

An Example of Wind Energy Applications: Türkiye (Kirsehir Province, Geycek Wind Power Plant)

Ömer Eyüboğlu[1*], Gökhan Eyüboğlu[2], Huri Eyüboğlu[3]

1. Department of Mathematics and Science Education, Faculty of Education, Ahi Evran University, 40100, Kirsehir, Türkiye
2. Hacettepe University, Mechanical Engineering, Ankara, Türkiye
3. Ministry of Environment, Urbanization and Climate Change, Kırşehir, Provincial Directorate of Environment, Urbanization and Climate Change, 4200, Kırşehir, Türkiye

* E-mail of the corresponding author: oeyuboglu@ahievran.edu.tr

Abstract
Kirsehir is in a location with natural richness, especially in terms of sun and wind. The renewable energy facilities currently invested and operating throughout Kirsehir are proof of this. In this study; The potential of wind energy, one of the renewable energy sources, in Kırşehir Province was examined and Geycek Wind Power Plant, the only active wind power plant in Kirsehir Province, was evaluated. The existing Geycek Wind Energy Power Plant continues to operate as a impressive work for the region with its installed power of 168 MWe. There is going to be a Wind Power Plant region with a total installed power of 528 MW, along with other investments to be made to use the full potential. In addition, suggestions have been made for Kirsehir to benefit from wind energy effectively and widely.

Keywords: Wind energy, Kirsehir, Geycek Wind Power Plant, Renewable energy
DOI: 10.7176/JETP/13-3-06
Publication date: November 30th 2023

1. Introduction

A significant portion of energy use consists of fossil resources (coal, oil and natural gas, etc.). The decrease in fossil fuels and environmental problems, as well as the obligation to reduce CO2 and other greenhouse gas emissions in accordance with international agreements (Kyoto Protocol, etc.), have greatly increased the need for new and renewable energy sources. Research on renewable energy sources plays an important role in reducing the emission of gases that are effective in global warming into the atmosphere (Gourieres 1982; Hepbasli 2004).

Energy is one of the most important inputs of a country's economic and social development (Yılmaz 2012). Industrialization and the increase in the world population rapidly increase the demand for energy (Koç & Kaya 2015). Energy resources are insufficient to meet the demand due to both unconscious use and the rapidly increasing world population (İlkılıc, Aydin, Behçet, 2011), and the interest in renewable energy resources increases day by day (Bilgili & Şahin 2007; Bozkur & Şentürk 2017; Gül & İzgi 2018). It is estimated by the World Energy Council that energy demand will increase threefold by 2050 due to population growth and urbanization (Önder & Gündüz 2017).

If environmentally friendly clean renewable energy resources are used well, multifaceted contributions can be made to the country's economy (Önal & Yarbay, 2010). Wind energy has renewable properties and is known as an environmentally clean energy source (Behçet et al., 2014). The technology that converts wind energy into other types of energy is more economical than other power sources (Türköz 2020). Accordingly, the establishment of wind energy systems in regions with intense wind speed distribution seriously supports the economy (İlkılıç 2016). In many parts of the world, wind energy systems have been developed, electricity production has started (İlkılıç 2012; Tetaş 2018; Ahika 2017). On average, 2% of the solar energy reaching the Earth becomes wind energy (Kılıç & Adalı 2022).

In studies on renewable energy sources, studies on the importance of wind energy (Akova, 2003; Akova, 2008; Aydın 2013; Hayli 2001; Hepbasli & Ozgener 2004) and its evaluation (Çetin 2009; Varınca & Varank 2005) have gained intensity. As a matter of fact, an increase in wind power plants is observed every year both in Turkey and in the world (Bayraç, 2011). Turkey is among the countries in the world that are suitable for the use of wind energy (Bayrakçı 2007; Güler 2009).
It is claimed that Turkey has 10 times as much wind energy as the 36 dams currently producing electricity. In parallel with the development in the world, it is aimed to meet 10% of the electrical energy expected to be consumed in Turkey in 2020 from wind. The estimated potential is approximately 60,000 MW. Increasing the

wind installed capacity in Türkiye means reducing the dependence on external energy, and at the same time, the development of this sector will create employment opportunities.

