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Research Article

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Determination of Suitable Areas in the Use of Renewable Energy Resources by Geographical Information System (GIS): The Case of Tekirdağ Province

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Abstract Recent increase in the energy usage proportionate to the increase in population, has directed people to renewable energy sources, which are sustainable and partially cleaner than non-renewable energy sources. With the help of Geographical Information Systems and Remote Sensing, decision of the location of renewable energy sources' establishments and power plant buildings can be made easily thanks to these technological developments' guidance.

In this study, wind energy from renewable energy sources is emphasized and one - year climate data obtained from meteorology, maps showing DEM (elevation - slope maps) and energy transmission lines and the location of wind power plants that can be established in Tekirdağ province are determined. Area determination was made by using Open Source QGIS software by entering data and coordinate overlaps.

Keywords Renewable energy sources, Geographic information systems, Wind energy, Wind power plant, QGIS

Introduction

The rapid increase in the world population and the developments in the technology that took place in parallel with this have led to more effective studies on the research and utilization of limited natural resources in order to meet human needs. However, the rapid increase of the population caused the same rapid decrease in natural resources. As a result of these situations, the role of technology is rapidly increasing in the determination of natural resources, their usage and ensuring environmental balances. As a result of advances in technology, Remote Sensing and Geographic Information System Techniques have been widely used in agriculture and energy.

As time goes on, with the rapidly developing technology and mechanization, the need for energy is constantly increasing. Fuels such as coal, oil and natural gas, which are classified as fossil fuels from underground sources, are used in supplying energy needs. However, in response to the ever increasing demand for energy, these fuels are expected to run out in the near future. In addition, while fossil fuels which are used in industrialization, damage on environment could easily be observed, renewable and clean energy sources should be investigated and studies should be carried out [1].

The use of wind energy, which is one of the renewable energy sources, has started to increase rapidly recently. Many countries in the world prefer wind energy as a result of these factors; the rapid implementation of the turbine installation, which can be used locally, continuously and has no raw material costs, is seen as a source of clean energy, is thought to reduce dependence on the outside. Various incentive for wind energy are applied in the world in order to be an alternative to non-renewable energy sources and to compete with fossil fuels. Along with these incentives, both an industry based on wind energy is formed and its usability is becoming widespread [2].

In this study, considering the energy consumption of Tekirdağ; The aim of this study is to determine the locations of the renewable energy sources, especially wind energy, by using open source geographical information systems. During the study, climatic data, Dem maps (slope - height data) and locations of energy transmission lines were easily taken into consideration and mapped by determining the places where wind energy can be used effectively.

Energy can exist in different forms around us. These are; electrical energy, nuclear energy, heat energy and chemical energy. The sum of the amount of energy in a closed system is always the same according to the first laws of thermodynamics and is known by the name of conservation of energy. In a more understandable way; it is not possible to produce energy from nothing or to destroy an existing energy. However, energy can be exchanged between the above-mentioned types [3].

The concept of energy can also be classified according to the sources from which energy is produced. In this classification, primary and secondary energy sources concepts should be emphasized. The primary sources of energy are, wood, coal, oil, natural uranium, natural gas, wind, water, solar, biomass, geothermal energy, etc. natural energy sources. Secondary energy sources are energy sources obtained by converting primary energy sources such as electricity and petroleum products. Primary energy sources are also classified in two ways as renewable and non-renewable (consumable). Among the primary energy sources mentioned above, wood, coal, crude oil, natural gas and uranium are the most common non-renewable energy sources. Wind, water (hydraulic), solar, biomass and geothermal energy are the most common renewable energy sources [4].

The increase in the contemporary requirements in parallel with the development of technology and the fact that this requirement will be met for two billion more people means that electricity consumption will increase gradually. Energy demand is expected to increase by sixty-five percent in developing countries and by thirty-five percent globally in 2040 compared to 2010 [5].

Wind energy is the most developed and most suitable type of trade for renewable energy sources. China is the country that uses wind most in electricity generation [6]. The positions of other developed countries are USA, Germany and Spain, respectively [7]. When called renewable energy sources in Turkey first thing comes to mind is hydropower. The total potential of our country in hydropower is 433 billion kWh/year [8].

Wind energy, one of the most important sources of natural wealth, has been used since ancient times. Its goals and technology have changed over time and its use has been disrupted. In this part of the study, wind energy will be examined in detail.

