



The Evaluating of Wind Energy Potential of Osmaniye

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Authors' contributions

This work was carried out in collaboration among all authors. Author Yelmen designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors Kurt and Çakir managed the analyses of the study. Author Çakir managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

In parallel with the rapid increase in energy consumption today, it is known that conventional energy resources will be exhausted in the near future. Renewable energy sources are becoming more important today with decreasing available fossil resources and increasing energy needs. Wind energy is a clean and renewable energy source and has a remarkable importance. Wind energy is one of the most important renewable energy sources, whose technology and use have developed rapidly and their economy has become competitive with fossil energy sources. The systems that convert the energy in the wind into electrical energy are wind turbines. Wind turbines are classified according to their rotational axes, revolutions, powers, number of wings, wind effect, gear characteristics and installation locations. Energy has become one of the most important problems of the world countries today. Energy demand, as in many countries, is increasing with each passing day in Turkey. For this reason, solutions are sought to provide the energy needed in a timely, sufficient and reliable manner. The energy needed in these solution suggestions should be provided from domestic production opportunities and local energy sources as much as possible. In this study,

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usability of wind energy is tried to be revealed in Osmaniye province and its surroundings. When the wind map studies in Turkey are examined, in Osmaniye Province it has been found that the presence of wind potential, it is necessary to increase the number of WPP to benefit more from the potential of wind energy.

Keywords: Renewable energy; wind energy; Osmaniye, windpower plant.

1. INTRODUCTION

While the need for energy is increasing day by day; some energy sources are gradually decreasing. One of the most important causes of global climate change and greenhouse gas emissions threatening our world is the use of fossil fuels. Non-renewable energy sources such as oil, coal, natural gas and nuclear energy both affect human health negatively and cause environmental pollution. In the transportation sector, meeting 95% of energy consumption from oil causes an increase in costs. These costs are expected to increase by 1.5% in developed countries and 3.6% in developing countries in the coming years [1]. The environmental impact, which is a significant disadvantage of energy generation technologies, is minimal in wind energy. As long as the sun and the world exist, it must be transformed into another form of energy to benefit from wind energy, which is a renewable energy source. Accordingly, wind energy systems are installed in places with good wind power density, and great economic benefits are provided. Wind power, as is known, is an indirect form of solar energy. This power is the result of the inability of each region of the earth to be heated evenly and the interaction of low and high pressure centers that occur accordingly [2]. Wind energy has been used as a driving force in the floating of sailboats, grinding wheat in mills and drawing water from wells. Wind energy investment was carried out first in 1998 in the town of Cesme (8.7 MW) in Turkey. In 2000, an investment of 10.2 MW was made only in Bozcaada. Wind power; It is a renewable and environmentally friendly energy source with little to no negative impact on the environment we live in. If only 10% of the electricity need is supplied from wind energy until 2025; CO₂ emissions released into the atmosphere will decrease by 1.41 Gton per year [3]. Turkey is providing 72% of the available energy supply from the outside. It raised the issue of evaluating the potential of renewable energy sources to reduce this dependency [4]. On the other hand, since the atmospheric emissions of renewable energy sources will be negligible, they will not cause pollution and the greenhouse effect will

decrease. Developments in wind energy technologies and widespread applications of wind energy reduce costs even more. Positive aspects of wind energy; it is freely available in the atmosphere, renewable, clean energy source and environmentally friendly. Its source is reliable, there is no risk of exhaustion and price increase over time. Its cost has reached a level that can compete with today's power plants [5]. According to the reports of the European Union; If renewable energy consumption can be doubled within 10 years, CO₂ emissions in Europe will decrease by 402 million tons every year [6]. It was concluded at the United Nations Climate Change Conferences that "consumption share of clean and renewable energy resources should be at least 25% among all energies" [7,8]. Renewable energy sources; It has become one of the most up-to-date sciences today when environmental pollution problems begin [9]. For these reasons, the variety of renewable energy sources is increasing today. These energy sources do not have a negative impact on the environment in the short and long term [10]. It is estimated that the world wind energy potential is 26,000 TWh / year in the area between 50° north and south latitudes and 9,000 TWh / year capacity is available for economic and other reasons [11]. It is stated that 27% of the total of world terrestrial areas are under the influence of the wind speed higher than the average annual 5.1 m / s. It is calculated that it will have an installed capacity of 240,000 GW with a production capacity of 8 MW / km², assuming that it will be possible to utilize wind energy [12].

