Small Wind Turbine And PV Power System Environmental Outcomes

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Abstract

Küresel ısınmadaki artış, petrol pazarındaki enerji kullanımı ile ilişkilidir. Bu temel iki nedenden dolayı bu tür enerji kullanımını azaltmak için hükümetler ve üretim şirketleri alternatifler aramaktadırlar. Çevre Koruma Ajansı (EPA) 2010 çalışması gösteriyor ki 1700'lü yıllardaki sanayi devriminden bu yana Atmosferdeki CO_2 emisyonunun % 35 oranında arttığı tespit edilmiştir (İklim Değişikliği - Sera gazı emisyonları, 2010). Günümüzde, yenilenebilir enerjideki gelişmeler ve kullanımı enerji güvenliğini, çevre korumayı güçlendirerek tüm dünyada iklim değişikliği ile mücadele için önemli bir strateji halini almıştır [1].

Bu çalışma, Muğla Sıtkı Koçman Üniversitesi Muğla Meslek Yüksekokulu ana bina çatısı üzerinde kurulu olan 400 Watt gücündeki küçük rüzgar türbini ve 280 Watt gücündeki PV hibrid sistemin Muğla iklim şartlarında üretilen elektrik enerjisinin incelenmesi ve çevreye etkileri çalışmalarını kapsamaktadır. Çalışma zaman aralığı olarak 4 Nisan – 2 Haziran/2016 tarihleri arasındaki rüzgar türbini ve PV güç sistem çıkışı olan dc akım, gerilim, güç değerleri ile inverter çıkışı olan ac akım, gerilim ve güç değerlerinin incelenmesini içine almaktadır.

The increase in global temperature and the volatility of the petroleum oil market share is a common factor in energy use. These are two of the principal reasons for governments and manufacturing companies to seek alternatives to reduce energy use. The Environmental Protection Agency (EPA) 2010 study on CO_2 emissions demonstrates that since the Industrial Revolution in the 1700s the concentration of CO_2 in the Atmosphere has increased by 35% (Climate change-Greenhouse gas emissions, 2010). Nowadays, the utilization and development of renewable energy has become an important measure to safeguard energy security, strengthen environmental protection, and tackle climate change all over the world [1].

This study includes a study of the analysis of the electricity generated by a small wind turbine of 400 watts, and a hybrid PV system of 280 Watt, which were installed on the roof of the Main Building of Mugla Vocational School at Muğla Sıtkı Koçman University 5 months ago, and their environmental impacts under the climate conditions of Muğla province. This study contains the analysis of dc current, dc voltage, dc power of the wind turbine and PV system output values, and the analysis of ac current, ac voltage, ac current, ac power of the inverter output values between the time span of the 4th April and 2nd June, 2016. Furthermore, the range of applications will be analyzing the wind data of months, as well.

Key words: Small Wind Turbine, PV System, Environmental Outcomes.

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1. Introduction

Efficiency in coal-fired power generation will play an important role in the future production of electricity. This is particularly the case with the potential of higher efficiency power generation to reduce CO_2 emissions. Improving efficiency levels increases the amount of energy that can be extracted from a single unit of coal. Increases in the efficiency of electricity generation are essential in tackling climate change. A one percentage point improvement in the efficiency of a conventional pulverized coal combustion plant results in a 2-3% reduction in CO_2 emissions. Highly efficient modern supercritical and ultra-supercritical coal plants emit almost 40% less CO_2 than subcritical plants. The power of the wind, the sun and other renewable resources are an increasingly important part of the world's energy mix. The push towards renewable is being driven by energy security as well as climate change concerns. Renewable energy offers a greater level of self-sufficiency with reduced dependence on outside fuel sources. But it also introduces greater volatility into energy availability and poses significant financing and, in the case of offshore projects, capital project challenges [2].