As a renewable, natural and clean power source, 1-2% of the sun is transformed into wind energy. The irradiation of solar energy, but not being able to heat each zone evenly, causes some differences in temperature and pressure and humidity, creating airflow. When this air flow creates pressure differences, the wind emerges. Wind varies in terms of time and region according to the geographical characteristics of the regions. In the study carried out by the World Energy Agency, it shows economic efficiency if the wind speed is above 5.1 m / s. RES can be applied in areas where wind speed is higher than 5.1 m / s. World wind energy technical potential is given as 53.000 TWh / year. At the end of 2016, the annual WP production in the world is 557 TWh / year and its share in the total energy production is 2.6%. It is stated that the installed capacity of WEPPs which are in operation at the end of 2017 is approximately 300 GW [9].

As a developing country, Turkey, the energy resources needed for sustainable development (hydroelectric, wind, solar, geothermal, biomass, such as wave and tidal) despite having the full terms of diversity, it is not sufficient amount of these resources. Therefore import of energy as well as need of energy is increasing day by day in Turkey. In order to meet Turkey's energy needs as in many developed countries, clean and external independent orientation to renewable energy sources has gained importance. According to the Wind Atlas of Turkey, even though wind speed display difference all our regions have a wide renewable energy sources [10].

Geographical Information Systems provide access to detailed information as a result of the classification of other data in connection with the information expressed with or without graphs, carrying out the arrangements, storing, preserving the information and evaluating the information contained in the system for specific purposes [11].

Determining the amount and distribution of existing agricultural areas in agricultural activities plays a major role in the better planning of the country's agriculture [12].

Materials and Methods

Tekirdag is one of the three cities where is in the northwest of the Sea of Marmara, is located in European continent, less hilly, is situated on land enriched with alluvium. Tekirdağ province is located on the coordinates of 26˚43 ’- 28˚08’ east longitudes and 40˚36 ’- 41˚31’ northern latitudes. It is surrounded by Istanbul to the east, Edirne and Çanakkale to the west, Marmara Sea to the south and Kırklareli to the north and the Black Sea with a short coast.

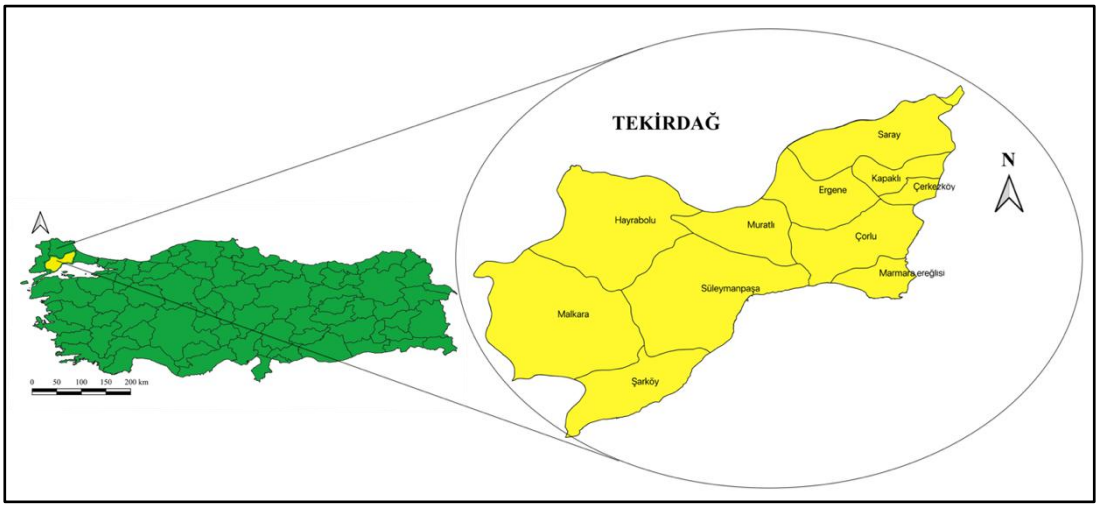

Figure 1: Research area

Tekirdağ, as the location is located in the northwest of Turkey. The districts of Tekirdağ province are; Çorlu, Kapaklı, Çerkezköy, Saray, Hayrabolu, Muratlı, Malkara, Marmara Ereğlisi, Şarköy and Ergene. Considering its location within the borders of the country, Tekirdağ has a very convenient location. In addition to being adjacent to Istanbul, Kırklareli, Edirne and Çanakkale, it has borders both to the Sea of Marmara and the Black Sea. This situation makes Tekirdağ advantageous in many areas such as transportation and trade. Despite similar features of the Mediterranean climate throughout the province, the presence of terrestrial climatic characteristics is observed as it progresses towards its inner parts. In the Black Sea borders, the presence of the elements of the Black Sea climate is remarkable. Cold winds blowing from the north cause temperatures to decrease throughout the province.

