BURSA ULUDAĞ ÜNİVERSİTESİ ZİRAAT FAKÜLTESİ DERGİSİ
Journal of Agricultural Faculty of Bursa Uludag University
e-ISSN 2651-4044
https://dergipark.org.tr/tr/pub/bursauludagziraat
http://www.uludag.edu.tr/ziraatdergi
Aralık/2021, 35(2), s. 313-332

ARAŞTIRMA MAKALESİ RESEARCH ARTICLE

Geliş Tarihi (Received): 31.03.2021
Kabul Tarihi (Accepted): 18.06.2021

Meeting Local Energy Requirement from Wind Energy in Areas without Grid: Northern Mesopotamia

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Abstract: In this study, it has been investigated whether the electrical energy needs of the agricultural plant, which have minimized their production range due to network deprivation in the Southeastern Anatolia Region (Northern Mesopotamia), can be met locally with small wind turbines to increase their product range. Turkey's largest development project in the Southeastern Anatolia Project (GAP), the topography where Tigris and Euphrates Rivers exist was investigated. Data from 24 meteorology stations in nine cities and their speed and direction data, Wind Energy Potential Atlas of the Renewable Energy General Directorate, and satellite images were analyzed simultaneously. In line with the information obtained, the wind characteristics and energy potential of the region have been determined. Also, considering the wind characteristics presence, possible power, and energy values from the small wind turbines that have been chosen as representative are presented. Finally, the capacity factors and the costs of these wind turbines have been compared, and their economic and technical installability has been examined.

Keywords: Wind energy, capacity factor, small wind turbines, northern mesopotamia, cost, agricultural incentives.

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Atıf/Citation: Bencuya İpekçioğlu, R.G., ve Vardar, A. 2021. Meeting Local Energy Requirement from Wind Energy in Areas without Grid: Northern Mesopotamia. *Bursa Uludag Üniv. Ziraat Fak. Derg.*, 35(2), 313-332.

Şebeke Bulunmayan Alanlarda Lokal Enerji İhtiyacının Rüzgar Enerjisinden Karşılanması: Kuzey Mezopotamya

Öz: Bu çalışmada, Güneydoğu Anadolu bölgesinde (Kuzey Mezopotamya) şebeke yoksunluğu sebebiyle üretimleri aksayan veya sınırlı kalan tarım tesislerinin elektrik enerji ihtiyaçlarının lokal olarak küçük rüzgar türbinleri ile karşılanabilirliği araştırılmıştır. Bölge olarak, Türkiye'nin en büyük kalkınma projesi olan Güneydoğu Anadolu Projesi (GAP) kapsamında olan Dicle ve Fırat nehirlerinin bulunduğu topografya ele alınmıştır. Toplam dokuz şehirdeki 24 meteoroloji istasyonuna ait veriler, Yenilenebilir Enerji Genel Müdürlüğüne ait Rüzgâr Enerjisi Potansiyel Atlası ve uydu görüntüleri eş zamanlı olarak incelenmiştir. Elde edilen bilgiler doğrultusunda öncelikle bölgenin rüzgâr karakteristikleri belirlenmiştir. Çalışmada ayrıca rüzgâr karakteristikleri dikkate alınarak temsili olarak seçilmiş küçük rüzgâr türbinlerinden muhtemel elde edilecek güç ve enerji değerleri ortaya konulmuştur. Son olarak da söz konusu rüzgar türbinlerinin kapasite faktörleri karşılaştırılmış ve ekonomik olarak kurulabilirlikleri irdelenmiştir.

Anahtar Kelimeler: Rüzgar enerjisi, kapasite faktörü, küçük rüzgar türbinleri, kuzey mezopotamya, maliyet, tarımsal teşvikler.