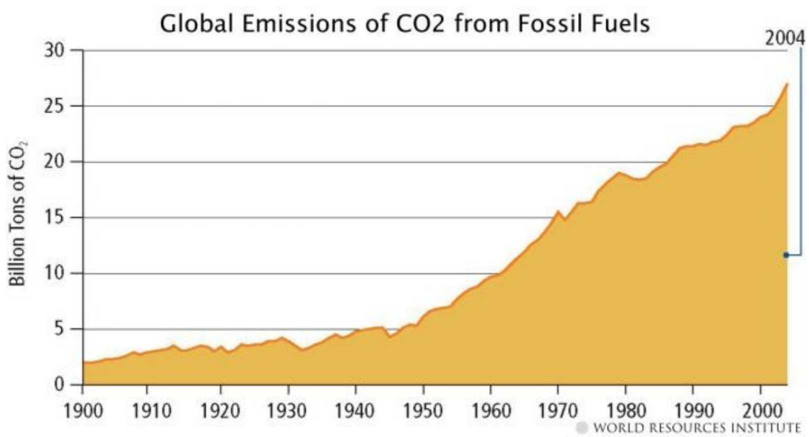

Figure 1. Global CO_2 emissions from fossil fuels [3]

Turkey has quite low amounts of oil and almost no natural gas reserves. Turkey's 270 million barrels of proven oil reserves are enough to satisfy only 8% of oil needs [4]. Thus, significant amount of oil and natural gas are imported from the Middle East, Iran, Russia and few other sources. Turkey is dependent on oil and natural production as primary energy supply and to produce electricity; therefore, it is considerably dependent on outside sources, which undermines the national security. In 1970, 77% of the total primary energy consumption was met by indigenous energy sources, this percentage decreased to 28% in 2003. In comparison, the share of resources in primary energy consumption decreased steadily in the years from 1980-2006; RE could meet 35% of the energy need in 1970, whereas it covered only 10% in 2010 [5]. Together with increasing energy consumption, air pollution gives a justifiable ground to develop more RE, especially for the cases of geothermal energy, solar energy and hydropower [6]. Despite being energy poor, Turkey has hit her to shown little interest in taking advantage solar and wind are considered as the most preferred renewable energy sources for their availability and in exhaustibility. But because of periodic characteristics of natural resources, it has been a challenge to generate a highly reliable power with PV (photovoltaic) modules or wind turbines. To solve this problem, intermediate energy sources can be used to reduce power production fluctuations [7]. Turkey imports much of its energy, and in 2012 this amounted to more than $60 billion. Improving energy efficiency and energy security are high priorities. Plans for nuclear power are a key aspect of the country's aim for economic growth, and it aims to cut back its vulnerable reliance on Russian and Iranian gas for electricity. The Ministry of Energy and Natural Resources (ETKB) projects 2020 electricity production as possibly 499 TWh in a high scenario of 8% growth, or 406 TWh with a low one with 6.1% growth [2]. With the rapid population and social development, Turkey's energy demand continues to grow during a particular long period of time. Besides, energy resources and environmental issues have become increasingly prominent in Turkey's power sector. Hydroelectricity power, wind power development has entered an all-round development stage, as well as geothermal power generation in Turkey [8].

2. Muğla Wind and Solar Energy Potential

In Muğla, The demand for energy is increasing for decades because of the population growth and the tourism development. For each of the two energy sources (wind and PV power); Energy source solar radiation differentially absorbed by earth surface converted through convective processes due to temperature differences air motion. Wind is atmospheric air in motion. Wind energy is the fastest growing energy source in the world and wind power is one of the most widely used alternative sources of energy today. It is a clean and renewable source of electricity. Economic development requires increasing amounts of energy. The total surface area of Muğla is 13.400 km². The population of the region is increasing up to three million in the summer because of the high tourism activities. The region has also a pollution problem. There are three coal power plants. These coal-fired power plants are the main source of atmospheric emissions in the region. This pollution may cause human diseases and environmental problems. Wind is "air in motion", especially natural and perceptible movement of air parallel to or along the ground. In the Muğla region, the annual average wind speed ranges between 3.5 and 8.5 m/s. The wind speed is highly dependent to the elevation level of the station. Localization and digital elevation model of study area [9].