The total power of the power plants established throughout the province is determined as 1,589 MW. This power generation has been reached by 34 electric power plants. The average annual energy production is 8,194 GW. This electricity is obtained from natural gas and wind power plants.

Using the open source GIS software QGIS, the slope, rug index, shading, appearance and relief maps of the study area were created and the topographic features of the study area were extracted. In the creation of these maps, the Digital Elevation Model (DEM) map with a resolution of 5 meters was used.

Within the scope of the study, the slope, aspect and direction distributions from topographic maps are presented by classifying with the help of QGIS 3.4 software based on vector-specific maps covering Tekirdağ province.

In determining the location of wind power plants, determining the wind potential of the region where the power plant will be installed is of utmost importance. It is envisaged that the installed power plant will have a wind speed above 7 m / s in order to provide the necessary efficiency [13].

Wind speed data for the study were obtained by using climate data (for 2015-2016) obtained from the General Directorate of Meteorology.

Slope and rough areas prevent wind energy from stable wind regime. During the study, a slope map was prepared for Tekirdağ province using DEM data.DEM data can be created mainly ‘.img, .tiff ’ and many other formats.

It can also be stored in Spatial Databases in Raster data format and easily integrated into existing GIS data. Distance to Energy Transmission Lines was determined by using TREDAŞ data.

Monthly average wind speed was determined from the climate data obtained from the meteorology and total average values were subtracted and the values were created in the station point geometry and the values were entered into the program. Then, the distribution map of the wind speed was created by interpolation method.
Using slope analysis in QGIS program, the elevation and slope maps of Tekirdağ were determined [14].
Weighted total coating was performed for conformity analysis and several weighted raster layers were used for calculation. For GIS Overlay analysis, Booelan logic (using conditional expressions in input layers to generate conformity maps) was used. Then, with the scoring system, the required location calculation was made by giving 10 points to the places where the elevation values are higher and the slope values are flat and close to the level, which are necessary for the wind energy installation areas. As a result, in the QGIS Program, weighted sum raster analysis was applied and the appropriate field selection was made by overlapping with Raster format data.

Results & Discussion

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Elevation and slope maps of Tekirdağ province were created and evaluated by using digital height data (DEM) and vector based maps together with QGIS free software (Figure 2 and 3).

