# COMPARISON OF THE EFFICIENCY OF WIND POWER PLANTS FROM RENEWABLE ENERGY TYPES TO REDUCE ATMOSPHERE POLLUTION IN MARMARA REGION

by

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*Our need for energy is increasing every day with the advancement of technology. Energy plays a major role in the social and economic sphere of life. The need for RES is increasing day by day although the need for energy is produced from fossil fuels in many countries. In addition to this, while the harmful gases emitted to the environment as a result of using fossil fuel for energy production harm the nature, this is not possible in renewable wind energy. Renewable wind energy is an endless source of energy obtained from natural processes. Therefore, wind power stations get attention of many countries. The wind industry is the world's fastest-growing energy source. However, the main problem of the renewable wind energy sector is that the desired wind intensity cannot be sustained at the same rate and the installation costs are high. Many countries are aware of the importance of wind energy and make certain investments in renewable wind energy in the long term. Wind turbines can be in different shapes according to their location and intended use. One of the most important reasons for their different designs is the wind types in their geographies. In this study, wind power plants in five different regions in Marmara region were discussed. These plants were compared among themselves, the results were evaluated and the efficiency of the plants compared.*

Key words: *alternative energy, wind energy, wind turbine, renewable energy*

## Introduction

Today, instead of energy sources such as coal and oil, which are going to be exhausted in the future, there is a search for energy sources that can be used as renewables and reduce environmental pollution. One of these sources stands out as wind energy [1, 5]. On the other hand, in recent years, great importance has been attached to biodiesel as a renewable and environmentally protected fuel [6-9].

Some geographical features are required in order to obtain electrical energy from the kinetic energy in the wind. These can be listed as wind speed, frequency and direction. As the speed of the wind increases, the pressure acting on the turbine blades increases and the turbine blades, which start to rotate faster, provide more energy. So, if we list the most suitable places

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for the wind turbine. We can identify that valleys with continuous wind, high, uneven hilly areas and plateaus in strong geostrophic wind zones, shores exposed to strong wind [10-12].

Wind, the movement of air, results from the conversion of a portion of the solar energy into kinetic energy [13-14]. A number of forces need to be applied to the air for the movement of air on earth. Just as the river flowing from a high mountain towards the plain does not show a straight line flow, the air does not travel along a straight line because of these forces. The specific forces in the atmosphere that influence the formation of wind and the velocity of the wind as the air masses in the high pressure belts advance to the low pressure belts to maintain stability are as follows: pressure Gradient force, Coriolis force, centrifugal force, and friction force [7, 15, 16].

The advantages of wind energy are it is a clean source of energy without harm to nature [16, 17]. It does not include wastes observed in other energy sources. It does not contain any waste observed in other energy sources. It does not cause the formation of GHG and the resulting acid rain and may indirectly reduce their formation. Also, using alternative renewable energy sources can reduce fossil fuel usage. The Altamount Pass wind farm in the USA avoids an average of 461000 tons of $CO_2$ and 423 tons of $NO_x$ per year according to the calculations. Wind energy plays an important role in reducing the global warming rate. It has benefits for other energy sources as well as for the environment, for example, it reduces the density and burden on fossil fuels and increases the useful life of these resources [18, 19]. It is an energy source with little cost. As it is a RES, there is no need for raw material cost. However, wind energy has a certain cost because it cannot work without its equipment. Wind energy reduces external dependence because it does not need raw materials. Although it is more expensive than traditional sources, it is an important gain for the national economy. In addition, new business areas will increase the job opportunities. For example, the cost of wind electricity is 50% of nuclear and solar energy in America. It corresponds to an average of 30% of the electricity obtained from other thermal power plants operating with natural gas, oil and coal [20-22].

Population of Turkey population is increasing rapidly and is advancing in the field of industry, it's need for energy is increasing in parallel. Nearly half of energy consumption in Turkey is met by oil and gas resources and a large part of these resources are not available in Turkey [23-25]. The trend towards RES has gained importance in our country as in many countries in order to meet the energy demand safely and to reduce dependence on external resources. Most of the fuels used in our country are non-renewable fuels and it causes serious harm to the environment with $CO_2$ emission and environmental pollution is expected to increase further with the fuels to be used with increasing energy need. Turkey cannot produce sufficient amount of energy despite the increasing energy demand, and is supplying most of the energy it uses from different countries [25].

Electrical energy needs of Turkey shows continuous increase as an emerging economy. Thanks to the incentives and importance given to renewable energy sources in recent years, it has been observed that the share of these 45 resources, especially wind, hydraulic and geothermal, within the installed power has increased in recent years. In this context, 28000 MW of power installed in Turkey in 2000, while in 2016 this figure is 77000 MW. Balikesir is in the first place with 969.75 MW power and 19.58% share in wind power. Balikesir is followed by Izmir with 936 MW (17.11%), Manisa with 574.95 MW (12.19%), and Hatay with 364.5 MW (7.73%). When the wind energy density of the regions is examined, it is observed that there is a wind power plant only in Adiyaman province in the South-eastern Anatolia Region. Our regions where the wind is intense are the coastal areas of Marmara, Aegean and Eastern Mediterranean [26, 27].