Fig. 2.shows wind speed map for Muğla (REPA-50m). According to the map, in central location of Muğla, average wind speed is 7 m /s. Muğla has a high potential for wind energy.

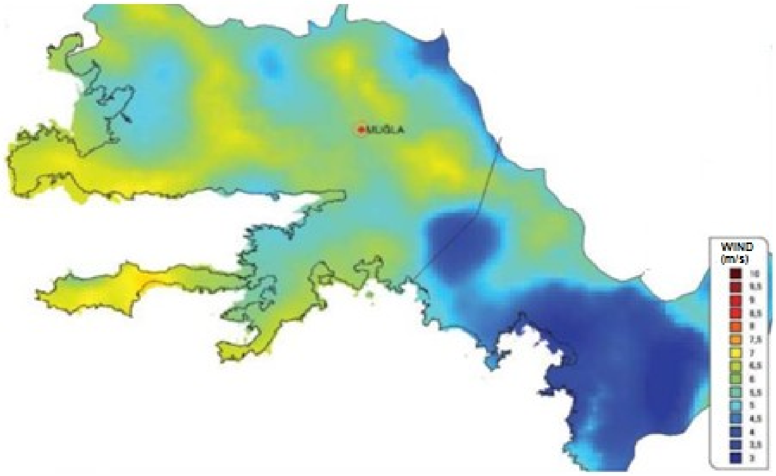

Figure 2. Wind speed map for Muğla (REPA-50m) [10]

Every day, the sun radiates (sends out) an enormous amount of energy. It radiates more energy in one second than the world has used since time began. This energy comes from within the sun itself. Like most stars, the sun is a big gas ball made up mostly of hydrogen and helium atoms. The sun makes energy in its inner core in a process called nuclear fusion. Solar energy can also be used to produce electricity. Two ways to make electricity from solar energy are photovoltaic systems and concentrated solar power systems [11].

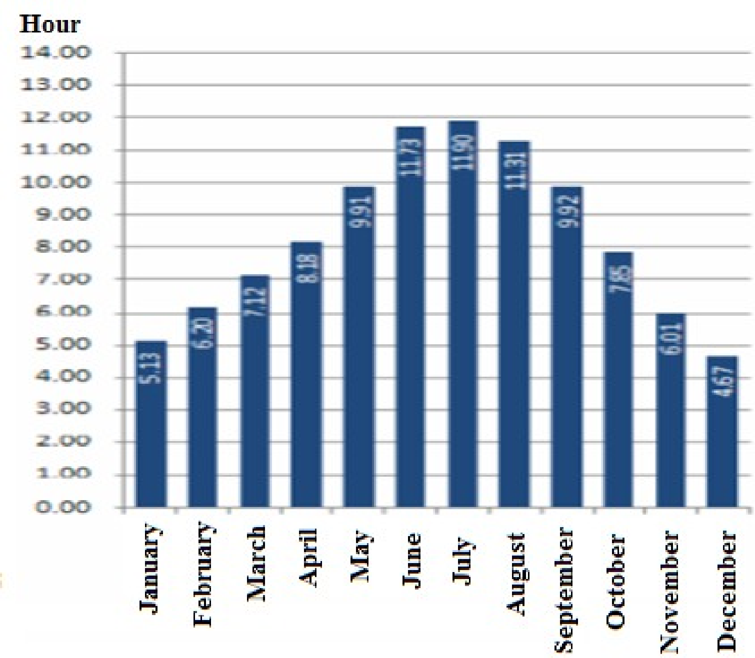

Figure 3. Muğla sunshine duration values (hour) [12]