The total installed power of wind power plants in operation as of the end of June 2018 is 6,671 MW (TÜREB, 2017). In Turkey, it has been accepted that wind power plants with a power of 5 MW per square kilometer can be established in areas 50 meters above ground level and with wind speeds above 7.5 m/s. In the light of these assumptions, the Wind Energy Potential Atlas (REPA), which provides wind resource information produced using the medium-scale numerical weather forecast model and the microscale wind flow model, has been prepared. Türkiye's wind energy potential is determined as 48,000 MW. The total area corresponding to this potential corresponds to 1.30% of Turkey's surface area.

Geothermal and wind-based production from renewable energy sources has increased significantly in the last decade, reaching 26,563 GWh from 1,009 GWh. In the same period, while the electrical energy produced from thermal power plants increased by approximately 28%, the energy produced from hydraulic power plants increased by 76% (Tedaş, 2018)3). When we look at the data of 2017, electricity production was 6% wind, 19.8% hydraulic and 2% geothermal (Figure 1).

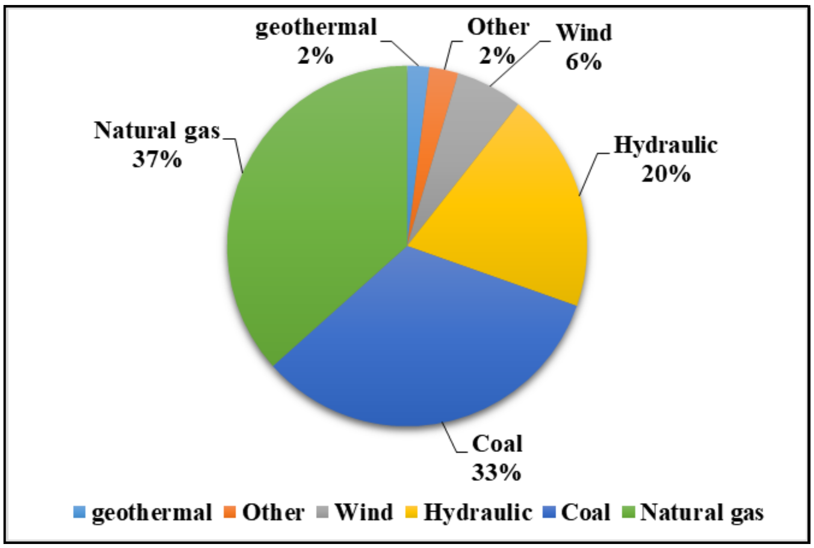


Figure 1. Electrical Energy Production Rates by Source as of the End of 2017 (Tedas, 2018)

Kirsehir is suitable for renewable investments because it is a province rich in renewable energy resources. Currently, investments have been made mainly in wind, hydroelectric and solar energy facilities, and the total installed power is 335.78 MW (Figure 2).Wind Power Plant has an important place in the distribution of existing Energy Production Plants in Kirsehir province, with a share of 50% and an installed power of 168 MW (Figure 2).

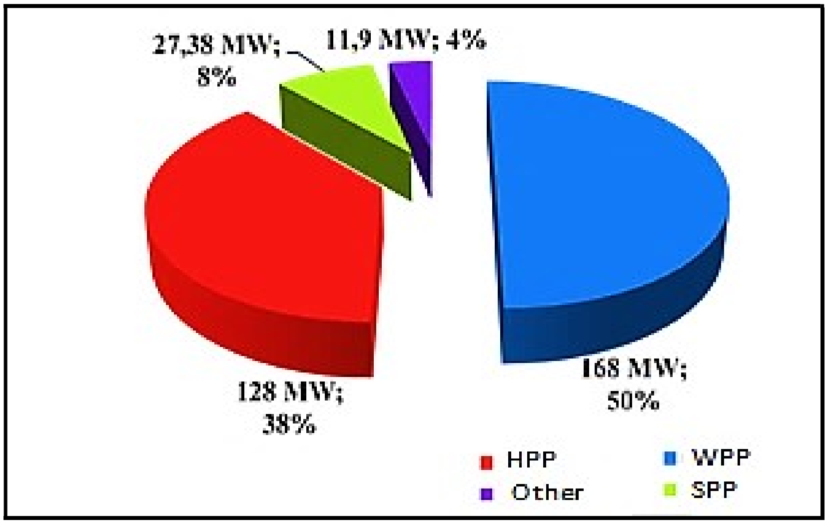


Figure 2. Distribution of Existing Energy Production Plants in Kirsehir Province (Ahiler,2019)

According to the National Renewable Energy Action Plan published by the Ministry of Energy and Natural Resources, the share of renewable energy sources in electricity production will increase to at least 30% in 2023 (Cebeci 2017).