Increasing energy requirements in the world, harmful emissions of fossil fuels and damaging the environment and people have led researchers to work on alternative and clean energy sources. The amount of energy generated by the wind farms in five different locations in the Marmara region, that is the most intense region in terms of population and industry, was examined.

## Material and method

Figure 1 shows the wind turbine diagram. The location indicated by (a) is the impeller center inside the number 3 center. The portions of the conservation part are listed as (b) brake, (c) low-speed shaft, (d) gearbox, (e) brake, (f) high-speed shaft, and (g) generator.

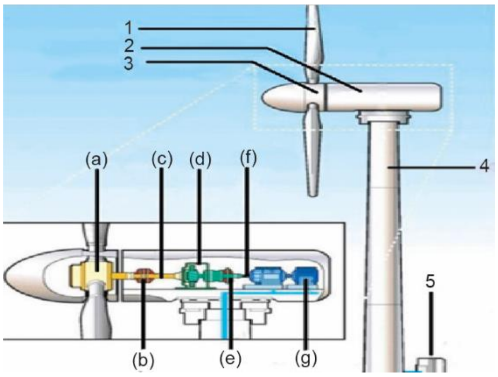

**Figure 1. Wind turbine diagram;** *1 – vane, 2 – conservation, 3 – the center, 4 – the tower, and 5 – transformer*

Table 1 shows the speed of the winds coming to some wind power plants (WPP) in the Marmara region was divided into monthly periods and averaged. If we compare the five wind farms given below with each other in terms of altitude, the highest altitude plant is located in Balikesir, while the lowest altitude plant is Burgaz WPP in Gelibolu. If we were to list the altitudes of power plants, respectively: Burgaz WPP 29 m, Catalca WPP 88 m, Balikesir WPP 155 m, Samli WPP 139 m, and Balabanli WPP 77 m. Looking at these elevations, it is seen that the monthly average wind speeds in Balikesir WPP, which has the highest altitude, are lower than the other foue regions. In line with this information, it is possible to say that besides the high altitude of the field where the power plant is installed, its land is not flat, but it is a rugged terrain with characteristics that can break some wind. In addition, the plant with the most efficient wind speed is seen as Catalca RES. One of the most important reasons for this is that the land is as flat as possible and the factors that will resist wind resistance on the land are less than other regions. Furthermore, the second fastest wind power plant is Balabanli WPP. Balabanli WPP is located in Tekirdag. As a result, if we make a comparison in terms of wind speeds and land regularity in the Marmara region, it can be easily seen from the table that the land arrangement is more favorable and the wind speeds are higher as we move north and west over the Marmara region.

## Brands and specifications of wind turbines

Table 2 shows the brands and specifications of the wind turbines used in the wind power plants in the Marmara region are detailed in the tab. 2.

## Comparison of wind turbines

Table 3 shows the specifications of the plants using wind turbines.

**Table 1. Wind speeds by months**

| Plant | Burgaz | Catalca | Balikesir | Samli | Balabanli |
|---|---|---|---|---|---|
| January | 5.30 | 6.79 | 3.20 | 4.14 | 6.18 |
| February | 5.86 | 6.85 | 3.79 | 4.58 | 6.40 |
| March | 5.6 | 6.1 | 3.6 | 4.4 | 5.8 |
| April | 4.54 | 4.94 | 3.45 | 3.94 | 5.65 |
| May | 4.13 | 4.49 | 3.24 | 3.71 | 4.22 |
| June | 4.19 | 4.59 | 3.58 | 4.50 | 4.23 |
| July | 5.28 | 5.30 | 4.13 | 5.94 | 5.28 |
| August | 5.45 | 5.62 | 4.17 | 5.86 | 5.66 |
| September | 4.62 | 5.58 | 3.45 | 4.54 | 4.84 |
| October | 4.65 | 5.92 | 3.06 | 3.94 | 5.13 |
| November | 4.49 | 5.97 | 2.92 | 3.61 | 5.13 |
| December | 5.00 | 6.91 | 3.13 | 3.98 | 6.05 |