Introduction

The world has undergone a great change with the industrial revolution. The raw materials in nature have started to be valued and shaped. It caused the need of increase for energy and raw materials. The concept of distance has been replaced to the concept of globalization (Doğan, 2013). After the Ottoman conquest of Istanbul, the Crusades and the First and Second World Wars caused the spread of technology and technological breakthroughs all over the world. Competition in the energy market has increased with the disappearance of colonialism by the Wilson principles. The radical divergence of the world from colonialism and the economic distress in accessing the workforce have also triggered industrialization. Engines and machines have started to replace unskilled workers. Employment quality has changed, and this has been the engine of increasing the level of the knowledge. Operating these devices was easier than hiring people. Conventional sources, the sources that made concrete energy access by easiest since then and today, have been identified as the primary energy source. Since renewable energy sources that are free in nature are discontinuous, people have adopted fossil fuels as the primary source of energy in the industrialization process. During this period, there have been many ecological changes in the world and the world has started to get populated. Production, consumption and therefore pollution increased as the world population increased. Global warming, melting of glaciers, and deterioration of ecological balance were ignored. Competition has started to increase and access to raw materials and fuels that are sources of energy was no longer easy. However, the oil crisis in 1973 has thrown off one's balance established on conventional power, bringing up the issue of "renewable energy sources and diversification of energy sources".

Historians state that there were mills for irrigation in Mesopotamia at the time of Hammurabi, King of Babylon in the 1700 BC (Before Christ). In addition to this, various documents related to the history of using wind power through circular moving mills, namely turbines, are encountered. It is estimated that the oldest wind power machine, the windmill, was built near Alexandria 3000 years ago (Shepherd, 1990). The use of wind power passed into the Western world around the 10th century. The products of this periodic technology's transition from east to west are first encountered in England in the 11th and 12th centuries. AD (Anno Domini) In the late 19th century and in the 20th century AD practices such as drawing water from the well and obtaining electricity with windmills emerged (Hayli, 2001). It is known that wind energy was used in Iran in 700 BC, long before the energy crisis occurred in 1973. Following the industrial revolution, the use of this energy source for electricity production was delayed until the near future due to interruption. There are several reasons for this discontinuity. First of all, the wind is an intermittent source and the superiority of fossil fuels in this regard is the main reason for this delay. This situation led to the development of clean energy technology and, thus, a new energy market. Today, the subject of "independent energy", where all needs are met with renewable energy sources, is on the agenda.

Renewable energy sources classified as wind, solar, biomass, geothermal, hydroelectric, hydrogen, wave energy is called as clean energy. "Wind energy" on which we are talking about is one of the most accessible sources in Turkey, located in the middle climate zone, where four seasons are experienced and surrounded by seas on three sides.

According to the Global Wind Energy Council (GWEC) 2019 report; After the 63.8 GW power installation of 2015, the wind energy sector showed the second biggest wind energy installation breakthrough in the world in 2019 with a 60.4 GW installation and the cumulative wind energy capacity increased to 651 GW. It is reported that the installation performance of the sector is 100 GW/year, but this performance has not been reached yet. Compared to the past twenty years, the newly established gas and fossil-related energy facility cost are comparable to wind and solar power plant installation costs. It is anticipated that it will become less costly in the next decade. In such a case, wind energy will be the cheapest energy source to stop environmental pollution and CO2 emissions. As it approaches at the 2030s, wind energy is expected to compete economically, and the annual installation potential of the sector is expected to be evaluable. For the GWEC 2020 projects, a 1-2-month delay is foreseen due to the COVID-19 pandemic. However, due to the pandemic recession, it is reported that there will be a current publication for the 2020-24 projection (Anonymous, 2020a).

On the other hand, according to the report for January 2020 of Turkey Wind Energy Association (TUREB): operating Wind Power Plant (WPP) capacity of 8056 MW and which is under construction WPP capacity of 1309.8 MW as specified (Anonymous, 2020b).

It is not known how the leaders (China and the United States) of the wind power industry is affected by the COVID-19 pandemic. Also, it is not known how the sectors will be affected when the pandemic disappears entirely, and the markets get back in circulation.

It is stated that in the future scenarios of economists, China has 16% of the global economy. Cause of late pandemic precautions of pandemic experienced in the first quarter of 2020, the sectors are locked in the world, many people became unemployed, and the supply & demand curve decreased. It will take time to return to normal (Even if China normalizes its supply by producing, it will take time for global demand to increase to a reasonable level). It is expected that the average economic growth will be 3.5% lower because of this situation, which especially affects the entire service sector and supply chain (It should be noted that the main source of global production of many clean energy technologies is from China). Looking at the data in the first two months of 2020, infrastructure investments of the countries decreased by 30% compared within previous years. On the other hand, it is stated that the cost of each month when pandemic measures are prolonged will be 2.0-2.5% (Fernandes, 2020).