Fig. 1 shows the distribution of world technical wind energy potential in 2016. Especially China and America try to evaluate their wind energy potential as efficiently as possible. When the distribution of wind power capacities in the world is analyzed by countries, as of 2016, China, the USA and Germany are the top three countries that benefit most from the wind power in the world. Only the total installed wind power capacity of these three countries constitutes 62% of the world total wind power capacity. Turkey in terms of wind power installed capacity is 11st in the world with a share of 1% (Table 1). Wind

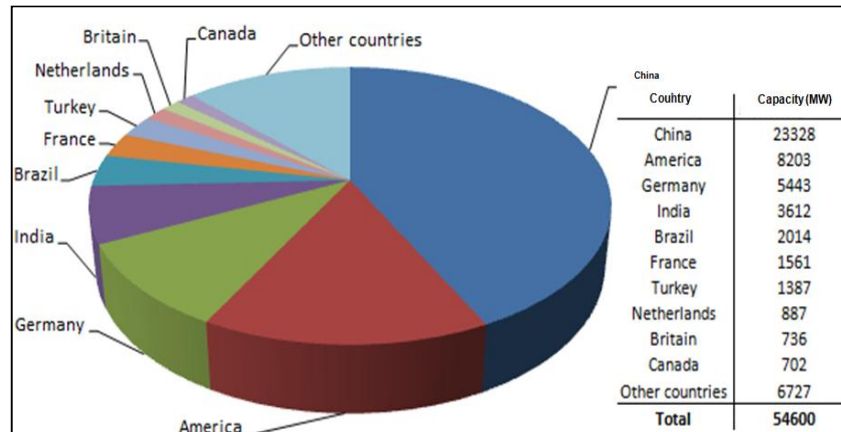


Fig. 1. The 10 countries that establish the most WPP in 2016 [13]



Fig. 2. Wind turbines [15]

power capacity installed in Europe; In 2016, it increased by 9% and reached 161,330 MW. Approximately half of the wind power capacity (54%) in Europe is installed in Germany, Spain and the UK; Turkey is 7st with a share of 4% [13]. The use of wind energy in the world is increasing day by day. As of the end of 2016, wind energy usage has reached 486,749 MW. The main goal in aerodynamic design, strength safety, use of high-strength materials, advanced production technologies and the creation of new concepts in wind turbines is to increase the percentage of usability of wind energy [14]. Wind turbines convert wind energy into electrical energy. It meets the electrical needs of various energy systems and houses with its wind turbine. As an example, wind turbines are given in Fig. 2.

According to the wind atlas, Turkey's top wind field regions are given in Table 1.

Wind energy atlas of Turkey is one of the most important studies on wind energy. In order to establish a reference to the evaluation and

planning of the wind energy resource in cooperation with EIE and DMI and to determine the places suitable for wind energy conversion systems; Turkey has prepared the Wind Atlas. Wind Energy Atlas of Turkey is a guide for companies that will conduct wind energy studies.

Turkey Wind Energy Potential Atlas (WPPM) is examined (Fig. 3). In the Mediterranean Region, regions with an average speed of 7 m / s and above, which are required to generate wind energy economically, are outstanding. Wind turbines are the main element of the power plant, which converts the kinetic energy of the moving air (wind) into mechanical energy and then electrical energy as the principle of operation. Turbines with 3 wings, horizontal axis and wind up front are used in electricity production with wind energy [18].

When the situation of Osmaniye is examined according to the latest data; It is observed that the WPPs in the enterprise come after Balıkesir, Manisa, İzmir and Hatay provinces in the

installed power distribution by provinces (Fig. 4). As can be seen from the figure, it is seen that the current wind potential of Osmaniye province is suitable and started to be evaluated. In this study, it is aimed to determine the Wind Energy Potential of the Osmaniye region. Wind speed data for Osmaniye province was obtained from the General Directorate of State Meteorology Affairs. In the study, based on the

hourly wind speed data measured for the Osmaniye region, the areas of wind energy potential in the Osmaniye region and suitable areas for wind power plant (WPP) installation were investigated. To emphasize the factors necessary to increase the efficient use of this resource, to determine how we can utilize wind energy more efficiently with the national renewable energy policy to be prepared.