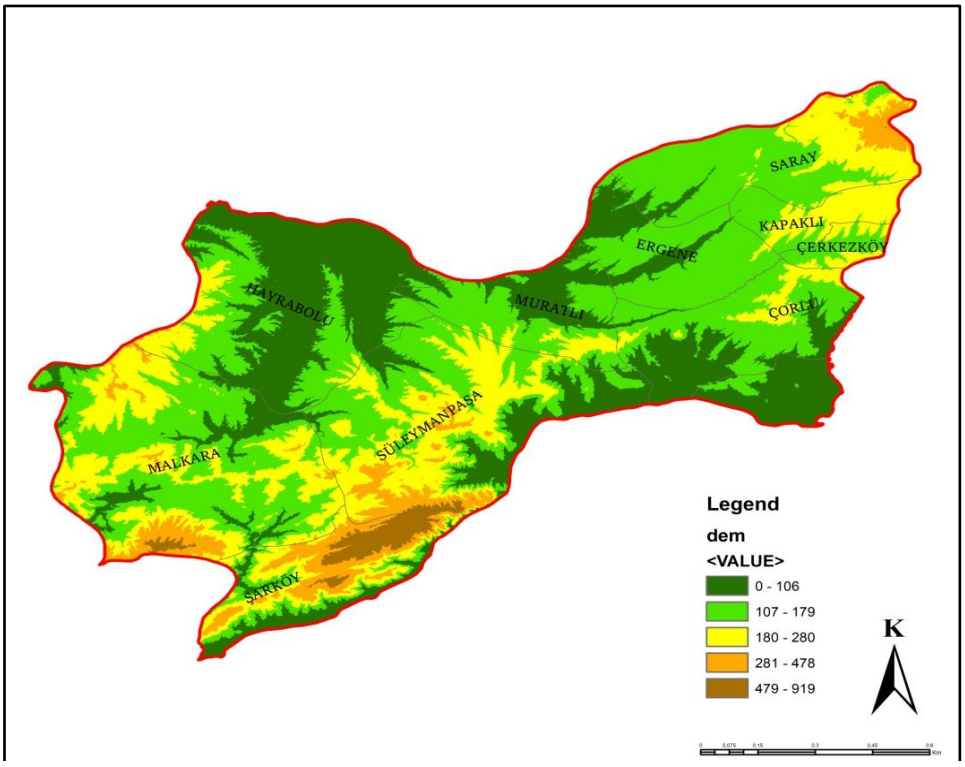

Figure 2: Elevation map of Tekirdag province

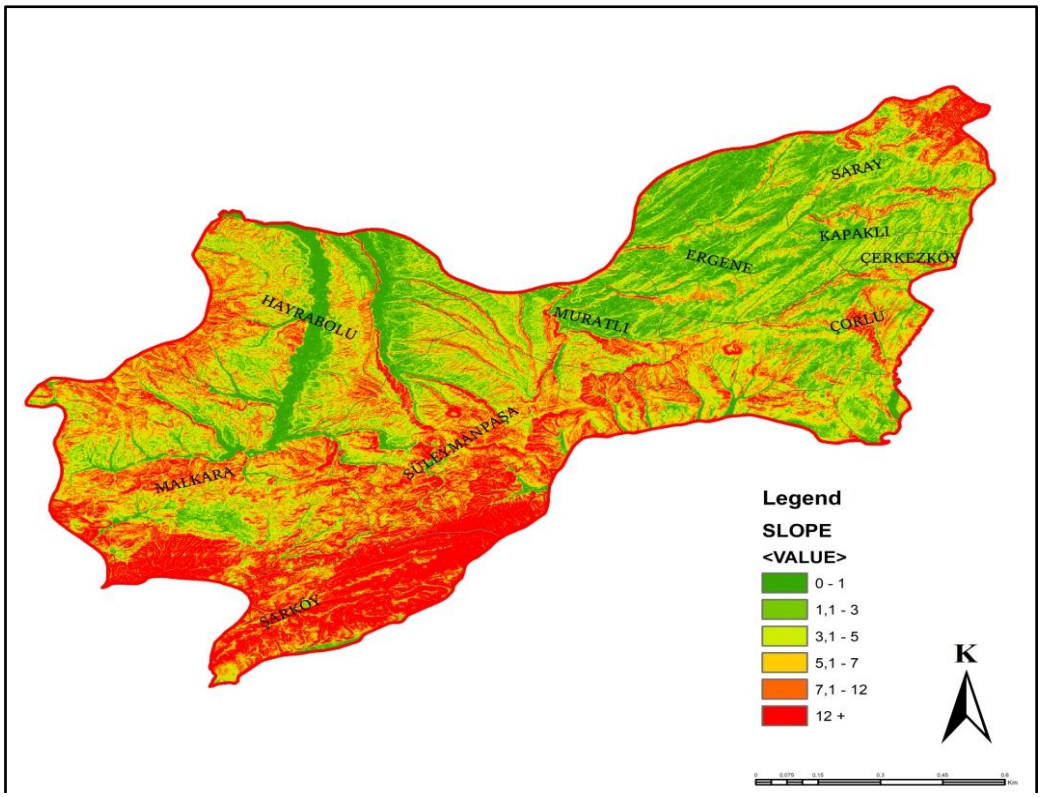

Figure 3: Slope map of Tekirdag province

The wind speed potential of Tekirdağ Province is shown in Figure 4.