Solar cells are made of a thin piece (called a wafer) of silicon, the substance that makes up sand and the second most common substance on Earth. The top of the wafer has a very small amount of phosphorous added to it. This gives the top of the wafer an excess of free electrons. This is called n-type silicon because it has a tendency to give up electrons, a negative tendency. The bottom of the wafer has a small amount of boron added to it, which gives it a tendency to attract electrons. It is called p-type silicon because of its positive tendency. When both of these chemicals have been added to the silicon wafer, some of the electrons from the n-type silicon flow to the p-type silicon and an electric field forms between the layers. The p-type now has a negative charge and the n-type has a positive charge. When the PV cell is placed in the sun, the radiant energy energizes the free electrons. If a circuit is made by connecting the top and bottom of the silicon wafer with wire, electrons flow from the n-type through the wire to the p-type. The PV cell is producing electricity—the flow of electrons. If a load, such as a light bulb, is placed along the wire, the electricity will do work as it flows. The conversion of sunlight into electricity takes place silently and instantly. There are no mechanical parts to wear out [11].

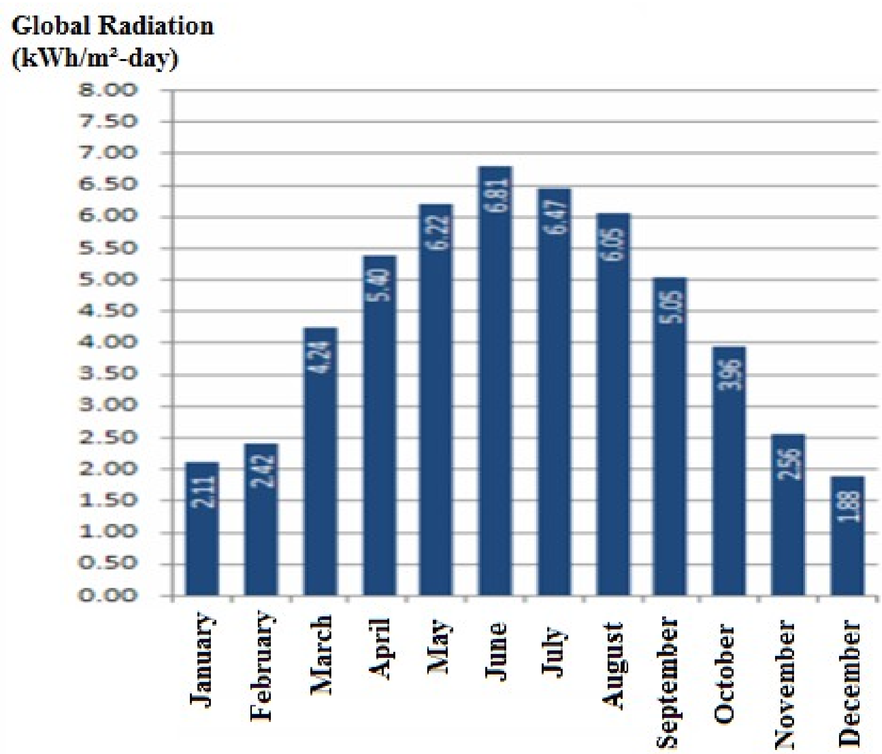

Figure 4. Muğla global radiation values (kWh/m²-day) [12]

3. Small Wind Turbine And PV Power System

Small wind power systems, small wind turbine and PV (hybrid) energy systems, along with other energy producing systems, can be applied in the houses, farms and in the areas away from the transmission lines.