Energy needs are increasing rapidly in parallel with Turkey's economic growth, increasing population, industrialization and improvement in living conditions. "Geycek Wind Power Plant" with an installed power of 168 MWm, operating in Mucur district of Kirsehir Province, is an example of this.

2. Materials and methods

2.1 Characteristics of the activity area

In the preparation phase of the study, the studies conducted in terms of both subject and field were reviewed. The activity area is located within the borders of Kirsehir province, Mucur district, Geycek Village, and the power plant site is located on a total area of 2,796.11 ha (Figure 3). The territory of Kirsehir province, where the Geycek Wind Energy Power Plant project is located, is surrounded by Kızılırmak in the south and southwest, Kılıçözü stream in the west and northwest, Delice river in the north and northeast, and Seyfe Lake depression area in the east.

Figure 3. Geycek Wind Power Plant activity area (Kirsehir, Mucur)

Kirsehir is located in the Middle Kızılırmak section of the Central Anatolia Region. Its population in 2017 is 234,529 and its surface area is 6,570 km^2. The province's territory is 8 per thousand of the country's territory and 2.9% of the Central Anatolia Region's territory, and it ranks 53rd in terms of surface area. The province is located between 38°50'- 39°50' Northern latitudes and 33°30'-34°50' Eastern longitudes. Currently, the "Geycek Wind Power Plant", with a total of 70 turbines and an installed power of 168 MWm, continues its operations (Figure 4).

Figure 4. Views from the facility area (Kirsehir, Mucur)

2.2 Capacity of Wind Power Plant

Of the 70 turbines in question, 10 have an installed power of 3 MWm and 60 have an installed power of 2 MWm. It is planned to produce a total of 588,672,000 kWh of energy annually with an installed power of 168 MWm. The projected operating period is 49 years.

The areas where the existing 70 turbines are located on areas designated as "Agricultural Land" and "Pasture Area". Another effective parameter in choosing a wind power plant construction site is land use characteristics. According to the Land Monitoring System; Land cover groups of the power plant area have been determined (Figure 5).

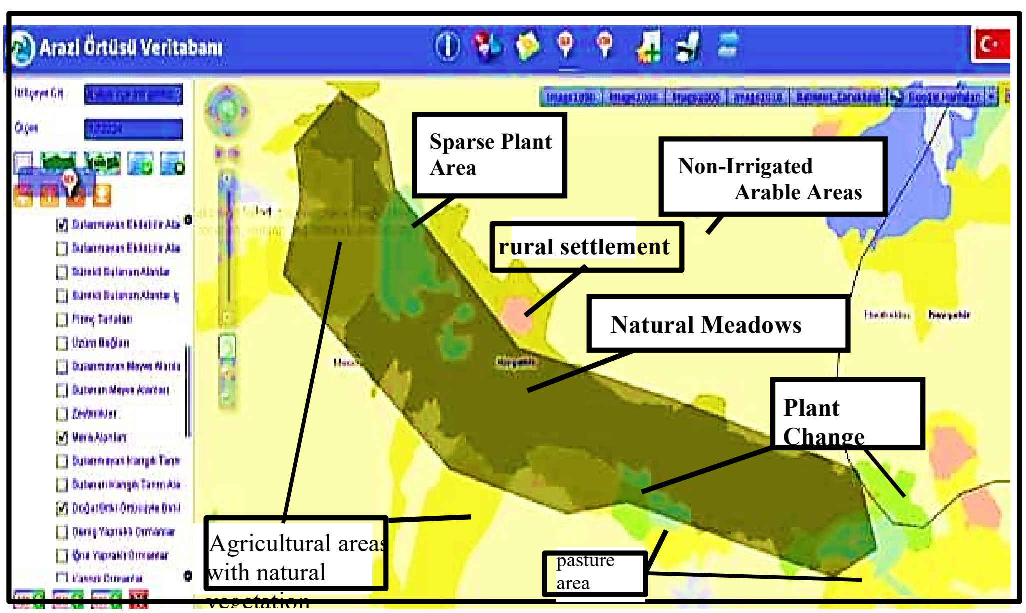


Figure 5. Location of the Power Plant Area According to the Land Cover Database

2.3 Technology in turbine selection

In turbine selection, ENERCON Brand E-82 2.3 MW and ENERCON Brand E-82 E3, 3 MW turbine models with new technology and proven production efficiency were chosen. Within the scope of the activity, 2 Vestas brand turbines are used in addition to the existing 70 turbine structures. Additionally, it is planned to use an Enercon brand turbine as an alternative for the T71 turbine point to be added.