Not all sectors will be affected equally by the pandemic. The restriction of the industry and the basic requirements will create a new balance during the epidemic.

When the factories are reopened, production curves will be “V” or “U”, and there will be ups and downs. The primary indicator of this situation is energy and raw material prices. Even if investment and gross national product (GNP) growth in exporter countries decrease, falling energy and raw material prices are potentially favorable for exporters, commercial users, and consumers. Besides, it is assumed that money markets will react with the tendency to soften the global economy (Mann, 2020).

They were locking the sector due to the pandemic, McKibbin and Fernando (2020) foresight that the energy sector in Turkey will remain under the influence of a shock 37%. However, according to Spitzmueller et al (2020) issue; it may be too early to predict that “Environmental, Social and Governance” (ESG) initiatives and their sustainability priorities for renewable energy for the energy industry may change over the next few months. Changes for the energy industry to predict renewable energy, due to the ongoing COVID-19 pandemic and low oil prices, However, even in times of turmoil, the energy industry and ESG have been shown to have experience and flexibility throughout the crisis, keeping them out of trouble. It is also stated in the same publication that as the industry quickly focuses on ready-to-use resources, financial and legal needs, and government regulation institution policies, de-carbonization and sustainability targets will be disrupted. De-carbonization is linked with ESG initiatives, and they have common goals; affordable price, reliability, and sustainability. Therefore, if companies continue to invest in creative, dynamic solutions for long-term recovery and resilience, ESG determinants can succeed in sustainability if a proactive interaction is engaged in the world market, and a safe environment for entrepreneurship is provided (Spitzmueller et al., 2020).

The law numbered 5346 “Electricity Law on Utilization of Renewable Energy Resources for the Purpose of Production” is in force in Turkey. In his scope, the electricity obtained from wind energy is pricing as 7.3 c$/kWh. Also, if components are domestic production, there is additional support for the price, it is reported that this pricing will be adjusted every ten years (Anonymous, 2005a) . This study, which is prepared considering that agricultural activities and an increase in agrarian income have an important role in the social and economic development of the Southeastern Anatolia region, also supports the Southeastern Anatolia Project (GAP). By the Agricultural and Rural Development Support Institution (TKDK); The Project to increase the use of renewable energy resources in the GAP region (with sector code 302-7) is supported by renewable energy investments (for Diyarbakır, Şanlıurfa, and Mardin cities) for use in diversifying and developing farm activities. Although, IPARD's (Instrument for Pre-Accession Assistance-IPA) the total support budget is 54000000 Euros, the support rate is between 55-65% (Anonymous 2020c). According to the communiqué (communiqué no: 2019/30) on the support of agricultural investments within the scope of the 13th stage of rural development supports and the communiqué (communiqué no: 2017/22) on the support of agricultural investments within the scope of rural development supports (50%) (Anonymous 2019; Anonymous, 2017). Also, according to the communiqué on the electrical energy support used in agricultural irrigation (communiqué no: 2005/22); 0.017 Turkish Lira support payment is made per kilowatt of active electrical energy consumed in agricultural irrigation (Anonymous, 2005b). The region is also supported by an institution such as Karacadağ Development Agency (Anonymous, 2020d) and İpekyolu Development Agency (Anonymous, 2020e) with development investments.

Wind turbines have come a long way until they reach today's technology. It was discovered and used in Asia, especially in Mesopotamia, and reached today's technology by spreading with the Crusades to Europe. In the prior period, the usage intensity decreased in the Middle East and Mesopotamia (Shepherd, 1990). This study was carried out to demonstrate the re-use, and feasibility of wind turbines used to generate electricity to all systems, pump water, cut wood, and create airflow, in the region where the renewable wind energy was born.

Materials and Methods

The research area was determined as the Southeastern Anatolia Region (northern Mesopotamia), which is one of the seven regions of Turkey and the region where the most significant national development Project GAP is carried out. A large part of the region contains Northern Mesopotamia, which lies between the Euphrates and Tigris rivers. Cities in this region are; Gaziantep, Kilis, Şanlıurfa, Mardin, Şırnak, Siirt, Batman, Diyarbakır, and Adıyaman.

Small wind turbines with horizontal and vertical axes that are selected as representative of the study are given in Table 1 and Table 2.