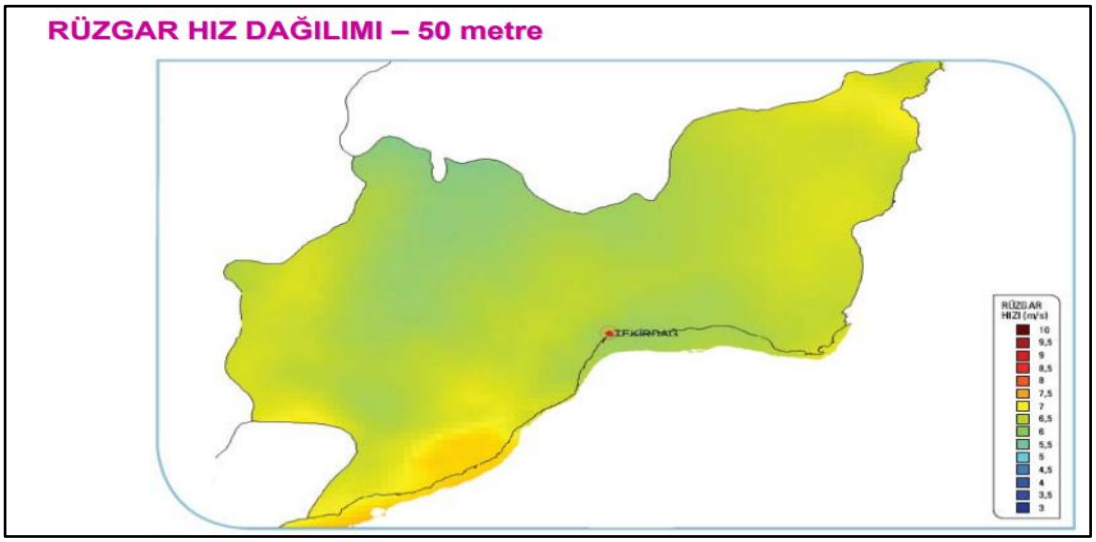

Figure 4: The wind speed potential of Tekirdağ Province

Distance to Energy Transmission Lines was determined by using TREDAŞ data. The current power transmission line for Tekirdağ is shown in Figure 5. From the climate data obtained from meteorology for Tekirdağ province, the distribution map of the wind speed generated by the interpolation method was calculated. The results obtained are processed with QGIS software and the areas where wind power plants can be established in Tekirdağ are determined and given in Figure 6.

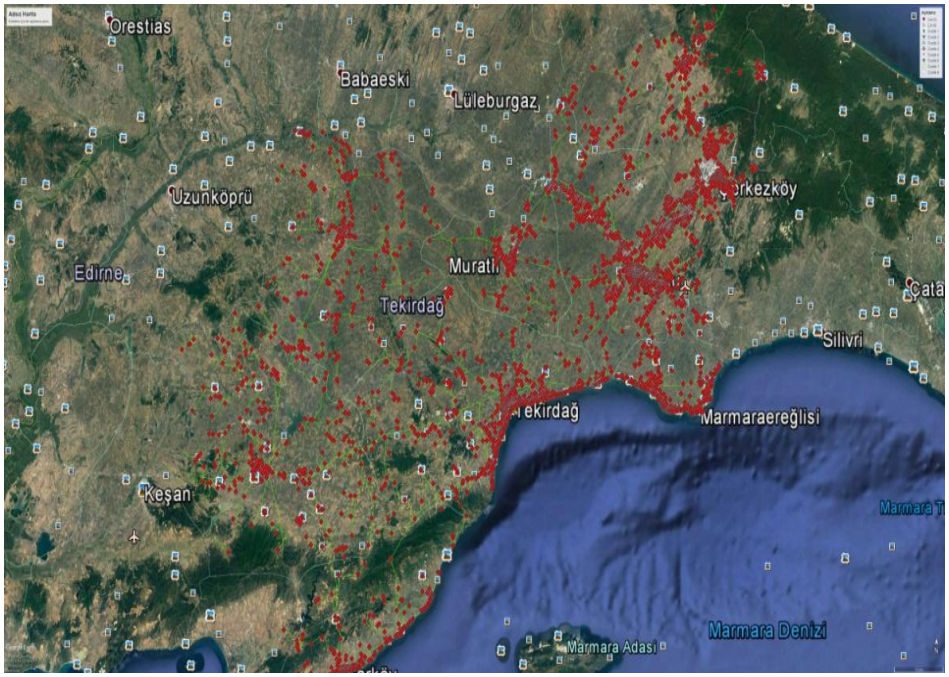

Figure 5: Power transmission line mapofTekirdağ province (TREDAŞ)