In Wind Power Plants, wind turbines are systems that convert the energy in the wind into electrical energy (Elibüyük & Üçgül 2014). Wind turbines convert the kinetic energy of the wind into mechanical energy. This mechanical energy obtained is converted into electrical energy by the alternator in the turbine. The energy produced by all turbines in a wind power plant is transmitted to a single point, and from there the voltage is adjusted and given to the grid.

Wind turbines, like other turbines, convert the motion of a linearly moving fluid (air) into rotational motion. In other words, they convert the kinetic energy of the wind into rotational mechanical energy. This mechanical energy obtained is converted into electrical energy by the alternator in the turbine. In a wind power plant, the energy produced by all turbines is transmitted to a single point (switchgear facility) and from there, its voltage is adjusted and given to the grid. A horizontal axis, high speed, very large, three-arm, front wind, gearboxless and onshore type turbine is used. The preferred turbine structure was chosen because it is suitable for today's technology and is highly efficient. The following criteria were taken into account when determining the technology and capacity of the Wind Power Plant in question:

- ✓ Wind characteristics,
- ✓ Turbine characteristics and performance,
- ✓ Economic life and guarantees of turbines,
- ✓ Tested and operational turbines and their performances,
- ✓ Its impact in terms of noise pollution is minimal,
- ✓ Turbines should be protected against lightning strikes,
- ✓ No need for cooling water in wind power plants,
- ✓ No greenhouse gases from wind power plants,
- ✓ The wind source is clean and sustainable,

Within the scope of the Wind Power Plant, wind turbines without gearboxes are used to make the electrical energy obtained from wind turbines more efficient. These gearbox-less turbines are easy to maintain and extremely safe, with less than half the number of moving parts and parts of a traditional gearbox turbine. The technical specifications of the turbines currently used within the scope of Geycek Wind Energy Power Plant activity are detailed in Table 1.

Table 1. Technical specifications of Turbines

ENERCON E-82 – 2,3MW Wind Turbine Features	
Number of Turbines	60 Pieces
Installed Power	2,3 MW
Rotor Type	Gearless, variable speed and pitch control
Rotor Diameter	82 m
Rotor Hub Height	85 m
Crawl Area	5.281 m^2
Number of Wings	3
Rotor Speed Range	6 – 18 rpm
Wing Material	Composite material reinforced with epoxy resin (with lightning protection system)
ENERCON E-82 – E3 - 3MW Wind Turbine Features	
Number of Turbines	10 Pieces
Installed Power	3 MW
Rotor Type	Gearless, variable speed and pitch control
Rotor Diameter	82 m
Rotor Hub Height	85 m
Crawl Area	5.281 m2
Number of Wings	3
Rotor Speed Range	6 – 18 rpm
Wing Material	Composite material reinforced with epoxy resin (with lightning protection system)

However, the schematic representation of the main parts of the wind turbines in question is given in Figure 6.