Table 1. Wind energy potential in Turkey's various regions [16]

Regions	Annual average wind speed (m / s)	Annual average wind density (W / m ²)
Marmara Region	3,29	51,91
Aegean Region	2,65	23,47
the Mediterranean Region	2,45	21,36
Central Anatolia Region	2,46	20,14
Black Sea Region	2,38	21,31
Eastern Anatolia Region	2,12	13,19
Southeastern Anatolia Region	2,69	29,33
Average	2,58	25,82

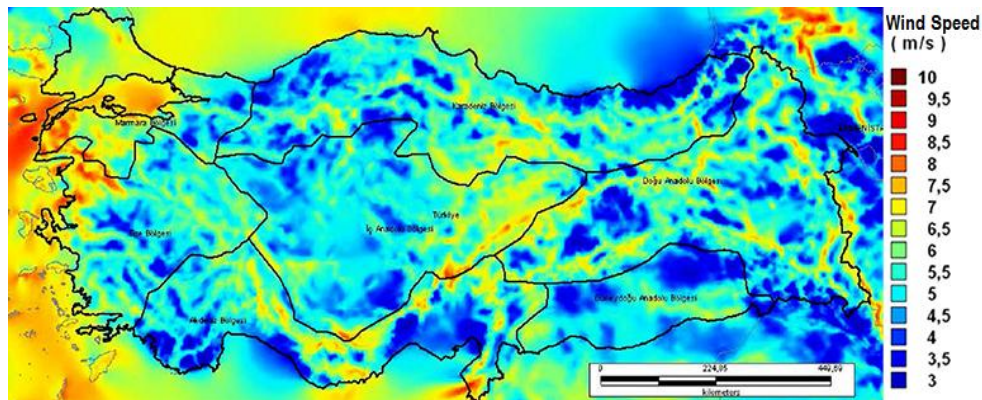


Fig. 3. Wind power potential map of Turkey (WPPM) Source [17]

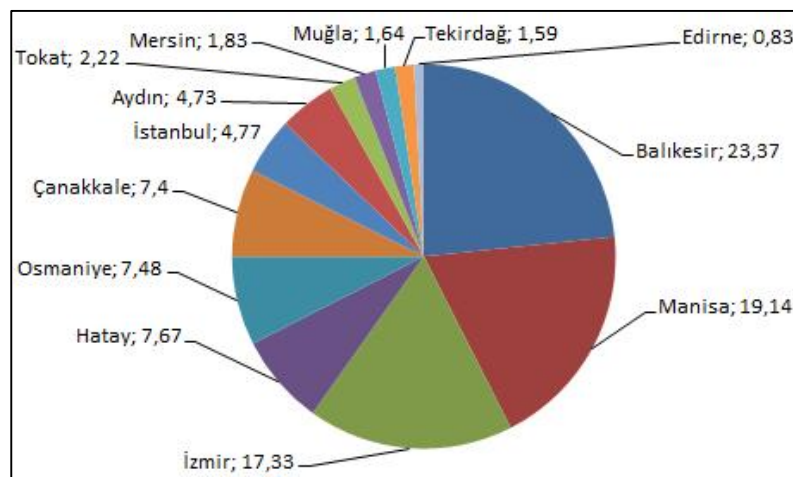


Fig. 4. Distribution of WPPs in the enterprise by provinces [19]

2. MATERIALS AND METHODS

2.1 Materials

Osmaniye province in the Mediterranean region, located in the south of Turkey.

Osmaniye geographical area as is Turkey's 67 largest cities. Osmaniye is located between 35° 52' – 36°42' East longitudes and 36°57' – 37° 45' North latitudes in the northern hemisphere [20]. The settlement map of Osmaniye is given in Fig. 5 [21].