Table 1. Types of horizontal axis wind turbines <Anonymous 2016a>

Horizontal Axis Wind Turbine	**1 kW**	**3 kW**	**5 kW**	**10 kW**	**20 kW**
Lowest Operation Wind Speed (m/s)	3	3	3	3	3
Highest Operation Wind Speed (m/s)	40	40	25	25	25
Optimal Operation Wind Speed (m/s)	12	12	12	12	12
Number of Wings	3	3	3	3	3
Rotor Diameter	2.6	4.5	5.8	8.2	11.6
Sweeping Area m^2	5.3	16.0	26.6	53.2	106.4
Wing length	1.2	2.5	2.7	4.0	5.0

Table 2. Types of vertical axis wind turbines <Anonymous 2016b>

Vertical Axis Wind Turbines	**V1s**	**V1**	**V1.8s**	**V1.8**
Available Power (W)	200	300	1000	1500
Highest Achievable Power (W)	250	350	1300	1800
Voltage (V)	14.5	14.5	180 dc	180 dc
Proper Operation of Wind Speed (m/s)	12	12	11	11
Service Wind Speed (m/s)	1.5	1.5	1.5	1.5
Suitable Number of Cycle (cycle/min)	270	250	200	180
Highest Speed Cycle (cycle/min)	320	300	220	200
Rotor Diameter (m)	0.9	0.9	1.5	1.5
Wing Length (m)	1.0	1.0	1.8	1.8
Total weight (kg)	25	25	110	110

In the framework of the study, the wind data-reached from the Republic of Turkey Ministry of Water State and Forestry, the General Directorate of Meteorology (2016) between 1968-2015 were analyzed for obtaining dominant wind direction and intensities, and a representative year was created by analyzing the frequencies.

“Compound Threat Method” (UTM) data was accessed using GoogleEarth, and meteorological station location information was processed in the ArcMAP program (Figure 1). The dominant wind direction is visualized with ArcMAP and Google Earth programs. Thanks to these images, the degrees of an exploit of the wind speed have been revealed. The roughness class and, therefore, the roughness length (Z_o) values at the station locations were selected from the present charts (Bektaş, 2013; Anonymous, 2003; Biçen and Vardar, 2020; Bölükbaş et al., 2020). Correction coefficients have been put forward. The primary correction factor has been submitted (Table 4 in the Results section).

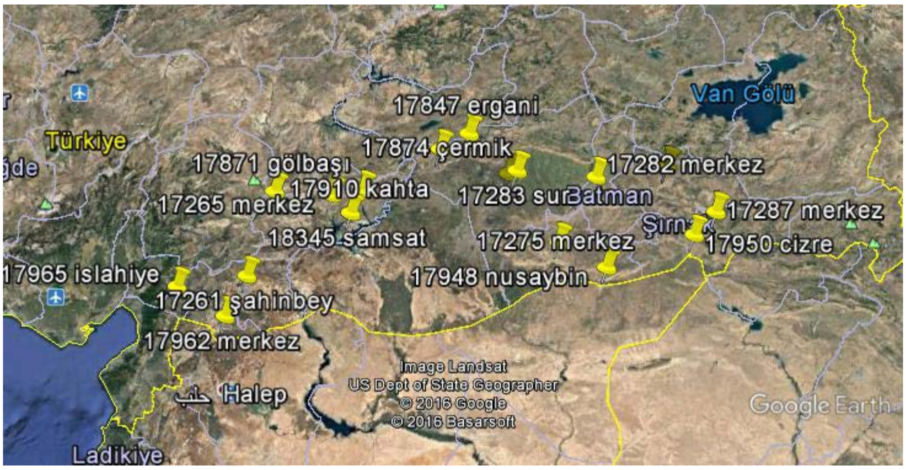

Figure 1: *ArcMAP Meteorological station locations in Northern Mesopotamia*

The meteorological average wind speed in the coordinates was compared with the Turkey Wind Energy Potential Atlas (Anonymous, 2007) data by using the interpolation method to the points, and the deviation in these values was examined mathematically. In addition, correction coefficients suitable for the meteorological station location were obtained. Meteorological station information and data in accordance with wind data, according to station location and the average annual wind speed distribution at 50 m from Turkey Wind Energy Potential Atlas (REPA) (Anonymou,s 2007), was reorganized under the influence factor correction coefficient in comparison with the data. The deviation resulting from the comparison was examined mathematically and a secondary correction factor was obtained.