**Table 2. Wind turbines specifications in Marmara region**

| Marmara Region | | Catalca WPP | Burgaz WPP | Balikesir WPP | Samli WPP | Balabanli WPP |
|---|---|---|---|---|---|---|
| Turbines specifications | | Vestas V90-3.0 | Enercon E-70 | General Electric (Ge) 2.75-103 | Vestas V112 3.0MW | Siemens SWT 2.3-108 |
| Power | Rated power [kW] | 3000 | 2300 | 2750 | 3000 | 2300 |
| | Rated wind speed [ms$^{-1}$] | 15 | 15 | 13 | 12 | 11.5 |
| | Cutting wind speed [ms$^{-1}$] | 4 | 2.5 | 3 | 3 | 3 |
| | Discharging wind speed [ms$^{-1}$] | 25 | 34 | 25 | 25 | 25 |
| Rotor | Diameter [m] | 90 | 71 | 103 | 112 | 108 |
| | Number of blades | 3 | 3 | 3 | 3 | 3 |
| | Maximum rotor speed [U per minute] | 18.4 | 21 | 18 | 17.7 | 16 |
| | Cleaned area [m$^2$] | 6362 | 3959 | 8332 | 9852 | 9144 |
| | Maximum speed [ms$^{-1}$] | 87 | 78 | 98 | 104 | 90 |
| Tower | Central summit [m] | 105 | 113 | 123.5 | 116 | 80 |
| | Shape | Conic | Conic | Conic | Conic | Conic |
| | Tube | Steel tube | Steel pipe/concrete | Steel pipe/hybrid | Steel pipe/concrete | Steel tube |
| | Corrosion protection | Painted | Painted | Painted | Painted | Painted |

**Table 3. The specifications of the plants**

| Plant | Number of turbines | Installed power | Annual avg. energy production | Electrical demand (person) |
|---|---|---|---|---|
| Burgaz WPP | 18 | 14.9 MW | 43.000.000 kWh | 16.000 |
| Catalca WPP | 30 | 93 MW | 280.000.000 kWh | 60.579 |
| Balikesir WPP | 52 | 142.5 MW | 376.000.000 kWh | 114.000 |
| Samli WPP | 43 | 114 MW | 285.000.000 kWh | 86.000 |
| Balabanli WPP | 25 | 60.5 MW | 137.000.000 kWh | 41.403 |

Figure 2. shows the comparison of average annual power generation per turbine in wind turbine power lines at 5 different locations in the Marmara region.

Figure 3 shows the comparison of the annual amount of energy supplied in the wind turbine power lines at five different locations in the Marmara region.

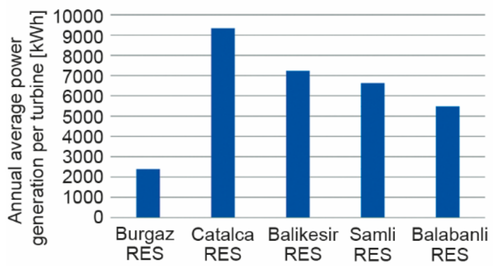


**Figure 2. Average annual power generation per turbine**

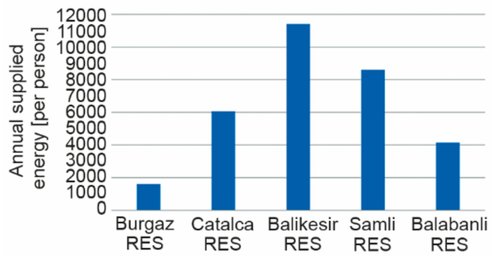


**Figure 3. Annual supplied energy**

Large wind turbines have high maintenance and installation costs. The installation site is costly. Minors are designed to meet personal needs, are low in cost, are stored in the battery and used according to needs. In turbines that take the wind from the front, production is fast because the wind first comes to the wings. Therefore, they are more commonly used. In the turbines that take the wind from behind, passive moving rotor is used because there is no yaw mechanism. The material structure is flexible and light. Therefore the load on the tower is also light. The damage caused to the turbine by the passive moving structure of the rotor is high. Therefore they are not preferred [28-31].

## Conclusions

As a result of the investigations, it is seen that among the five plants we have examined in the Marmara region, Catalca WPP has the highest annual electricity production and the highest land efficiency.

On the other hand, it is seen that the electricity generation value of Burgaz WPP is lower than the other four regions. In wind speeds, it is seen that the wind speeds of Burgaz WPP have a more average value compared to the data of 5 plants. However, it is seen that the annual energy production is lower due to the fact that the number of wind turbines in the power plant is fewer than that of other power plants.

As a result of the researches, it has been concluded that switching to renewable and zero emission energy sources such as wind energy instead of consumable energy sources is important for the future of the world and the protection of the ecosystem. Taking into consideration the value given by the developed world countries to the wind energy and the investments they make in this context, the investments and initiatives to be made in the context of protecting and developing the lands of our country spreading to a geography where four seasons are fully experienced and annual wind transitions are abundant are of great importance. Moreover, considering the criteria of developed countries, switching to such renewable energy plants in order to minimize the foreign dependency of the country's economy is considered as a great necessity of being considered advanced. Therefore, alternative energy and renewable energy sources should be used and facilities should be established.

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