Fig. 5. Location of Mersin on Turkey map [21]

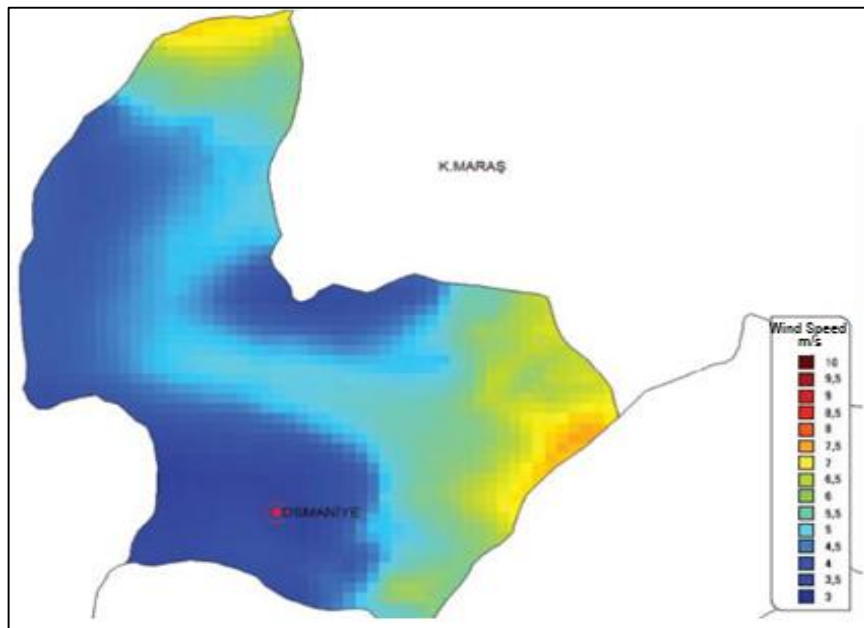


Fig. 6. Osmaniye wind speed distribution (for 50 m height)