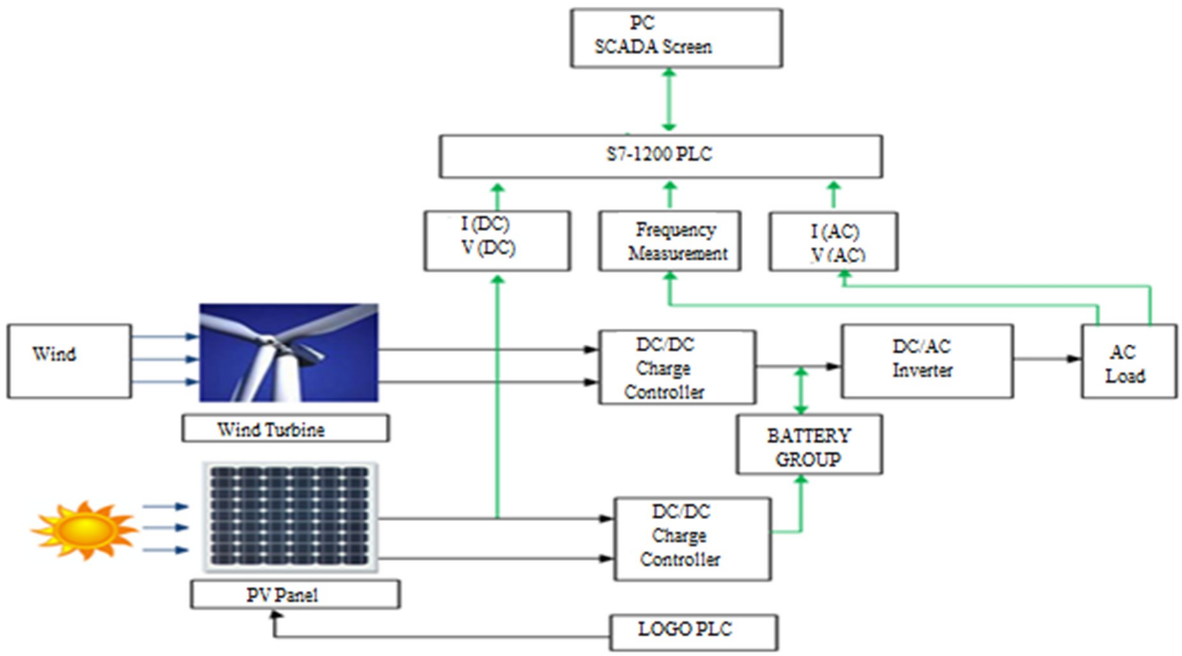

Figure 5. Small wind turbine and PV power system application block diagram

This study was conducted between 4th April and 2nd June in 2016. The parameters of dc current, dc voltage, dc power outputs of the wind turbine and PV system outputs, and ac current, ac voltage, ac power values of the inverter outputs were analyzed. Besides, the range of applications will be analyzing the wind data of December, January, and February. The measurements conducted in the application are shown in figure 5.

Table 1. Wind measurement data

	Direction (°)	Wind1avg (m/s)	Wind1max (m/s)	Wind1std (m/s)	Batt (V)
December	191.35	5.38	7.64	1.41	3.20
January	183.17	5.81	8.22	1.52	3.11
February	185.61	6.49	8.85	1.51	3.06
Average	186.71	5.89	8.24	1.48	3.12

The wind measurements (of December, January and February) are indicated in table 1. according to these data, the wind direction varied between 183.17°and 191.35°. In the application area, it was determined that the wind direction did not change much. Besides, the wind speed was measured respectively, average was 5.89 m/s, and the maximum was 8.24 m/s, while and the steady was 1.48 m/s. The Wind turbine needs 3.5 m/s wind speed in order to produce electrical energy. Considering the average wind steady, it was determined that wind was not sufficient in the application area.

Table 2. Small wind turbine and PV power system electrical measurement data

	PV (V)	PV (A)	PV (W)	WIND (V)	WIND (A)	WIND (W)	BATT (V)	AC (V)	AC (A)	AC (W)	AC (kWh)
April	25.39	3.81	96.84	24.98	1.45	36.22	25.26	224.90	0.28	62.01	6.79
May	26.33	4.61	121.29	25.08	1.37	34.46	25.71	225.34	0.27	59.77	5.71
Average	25.86	4.21	109.06	25.03	1.41	35.34	25.48	225.12	0.27	60.89	6.25

The Small wind turbine and PV power system electrical measurement data (April and May) are given in table 2. According to the data in terms of PV voltage, PV current, PV power, wind voltage, wind current, wind power, AC power varied respectively between 25.39 and 26.33, 3.81 and 4.61, 96.84 and 121.26, 24.98 and 25.08, 1.45 and 1.37, 36.22 and 34.46, 62.01 and 59.77. It was determined that the electrical measurement data did not change much in the small wind turbine and the PV power system. In April, electricity production value was lower than the one in May. In April, electricity consumption value was determined to be higher than the one in May. The energy generated by PV power was noted to be higher than the wind energy production in the application area.