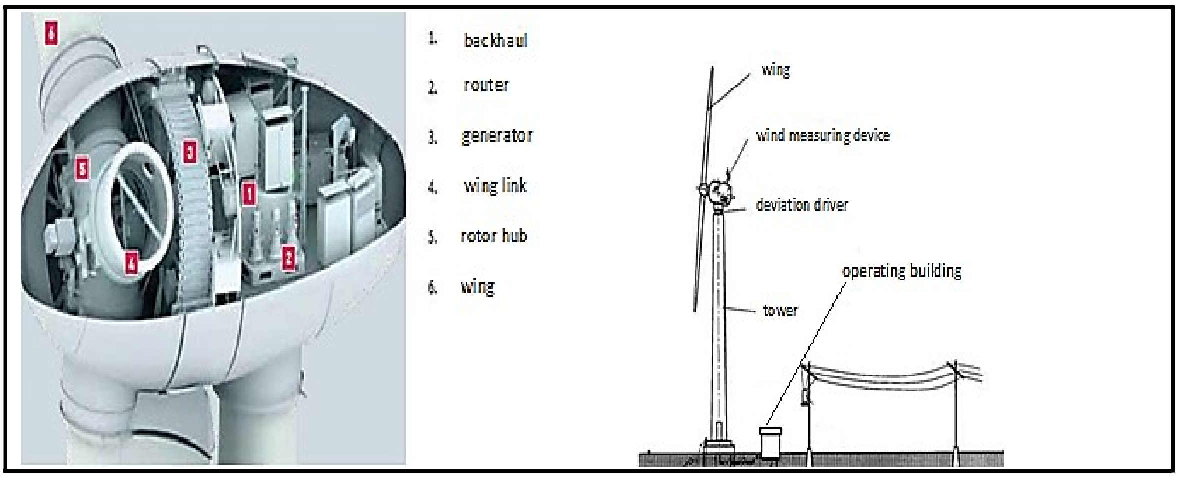


Figure 6. Schematic representation of the main parts of Geycek Wind Turbines

The most important factor in choosing the location of the Wind Power Plant is that the wind efficiency in the areas where the wind turbines will be installed is sufficient to produce electrical energy from the wind. In addition, the easy and short availability of spare parts and qualified personnel can be listed as important advantages. The technology used in the power plant is modern and applicable and is still applied in similar facilities. Therefore, it is thought that the technology chosen for energy production will provide optimum conditions. The project technology is capable of adapting to the studies to be carried out in the minimization phase of the environmental impacts that are likely to arise from the project.

2.4 The suitability and economy of the place and production method chosen for the activity

In this context, when the available alternatives are examined, there is no other alternative in terms of suitability and economy for the Wind Power Plant, the location chosen for the activity and the production method. 1/1000 and 1/5000 scale Zoning Plans have been prepared and approved for the turbines currently operating within the scope of the Wind Power Plant, the switchyard and the existing transportation roads within the power plant. The following criteria were taken into account when determining the technology and capacity of Geycek Wind Power Plant:

•Türkiye's energy needs,
•It is advantageous compared to facilities such as thermal and nuclear power plants in terms of ease of operation and economy,
•Wind characteristics in the region,
• Characteristics, performance and economic life of the turbines used and to be added,
•Ease of service and maintenance,
• Its impact in terms of noise pollution is minimal,
•The absence of any greenhouse gases that may arise from the project,
•Turbines must be protected against lightning strikes,

Apart from the water and carbon dioxide damages that occur when producing energy with conventional methods; Losses caused by the distance between the place where energy is used and the place where it is produced, the problem of transportation of gas, solid and liquid fuels and the accidents that occur from time to time, the costs of protecting these facilities safely if they are far from residential areas, the problems of gas, heat, poison, acid and ozone emitted by the fuels. Therefore, there is an opinion that the cost of life-reducing and damaging effects on human health should now be included in energy costs.

Electricity obtained from wind has come a long way to become one of the smartest solutions, as the costs of oil, gas and coal will increase over time, but wind will have no cost and no end.

3. Results and Discussion

3.1 wind speed distribution

The primary factor for establishing a suitable Wind Power Plant in an area is to determine the wind speed distribution (Bennui et al., 2007; Berken 2009). Direction information and hourly wind speed in the region are basic indicators of wind speed potential, and measurement of these indicators throughout the year is important. In this context, environmental obstacles that will affect the data at the stations where measurement will be made must be prevented (Bilgili & Şahin, 2005). In this context, the average wind speed distribution map at 50 m altitude determined by the General Directorate of Renewable Energy in Kırşehir was used. For an economical Wind Power Plant investment, a wind speed of 7 m/s or above is required (Figure 7).

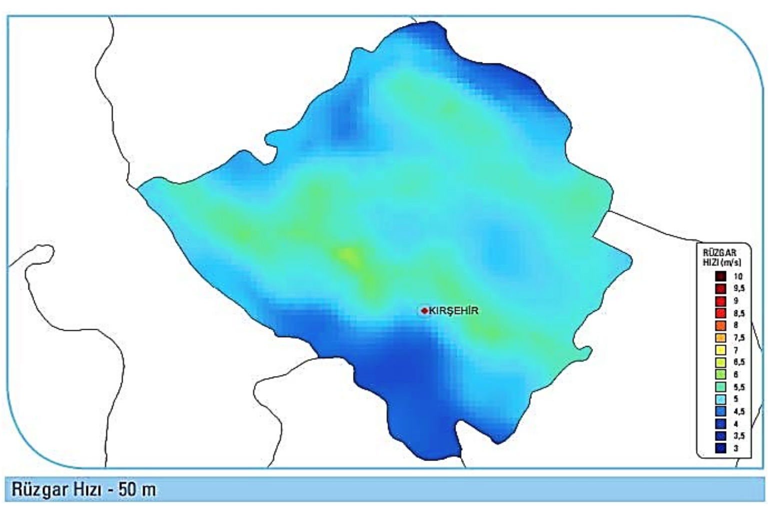


Figure 7. Kirsehir Province Wind Speed distribution (50m)

Wind power density, determined according to wind speed distribution (Yıldırım *et al*. 2012), also emerges as a determining factor for the construction site of a Wind Power Plant in any area. This is a factor that directly affects economic investment. Landforms are an important criterion in choosing a suitable place to install a wind turbine (Özşahin & Kaymaz 2013).