Available daily data, which was obtained at 10 m high from meteorological stations, was converted to average data on a station basis. Wind speeds are calculated for altitude calculations of 10 m and 50 m.

The corrected and lean station wind speed data obtained was calculated linearly between the increase model, and correlation coefficients were obtained.

In addition, calculations were made on the unit area. Total potentials of cities and districts have not been investigated. Also, due to the rapid urbanization in terms of the accuracy of our findings, the UTM images obtained from the GoogleEarth software are not known. As Özşahin and Kaymaz (2013) suggested; Before proceeding to the investment phase, it should be remembered that detailed studies should be used on larger scale maps and the most up-to-date land image possible.

In line with the data of station and the representative turbines data which are selected to sampling, the capacity factor was determined by proportioning the energy intensities obtained annually.

Costs of turbines and towers at various heights were calculated separately. By applying the capacity factor effect, unit energy cost calculations were examined. In addition, calculations have been examined to better visualize the effect of incentives and supports on unit energy cost. Government supports (non-refundable loans) and government incentives (if applicable) were exercised in these calculations.

Also, accordingly, the minimum cost that can be reached with simple cost and grant support was calculated, analyzed, and compared according to various hub heights of turbines. According to the Republic of Turkey, published in the official gazette notification and Agriculture and Rural Development Support Agency (TKDK) specified in the IPARD Program grants are processed.

IPARD’s the support rate is between 55-65% (Anonymous, 2020c). According to the communiqué (communiqué no: 2019/30) on the support of agricultural investments within the scope of the 13th stage of rural development supports and the communiqué (communiqué no: 2017/22) on the support of agricultural investments within the scope of rural development supports (50%) (Anonymous, 2019; Anonymous, 2017).

In this study, value added tax and freight costs of turbines are not included in the calculations as they are a relative and dynamic factor in energy kWh cost calculations. Licensed and unlicensed wind energy generation facilities are exempted from the above items if they are connected to the grid (Anonymous 2005a).

Theory/ Calculation

Information about the study site, station wind data and wind turbines were interpreted mathematically with a series of equations. While calculating the kWh cost of the amount of energy that the turbine can produce at the working site, the following equations are used.

The primary correction coefficient we use to obtain the value of the wind speed at various heights under the influence of surface roughness (Jhoinson 2006).

$$u^{*} = \frac{v(h) \times k}{ln\left(\frac{h}{z_0}\right)} \qquad (1)$$

Secondary correction coefficient created to increase REPA values by comparing REPA data with findings (Yağcı 2013).

$$\text{Ƥ} = \frac{REPA\ data}{Average\ speed\ of\ station} + 1 \qquad (2)$$

Wind data of 50 m subjected to these two factors were used in the field unit area power and energy density calculations.

$$P = 0{,}5\rho A v^{3} \qquad (3)$$

If the capacity factor is at least 25% in horizontal axis wind turbines (Anonymous 2005a; Anonymous 2020c) and 6.4% in vertical axis wind turbines, it is considered to be suitable for **economic** WPP investments. And if the capacity factor is at least 20% in horizontal axis, 2% in vertical axis wind turbines, it is considered to be suitable for **technical** Wind Power Plant investments. According to Anonymous (2006), the capacity factor in vertical axis wind turbines should be between 1.6% and 13.6%, and the average is 6.4%. The equation used in the calculation of the capacity factor is given below.

$$\mathrm{c_F} = \frac{\text{Total amount of energy produced annually}}{The\ amount\ of\ energy\ that\ the\ turbine\ should\ produce\ annually\ with\ nominal\ power} \qquad (4)$$

The following equation shows the present value cost of the investment made throughout the life of the turbine.

$$PVC = I + B\left[\frac{1+i}{r-i}\right]\left[1-\left(\frac{1+i}{1+r}\right)^{t}\right] - S\left(\frac{1+i}{1+r}\right)^{t} \qquad (5)$$

Unit cost of energy produced from wind turbines Present Value Cost (PVC); The investment made during the life of the turbine is the current time costs. “I” is the turbine cost. This value is the connection costs of the turbine price and the turbine price, the connection costs are 20% of the turbine price. “B” is the annual maintenance and repair costs, “i” shows inflation rate, “r” interest value, “S” scrap value (10% of equipment cost) and t turbine life (Bagiorgas 2007; Elibüyük at al 2016) and (Dabbaoğlu et al 2014). According to the data of Central Bank of the Republic of Turkey; The inflation rate in December 2019 is 11.84% and the interest rate is 12.16% (Anonymous 2020f).