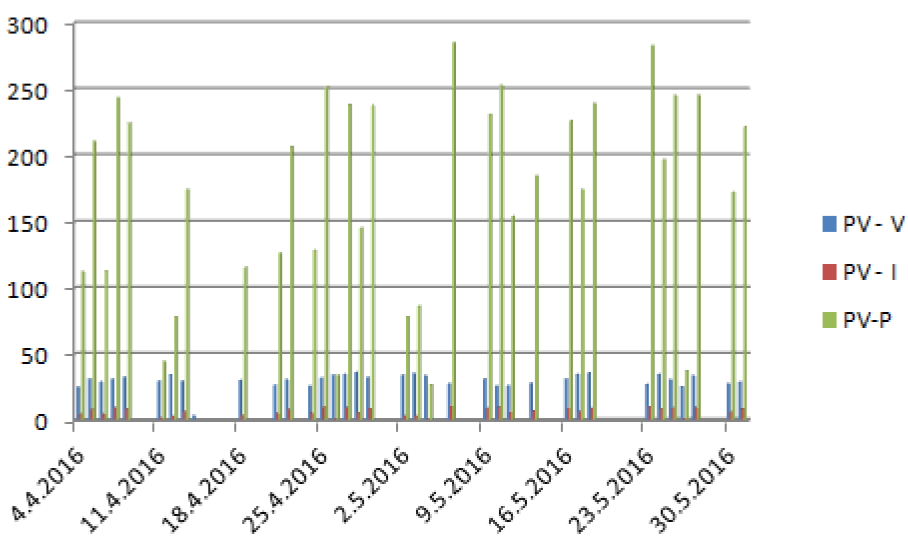

Figure 6. PV power system voltage, current and power chart

In Figure 6., the PV power system values are shown in chart.

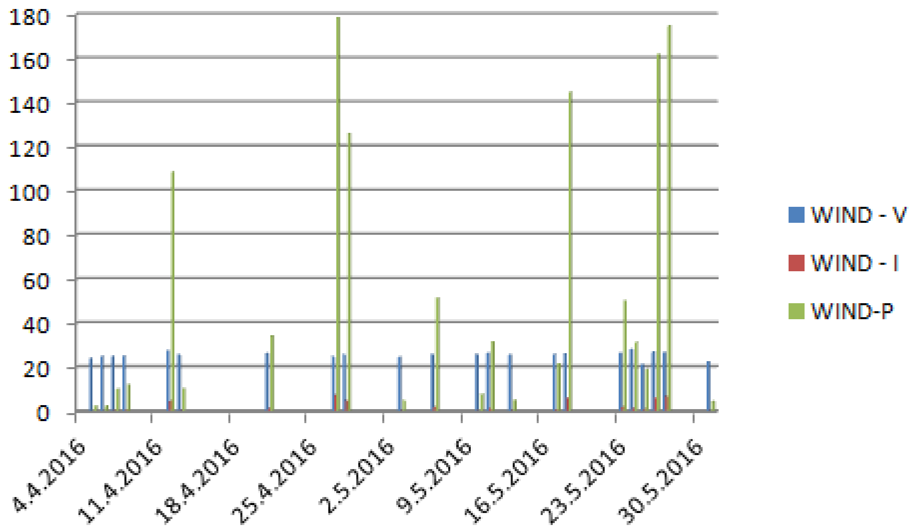

Figure 7. Small wind power system voltage, current and power chart

In Figure 7., Small wind power system values are shown in chart.