3.2 Contribution to CO_2 emission reduction

The most important environmental problem in the world today is global warming, caused by CO_2 emissions in the atmosphere and the greenhouse effect. Developed countries committed to reducing greenhouse gases under the auspices of the Kyoto Protocol to the United Nations Framework Convention on Climate Change will support renewable energy sources for clean energy technologies (Duic 2003).

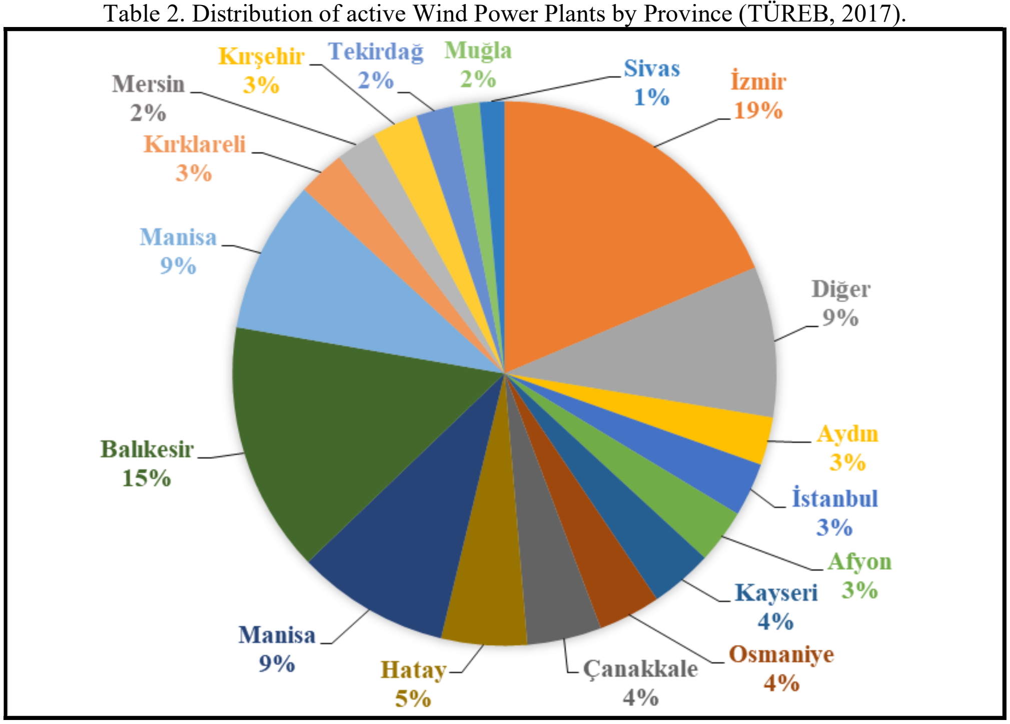
Wind power plants are a clean energy source that does not create CO_2 gas. It is a continuous and endless energy source that does not cause acid rain or atmospheric warming, saves fossil fuels, has no radioactive effect, and has no shortage of raw materials. It is also a power source that can be installed and dismantled in a short time. This Power Plant will contribute to meeting Türkiye's energy deficit.

In this context; Approximately 245,000 tons of CO_2 emissions are reduced annually, equivalent to planting 20 million trees. In addition, Geysek Power Plant is Turkey's fifth- largest wind power plant with an installed power of 168 MW and meets the annual electricity needs of 116,000 people.

3.3. Projects planned to be established in Kırşehir and under evaluation

Since Geycek Wind Power Plant is in operation, Kırşehir is represented with a 3% share in the distribution of Wind Power Plants by province (Table 2).

Table 2. Distribution of active Wind Power Plants by Province (TÜREB, 2017).



However, there are 6 projects (360 MW) planned to be established in Kırşehir and under evaluation (Table 3).