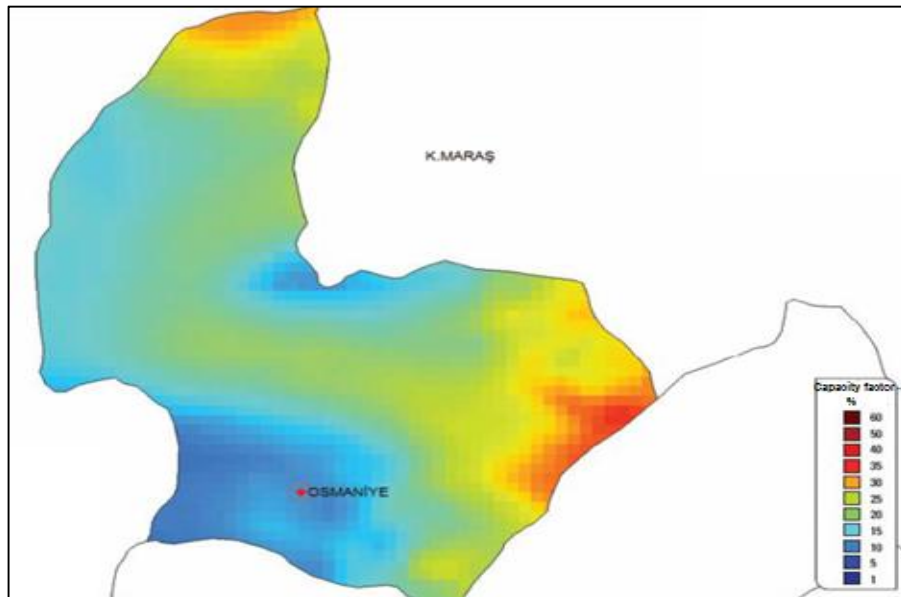


Fig. 7. Capacity factor

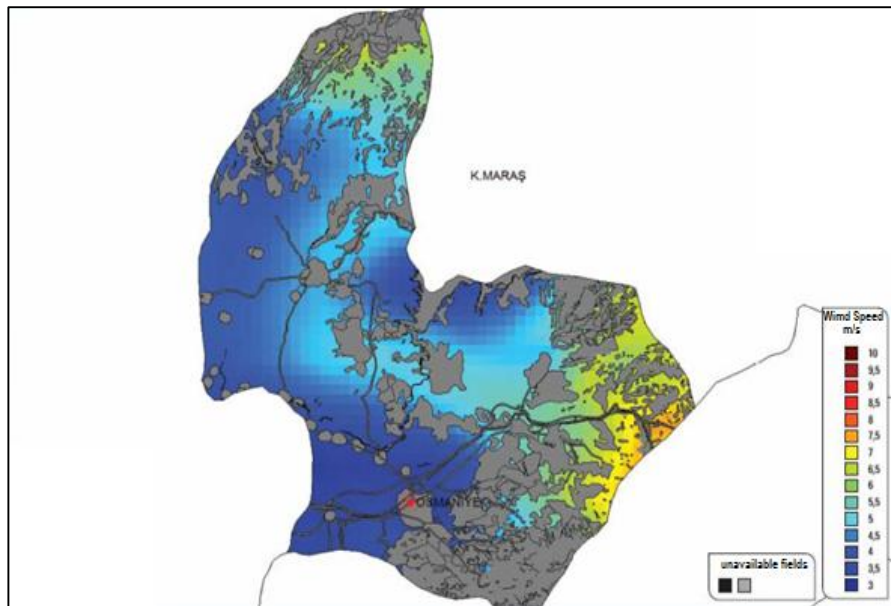


Fig. 8. Areas where wind power plants can be installed

In the study, the development of the world-wide installation of wind power capacity over the years and Turkey was mentioned place in that development. For this, statistical data obtained from institutional reports were used. installed wind power capacity in Turkey; The regions, provinces and their distribution in the province of Osmaniye are mentioned. Proportional comparisons have been made regarding the current situation. In addition, these comparisons

are supported by tables and graphics [22]. Approximately 2% of solar energy reaching the world is converted to wind energy. The places where the wind occurs are generally; These are places where pressure changes are high and high, uneven hills and valleys, shorelines and canal effects occur. In terms of producing wind energy, the average wind speed is; 6.5 m / s is considered as 'medium level', 7.5 m / s is 'good' and 8.5 m / wind is 'very good' [23]. For an

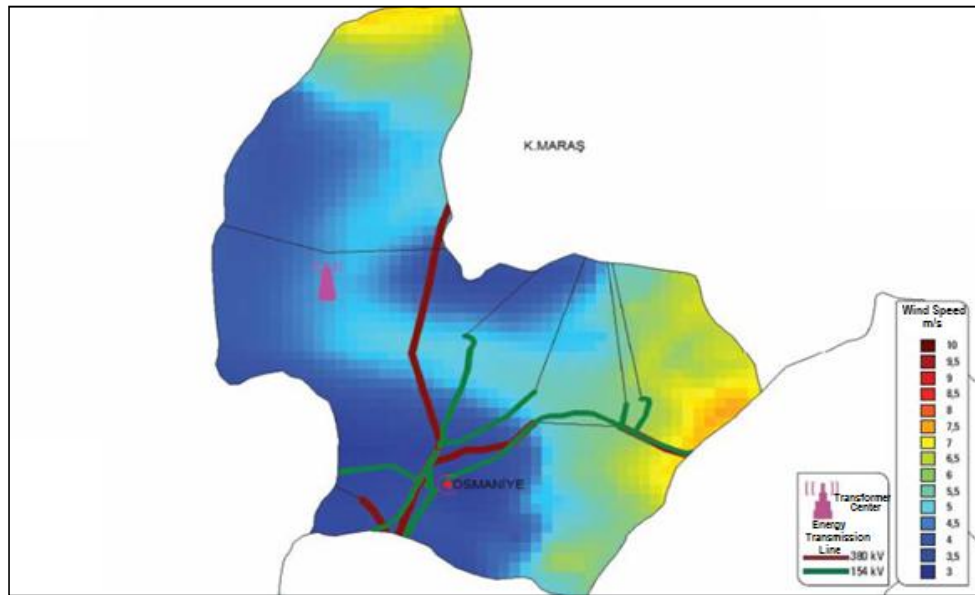


Fig. 9. Wind power plant transmission lines and substations

Table 2. Wind power plant power capacity that can be installed in Osmaniye province(2016) (80 m) [26]