The equation below shows how equipment cost is calculated.

$$B = \frac{I}{(tx4)} \tag{6}$$

The kWh cost of electrical energy is seen in the equation below.

$$kWh\ Cost = \frac{PVC}{P_R C_f t} \tag{7}$$

The kWh cost of electrical energy under the influence of the grant factor is seen in the equation below.

$$kWh\ Cost = \frac{PVC}{P_R C_f t} x\ (1 - Grant\ Factor) \tag{8}$$

Results

Within the scope of the study; Meteorological station data were processed, available datasets were obtained, and the locations of meteorological stations were evaluated by using GoogleEarth program images. In line with this information, surface roughness classes and roughness lengths are determined according to the locations of the stations. Table 3 shows the 50 m wind averages obtained from the REPA visuals by interpolation and the wind speeds of the stations at 50 m and the correction coefficient between them with REPA.

Table 3. Roughness class, roughness length, etc. field values

City	**District**	**Available Data (Year)**	**REPA Wind Speed (m/s)**	**Roughness**		**Wind Speed Average (50 m)**	**Correction Coefficient**
				Class	**Length (m)**		
Şırnak	Cizre	34	4.5	2.5	0.2	3.55	1.27
	Central	20	5	3	0.4	3.08	1.62
Siirt	Central	41	4	0.5	0.0024	1.91	2.09
Batman	Central	35	4	0.5	0.0024	2.01	1.99
Mardin	Central	39	6	1.5	0.055	5.22	1.15
	Nusaybin	23	6	2.5	0.2	2.46	2.44
Diyarbakır	Çermik	25	5.5	2	0.1	1.96	2.81
	Central	41	5.5	2.5	0.2	3.47	1.59
	Ergani	12	6.5	1	0.03	3.01	2.16
	Sur	6	4.5	0.5	0.0024	2.02	2.23
Şanlıurfa	Akçakale	19	5	1	0.03	2.43	2.06
	Birecik	34	4.5	3	0.4	2.49	1.81
	Bozova	7	4.5	1	0.03	1.3	3.46
	Ceylanpınar	25	5	1.5	0.055	1.96	2.55
	Hilvan	10	4	1.5	0.055	3.31	1.21
	Siverek	38	5.5	3	0.4	4.5	1.22
	Central	38	5.5	3.5	0.8	2.87	1.92
Adıyaman	Central	42	4.5	3	0.4	3.01	1.50
	Gölbaşı	9	5	2	0.1	2.32	2.16
	Kahta	6	4.5	1.5	0.055	3.86	1.17
	Samsat	8	4.5	0.5	0.0024	2	2.25
Gaziantep	Central	43	6.5	3.5	0.8	2.41	2.70
	İslâhiye	40	5.5	0.5	0.0024	2.37	2.32
Kilis	Central	41	6.5	1	0.03	3.42	1.90

Considering the annual total power and energy density of stations based on the correction coefficient of wind speed depending on the station location and based on REPA wind speed difference, the field unit power, and energy potentials obtained theoretically. The ratio of the amount of energy that can be achieved if the wind turbines operate at nominal speed for a whole year and the ratio of the amount of energy that can actually be obtained due to the wind potential of the region is defined as the capacity factor. Using the equation given in the method section, the capacity factors that can be obtained with the wind turbines handled on the basis of the stations in the region were calculated and presented in Table 4 and Table 5.

While examining the economic and technical installability of horizontal and vertical axis wind turbines in the Southeastern Anatolia Region, energy unit costs were examined under the influence of lean and grant.

Cost calculations based on the grant support information specified at Materials and methods section; city, region, turbines with various power and features and various hub heights.

Economically and technically installability is discussed in the Table 4-13, italic/bold colored values are economically installable and italic/grayly colored values are technically installable express.