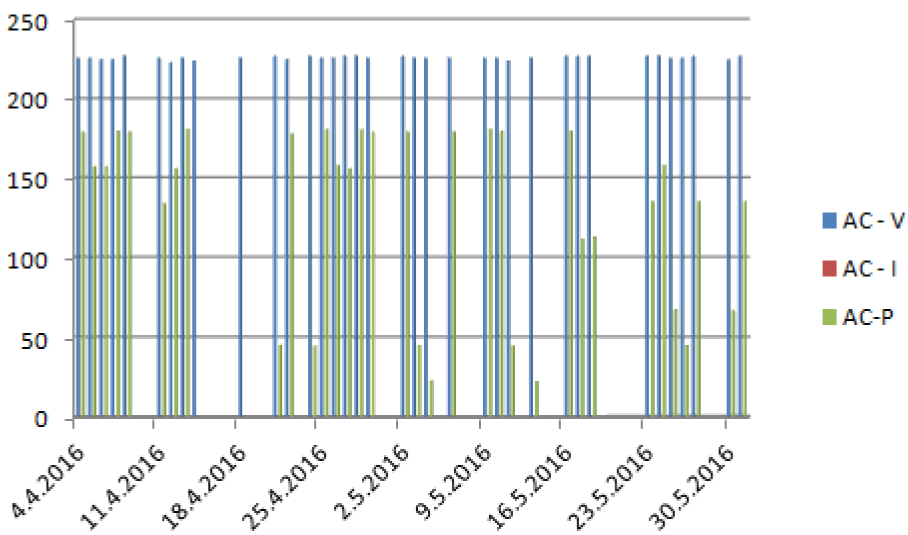

Figure 8. AC load voltage, current and power chart

In Figure 8., AC load values are shown in chart.

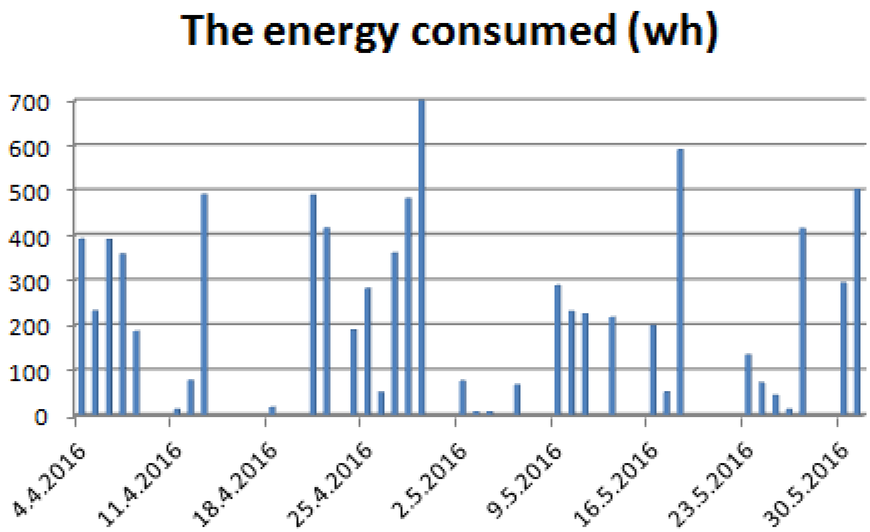

Figure 9. AC load energy consumption chart

In Figure 9., AC load energy consumption values are shown in chart.

4. Results and Discussions

In this research, electrical parameters and electricity production values of the small wind turbines and PV power system were measured and compared. Small wind turbines and PV power systems were found to be higher between May and April in terms of electricity generation. The efficiency of the PV power system was found to be higher than that of the wind power system in the application area. Therefore, preference of PV power systems will increase the productivity. If local government wants to reduce the air pollution and CO_2 emissions, PV power system installations should be encouraged in Muğla city center.

5. Conclusion

- The wind speed was measured average was 5.89 m/s, and the steady was 1.48 m/s. Considering the average wind steady, it was determined that wind was not sufficient in the application area.
- The Small wind turbine and PV power system electrical power measurement data average is varied PV power 109.06 W, wind power 35.34W. The energy generated by PV power was noted to be higher than the wind energy production in the application area.
- Energy production surpluses can be transmitted to grid systems at night; and consequently, this will generate extra revenue.

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