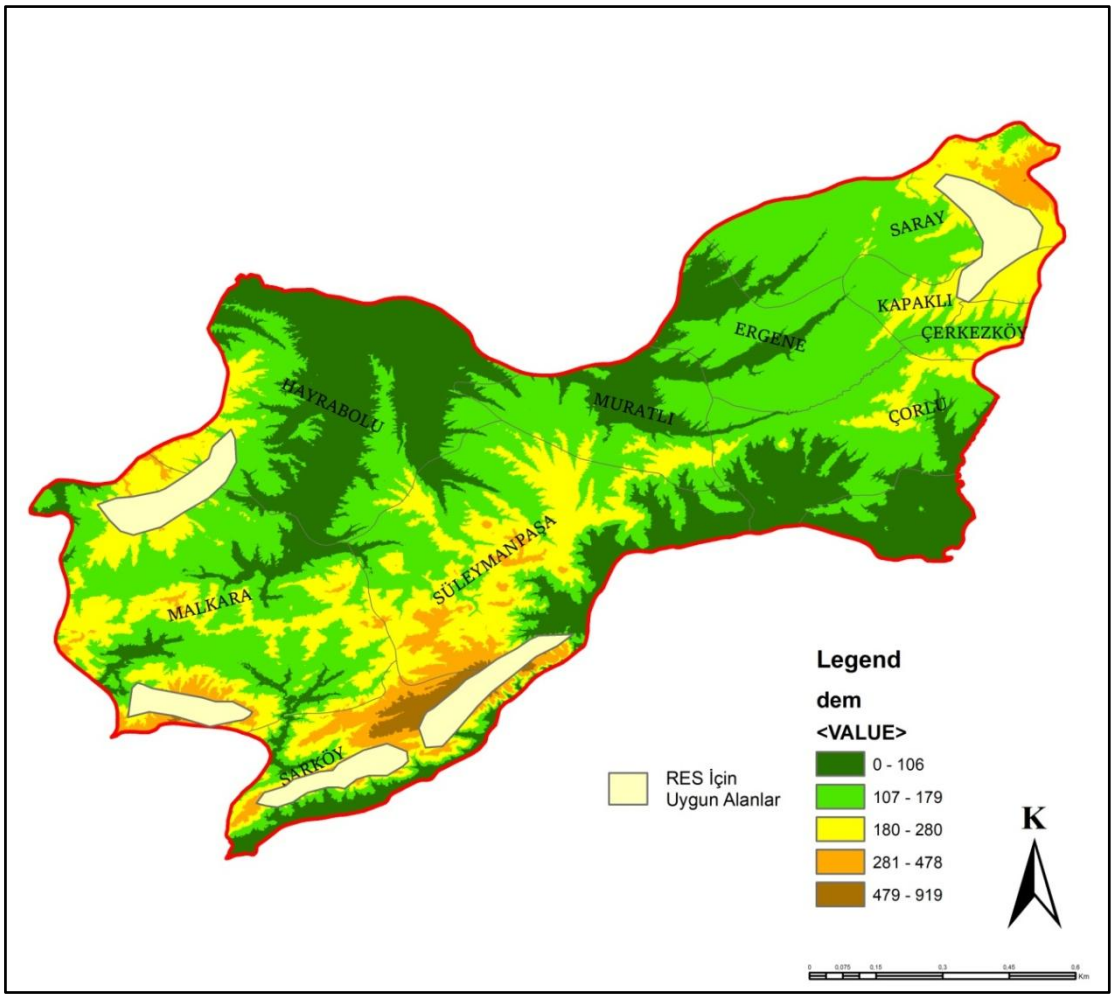

Figure 6: Areas where wind power plants can be installed in Tekirağ province

Conclusion

With this study, the determination of the areas where the power plant can be established by integrating the geographic information systems which are inevitable to be used with the developments in technology in the same way as the wind energy, which is now being used widely and is deemed necessary, has been made by using a few data.

All these studies and the use of geographic information systems have served as an example of the effective use of renewable energy resources in the region.

By updating the information on geographic information systems, especially on open source software, it has been shown that there is no need for an external source to determine renewable energy resources' locations.

As a result; 41 ve24'39.40 "N, 28 °02'42" E of the Saray and Kapakli Districts, 40° 39'51.24 "N of the Sarkoy District, 27° 11 '05.61" E 40°49'18.81 "N of the District of Suleymanpasa, 26° 56' 39.86" E of the District of Malkara As a result of the studies carried out with QGIS at 40°45'53.91 "N, 26° 51 '18.49" E, Hayrabolu District 41"7' 24.03 "N, 26° 56 '39.86" E latitude and longitude, it was determined that a wind power plant could be installed.

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