Table 3. Wind Power Plant Projects Being Evaluated (Kirsehir)

Company name	**Project name**	**Capacity (MW)**
2M Wind Energy and Investment Production Company	Kırşehir Şehitler Wind power plant	59,4
Agora Yıldız Energy and Industry Trade Company	Bahçecik Wind power plant	60
Çalık Energy Industry and Trade Company	Kırşehir Wind power plant	60
Doğa Wind power plant Energy Investment Production Company	Kaman Wind power plant	20
Kırlangıç Energy and Electricity Generation Company	Karaca Ören Wind power plant	59,5
Samres Electricity Generation Company	Samres Wind power plant	49
Sardubya Renewable Energy Electricity Generation Company	Sardunya Wind power plant	49,5

Kirsehir is going to be a region with a total installed power of 528 MW, with the potential of 360 MW planned to be newly established in addition to the existing Geycek Wind Power Plant.

4. Conclusion

Türkiye has a very serious potential in wind energy compared to other countries. The estimated potential is approximately 60,000 MW. Firstly, wind, which is a clean and renewable energy source, does not have disadvantages such as carbon emissions and environmental pollution. Increasing wind installed capacity in Türkiye means decreasing external energy dependency. Although there are conditions for obtaining electrical energy from wind energy in many regions of Türkiye, these opportunities are not utilized sufficiently. Kirsehir is one of the most suitable areas in the Central Anatolia Region for the establishment of wind power plants due to its geographical location. When the wind data of Kirsehir Province is examined, it is seen that there are suitable investment regions. As can be seen from the research results obtained in this study, Kirsehir Province has wind energy potential.

The wind power plants to be established in this region will contribute to the economy of the region, and new employment areas will be opened with the wind power plants to be established. Considering the environmental problems that threaten the future of humankind, such as global warming, increasing studies, research and incentives on renewable energy resources are very encouraging developments.

Competing interests: The authors declare that they have no competing interest

References

Ahika. (2017). Kirsehir 2017 Investment Support and Promotion Strategy, AHİKA Kırşehir Investment Support Office Publication.

Ahiler. (2019). Kirsehir, Energy Specialized Organized Industrial Zone KEIOSB Feasibility Report.

Bayrakçı C. H. (2007). Wind Energy and Potential Determination Studies in Turkey, *Engineer and Machinery*, **48**,78-80.

Bilgili, M. & Şahin, B. (2005). Determination of Wind Energy Potential According to Directions and Roughness Values, 15th National Thermal Science and Technology Congress, Trabzon, 107-113.

Bilgili, M. & Şahin, B. (2007). Wind Speed Estimation of a Target Station with Artificial Neural Networks Method, 16th National Thermal Science and Technology Congress, Kayseri, 162-167.

Önder, H. & Gündüz, İ. (2017). The Relationship between Nuclear Energy Consumption and Economic Growth: A Review of the Literature. *Recep Tayyip Erdoğan University Journal of Social Sciences*, **5**, 117-133.

Önal, E. & Yarbay, R. Z. (2010). Potential and Future of Renewable Energy Resources in Turkey. Istanbul *Commerce University Journal of Science*. **9** (18), 77-60.

Ilkılıc, C., Aydin, H. & Behçet R. (2011). The Current Status of Wind Energy in Turkey and in the World, *Energy Policy*. **39** (2),961-967.

Güler, Ö.(2009). Wind energy status in electrical energy production of Turkey, *Renewable and Sustainable Energy Reviews, Elsevier*.**13**(2),473-478.

Gül, SE. & İzgi, E (2018). Analysis of an industrial facility with smart or conventional panels connected to wind and solar energy production systems. Power Systems Conference, 59-63, Ankara.

Kılıç, MY. & Adalı, S. (2022). Hybrid Renewable Energy System to Meet Electricity Needs - Supermarket Example. *Osmaniye Korkut Ata University Institute of Science and Technology Journal*, **5**(1), 224-235.

Tetaş, (2018). 2017 Sector Report, Türkiye Elektrik ve Ticaret A.Ş. General Directorate.

Türeb, (2017). Türkiye Wind Energy Statistical Report, Turkish Wind Energy Association Report.

Cebeci, S. (2017). Evaluation of Electricity Production Potential from Solar Energy in Turkey, Planning Specialist Thesis, Ministry of Development Publications. Access address: http://www.sbb.gov.tr/wpcontent/uploads/2018/11/Seda-Cebeci

Gourieres, D.L. (1982). Wind Power Plants Theory and Design, Pergamon Press, Oxford.