Wind Power (W/m ²)	Wind Speed (m/s)	Total area (km ²)	Total Installed Power (MW)
300–400	6.8–7.5	139,47	697,36
400–500	7.5–8.1	4,14	20,72
500–600	8.1–8.6	0	0
600–800	8.6–9.5	0	0
>800	>9.5	0	0
		143,62	718,08

economical wind power plant investment, the wind speed must be higher than 7 m / s [24]. Under this wind speed, electricity cannot be produced economically. For this reason, wind turbines are built on areas with this wind speed on average [25]. As a result of researching the wind potential of Osmaniye, the available data and the regions that can be used efficiently are shown in Figs. 6 -9 [26].

3. RESULTS AND DISCUSSION

A wind speed of 7 m / s or more is required for the economic WPP investment.

35% or more capacity factor is required for Economic WPP investment.

It is assumed that wind power plants cannot be installed in gray areas.

Osmaniye Gökçedağ (Rotor) Wind Power Plant in Osmaniye; With an installed capacity of 135

MWe, it meets all electrical energy needs of an average of 117,482 people.

Osmaniye Gökçedağ (Rotor) Wind Power Plant is in the garden district of Osmaniye. Rotor Elektrik Üretim A.Ş., a partner of Zorlu Energy. This power plant operated by; Turkey's installed capacity of 113 MW and 135 is the 3rd largest power plant in Osmaniye. The resort is also Turkey's 5th largest wind energy plant. number of 54 wind turbines were used in WPP. With an average of 388,865,478 kilowatt-hours of electricity generation, Osmaniye Gökçedağ RES can meet all the electrical energy needs that 117,482 people need in their daily life (such as housing, industry, metro transportation, official apartments, environmental lighting). Osmaniye Gökçedağ WPP produces electricity that can meet the electrical energy needs of 123.449 residences only when the residential electricity consumption is considered. Osmaniye Gökçedağ (Rotor) Wind Plant has

Table 3. Osmaniye Gökçedağ Wind Power Plant (WPP) [27]

Osmaniye Gökçedağ Wind Power Plant (WPP)	
Installed Power	135 MWe
Ratio to Installed Power	%0,1659
Production capacity	510 GWh-year
Annual Electricity Production	~389 GWh-year
2016 Production	395 GWh
Turbine Brand	GE
Number of Turbines	54
Location of the Power Plant	Bahçe, Osmaniye

Table 4. Osmaniye Gökçedağ WPP annual electricity production [27]

Year	Production (kWh)	City Consumption Rate (%)	Country Consumption Rate (%)
2012	276541642	9,32	0,11
2014	334389203	10,65	0,13
2015	382131873	11,74	0,14
2016	395130152	11,75	0,14



Fig. 10. Osmaniye WPP [28]

the Gold Standard registration and provides approximately 300000 tons of CO₂ (carbon dioxide) emission in one year. RES consists of number 54 wind turbines with a capacity of 2.5 MW. The generated energy is transferred to Bahçe TM via 154kV connection. Osmaniye Gökçedağ WPP will benefit from the Renewable Energy Resources Support Mechanism (YEKDEM) in 2016 and will sell 1 kilowatt-hour electricity it produces to the state at a price of \$ 0.0730. Osmaniye Gökçedağ (Rotor) Wind Power Plant Lastly from YEKDEM; It will be able to benefit in 2020.

3.1 Electricity Generation Information

Zorlu Energy Saritepe-Demirciler Wind Power Plant was opened in the Garden District of

Osmaniye. The facility, which was fully operational in 2016, has 31 wind turbines and has the capacity to meet the electricity needs of 25 thousand households with 80.3 MW.

