-term forecast of generation of electric energy in photovoltaic systems," Renewable and Sustainable Energy Reviews, vol. 81, pp. 306–312, 2018

[13] "World wind energy report 2010", World Wind Energy Association (WWEA), 23p, April 2011, 3703-3716.

[14] Lüy, M. Saray, U., Wind Speed Estimation for Missing Wind Data with Three Different Back propagation Algorithms. Energy Education Science and Technology Part A, Vol. 30(1), 45-54, 2012.

[15] Tekin, Mahmut. Üretim Yönetimi /Management of Production, Vol. 1, Cilt 1 / Vol. 1, (6. Baskı). Konya: Günay Ofset, 2009.

[16] Öztemel, Ercan. Yapay Sinir Ağları /ANN, (2. Baskı). Istanbul: Papatya Yayıncılık, /Papatya Publishing Company, 2006.

[17] Yu, Lean; Wang, Shouyang and Lai, Kin K. Forecasting crude oil price with an EMD-based neural network ensemble learning paradigm, Energy Economics, 30 (2008): 2623-2635.

[18] Zheng, D., Eseye, A.T., Zhang, J., Li, H., Short-Term Wind Power Forecasting Using a Double-Stage Hierarchical Hybrid GA-ANFIS Approach, 2nd IEEE International Conference on Cloud Computing and Big Data Analysis, 499-503, 2017.

[19] Toktaş, İhsan ve Aktürk, Nizami. Makine Tasarım İşleminde Kullanılan Yapay Zeka Teknikleri ve Uygulama Alanları, AI Techniques in Machine Design, Makine Teknolojileri Elektronik Dergisi, The Journal of Machine Techniques and Electronics, 2004 (2) 7-20.

[20] Deperlioğlu, Ö. The Effects of Different Training Algorithms on the Classification of Medical Databases Using Artificial Neural Networks, European Conference on Science, Art & Culture ECSAC 2018, April 19 to 22, 2018 Antalya, Turkey.

[21] Kaya, B., (2022), APPLYING WIND VIOLENCE AND SOLAR RADIATION FORECAST FOR KADIKÖY-GÖZTEPE DISTRICTS IAU, M.Sc. Thesis, (Supervisor: Prof. Dr. Zafer ASLAN), Institute of Graduate Studies, Istanbul. (https://ejeas.euras-edu.org/)