Hepbasli. & O. Ozgener (2004). A review on the development of wind energy in Turkey, *Renewable Sustainable Energy Reviews*, **8**(3), 257–276.

İlkılıç, C. (2012). Wind Energy and Assessment of Wind Energy Potential in Turkey, *Renewable & Sustainable Energy Reviews*, **16**(2), 1165-1173.

Duic, N., Alves, L.M., Chen, F., da Grac & Carvalho, M. (2003). Potential of Kyoto protocol clean development mechanism in transfer of clean energy technologies to small ısland developing states: case study of Cape Verde. *Renewable and Sustainable Energy Reviews***, 7** (1), 83–98.

İlkılıç, Z.(2016). Development of Wind Energy and Wind Energy Systems in Turkey, *Journal of Life Sciences*, **6** (2),1-13.

Elibüyük, U. & Üçgül, İ. (2014). Wind Turbines, Types and Wind Energy Storage Methods. *Jekarum*, 2 (3),1-14.

R. Behçet, H. Gül, H. Oral, F. Oral. (2014). Place of Malatya Province in Eastern Anatolia Region in Terms of Wind Energy Potential, *BEÜ Journal of Science*, **3** (1), 65-73.

Yıldırım, U., Gazibey, Y. & Güngör, A.(2012). Wind Energy Potential of Niğde Province" *Niğde University Journal of Engineering Sciences*, **1**(2), 37-47.

Bozkurt, C., Şentürk, A.(2017).Renewable Energy and Economıc Growth: An Investıgatıon on Turkey and European Unıon, *Journal of International Trade and Economic Research*, **1**(2), 1-18.

Türköz, K. (2020). Modeling Renewable Energy Supply: A Sectoral Analysis for Turkey, Doctoral Thesis, Dokuz Eylül University Institute of Social Sciences, Izmir.

Koç, E. & Kaya, K. (2015). Energy Resources–Renewable Energy Status. *Engineers and Mechanics*, **56** (668), 36-47.

Yılmaz, M. (2012). Turkey's energy potential and the importance of renewable energy resources in terms of electrical energy production. Ankara University Journal of Environmental Sciences, 4 (2), 33-54.

Özşahin, E & Kaymaz, Ç.K.(2013). A CBS Analysis on the Construction Site Selection of Wind Power Plants: Hatay Example, *Tubav Science magazine*, **6**(2),1-18.

Hepbasli, A. & Ozgener, O.(2004). A review on the development of wind energy in Turkey. *Renewable and Sustainable Energy Reviews*, **8,** 257–276.

Hayli, S.(2001). The Importance of Wind Energy, Its Situation in the World and in Turkey. *Fırat University Journal of Social Sciences*, **11** (1), 1-26.

Akova, İ.(2003). World Energy Problem and Use of Renewable Energy Resources. I. Ü. *Journal of Geography*, **11**, 47-73.

Akova, İ. (2008). Renewable Energy Resources, Nobel Publications No: 1294, Technical Sciences No: 100, Ankara.

Aydın, İ.(2013). Balıkesir Wind Energy. *Eastern Geography Journal*, **29**, 29-50.

Varınca, K. B. & Varank, G.(2005). Evaluation of Environmental Impacts in Wind Sourced Energy Production Systems and Solution Suggestions, New and Renewable Energy Sources/Energy Management Symposium (YEKS 2005), *Proceedings Book*, Kayseri, 367- 376.

Çetin, A. C.(2009). Wind Energy Investments and Wind Power Plant Establishment Site Selection in Isparta Province, International Davraz Congress, Isparta, 368-389.

Bayraç, H. N. (2011). Global Wind Energy Policies and Applications, *Uludağ University Faculty of Economics and Administrative Sciences Journal*, **30** (1), 37-57.

Bennui, P., Rattanamanee, U., Puetpaiboon, P., Phukpattaranont. & K. Chetpattananondh. (2007). "Site Selection For Large Wind Turbine Using GIS" PSU-UNS International Conference on Engineering and Environment - ICEE2007, 90-112, Prince of Songkla University, Faculty of Engineering, Hat Yai, Songkhla, Thailand.

Berken, J. T. (2009). Using GIS to Analyze Wind Turbine Sites within the Shakopee Public Utilities Electric Service Territory Shakopee, *Papers in Resource Analysis*, **11**, 1-11.