Turbines used in the construction of the wind farm is the largest wind turbines is established in Turkey. The turbines have a 30-story building height with a 85-meter tower body. It consists of 7 2.5 mw turbines with a wing diameter of 100 meters. Zorlu Energy Group has been operating wind turbines from 54 turbines until the end of the year with full capacity and 500 million kwh of electricity has been produced annually. In addition to the 135 mw wind power plant located within the borders of Bahçe and Hasanbeyli, a total of 110 mw wind power plant projects were completed in Osmaniye's

Saritepe and Demirciler locations in two sections of 50 mw and 60 mw. In the Çukurova Region, especially in Adana, the machinery and metal goods industry emerges as a sector that stands out in terms of number of companies and employment. Taking advantage of the experience of the region in this sector and supporting the growing and changing needs of the wind energy sector at the national and international level, the aim should be to support the companies in the region to become suppliers of the wind energy sector. Considering that 20% of the land use of Çukurova Region consists of agricultural areas and much more forest areas, it can be said that most of the region is rural. In this context, it is important to expand the use of small-scale wind turbines in the countryside. In the upcoming periods, Osmaniye wind energy potential will be evaluated, the share of the unlicensed wind energy installed power in the total installed power will increase rapidly with the intensive studies and improvements of both investors, distribution regions and TEDAŞ, Hatay and Osmaniye will be the pioneer in the increase in the installed power of the region and the wind energy of the region. It is possible to say that the installed power of the power plants will increase by accelerating [29].

4. CONCLUSIONS AND RECOMMENDATIONS

Although our country has high energy production potential, it meets about a quarter of its total energy consumption from its own resources and the rest through imports. When the wind data of Osmaniye is examined, it is seen that the potential exists and that there are suitable investment areas especially within the Garden district. It is seen that current wind farm applications started intensively in this region and there is potential in the region. These systems can be used primarily in energy production due to their advantages such as positive contributions to the environment and not harming the agricultural areas and changing according to the purpose of use. Electricity production from wind power in Turkey has increased over the years. The development of renewable energy sources in Turkey, thereby contributing to the increase of investment and electricity production, both to reduce costs in many areas is of great importance in terms of reducing both energy imports. In today's rural societies, the physical and economic difficulties of meeting the energy need by traditional

methods remain dominant. As a result, it prevents families living in rural areas from demonstrating their production potential at the expected efficiency. This situation draws attention as a negative externality in increasing income imbalance between rural and urban areas. Installation of wind turbines in regions with wind potential should be extended with various grants and supports within the framework of a specific strategic plan, with minimum cost. In lighting, agricultural production; electricity and diesel expenses are the biggest expenditure items. This shows us that electrical energy to be obtained from wind energy can be much cheaper than other energy sources. With the government support and incentives to be provided at the individual level, the electricity production and import burden of the state will also decrease and will contribute to the reduction of production costs. For the rapidly increasing energy demands of Turkey, It imports 72% of the energy needed. Turkey's current energy sources; the increasing population and developing industry cannot meet the energy needs. Therefore, the gap between energy production and consumption is growing rapidly. Turkey is extremely convenient for the establishment of wind farms as geographical location.

This can be used as a good potential for appreciation will be provided in a variety of energy sources produced in Turkey at the same time, it will open new employment areas in power plants to be established in these regions. Considering the rapid depletion of energy resources, the use of green energy resources should be encouraged and the private sector should be encouraged in this area. Turkey's economy will grow rapidly wind energy conversion systems with their investment. At the same time Turkey's potential to compete with developed countries will also increase. For this purpose, the importance of using the country's own resources more effectively has increased. Alternative energy sources should be used effectively in meeting the rapid increase in energy demand and research in this area should be supported. R&D studies should be accelerated on the basis of universities and companies in order to eliminate the technical and material deficiencies related to renewable energy sources, in other words, to reduce dependency abroad. More support should be provided to institutions involved in such studies. When using energy production methods, care should be taken to protect the environment and

the climate. In terms of capacity, 65 percent of the wind energy projects under construction are located in Osmaniye and 25 percent in Mersin. 71% of the built-in wind power plants are supplied from General Electric brand turbines, 21% from Vestas and 8% from Gamesa turbines. Operating under the Zorlu Energy Group, Rotor Elektrik Üretim A.Ş. generates over 300 million kWh of electricity annually at the Gökçedağ Wind Power Plant in Osmaniye. Gökçedağ Power Plant has Gold Standard certificate with its sensitivity to ecological and social balance. The 80.3 MW Saritepe and Demirciler Wind Power Plants Projects, which became operational this year, also have Gold Standard certification.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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