Table 4. Horizontal axis wind turbine capacity factors

CITY	District	1 kW			3 kW		5 kW			10 kW						20 kW		
		Cf 10	Cf 12	Cf 15	Cf 10	Cf 12	Cf 10	Cf 12	Cf 18	Cf 12	Cf 15	Cf 18	Cf 24	Cf 30	Cf 36	Cf 18	Cf 24	Cf 30
Şırnak	Cizre	0.01	0.01	0.01	0.03	0.03	0.02	0.02	0.04	0.02	0.02	0.03	0.03	0.05	0.05	0.02	0.04	0.05
	Central	0.04	0.04	0.06	0.13	0.14	0.10	0.10	0.10	0.10	0.10	0.11	0.12	0.15	0.14	0.06	0.10	0.14
Siirt	Central	0.02	0.02	0.02	0.08	0.09	0.07	0.07	0.08	0.06	0.06	0.06	0.06	0.07	0.06	0.02	0.04	0.06
Batman	Central	0.02	0.02	0.02	0.08	0.09	0.07	0.07	0.08	0.06	0.06	0.06	0.06	0.07	0.06	0.02	0.04	0.06
Mardin	Central	0.09	0.09	0.11	0.19	0.20	0.15	0.15	0.14	0.16	0.16	0.16	0.17	0.18	0.17	0.08	0.12	0.16
	Nusaybin	0.07	0.08	0.09	0.16	0.17	0.13	0.13	0.12	0.13	0.14	0.14	0.15	0.18	0.17	0.08	0.12	0.16
Diyarbakır	Çermik	0.06	0.07	0.08	0.15	0.15	0.12	0.12	0.11	0.12	0.12	0.13	0.13	0.15	0.14	0.06	0.10	0.13
	Central	0.05	0.06	0.07	0.13	0.14	0.11	0.11	0.11	0.11	0.11	0.12	0.12	0.15	0.14	0.06	0.10	0.13
	Ergani	0.15	0.16	0.17	0.24	***0.25***	0.20	0.20	0.18	*0.21*	*0.21*	*0.21*	*0.22*	*0.23*	*0.23*	0.12	0.17	*0.21*
	Sur	0.07	0.07	0.08	0.15	0.15	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.06	0.08	0.11
Şanlıurfa	Akçakale	0.07	0.07	0.08	0.14	0.14	0.11	0.11	0.11	0.11	0.12	0.12	0.12	0.14	0.13	0.06	0.09	0.12
	Birecik	0.01	0.02	0.02	0.06	0.06	0.05	0.05	0.06	0.04	0.05	0.05	0.06	0.09	0.08	0.03	0.05	0.08
	Bozova	0.06	0.06	0.07	0.11	0.12	0.09	0.09	0.10	0.10	0.10	0.10	0.10	0.11	0.11	0.05	0.08	0.10
	Ceylan-pınar	0.06	0.07	0.07	0.12	0.13	0.10	0.10	0.10	0.10	0.10	0.11	0.11	0.12	0.12	0.06	0.09	0.11
	Hilvan	0.02	0.02	0.02	0.06	0.07	0.05	0.05	0.06	0.05	0.05	0.05	0.05	0.07	0.06	0.03	0.04	0.06
	Siverek	0.03	0.04	0.05	0.11	0.12	0.09	0.09	0.09	0.09	0.09	0.09	0.10	0.13	0.12	0.05	0.09	0.12
	Central	0.02	0.03	0.05	0.08	0.09	0.07	0.07	0.08	0.07	0.07	0.08	0.10	0.15	0.13	0.05	0.09	0.13
Adıyaman	Central	0.01	0.02	0.02	0.05	0.06	0.04	0.04	0.06	0.04	0.04	0.05	0.06	0.08	0.07	0.03	0.05	0.08
	Gölbaşı	0.03	0.04	0.05	0.11	0.12	0.09	0.09	0.09	0.09	0.09	0.09	0.10	0.12	0.11	0.04	0.07	0.10
	Kahta	0.05	0.05	0.05	0.08	0.09	0.06	0.06	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.03	0.04	0.06
	Samsat	0.05	0.05	0.06	0.12	0.13	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.04	0.07	0.09
Gaziantep	Central	0.06	0.07	0.09	0.13	0.15	0.11	0.11	0.11	0.12	0.12	0.13	0.15	0.22	0.19	0.09	0.14	0.19
	İslâhiye	0.15	0.16	0.16	*0.23*	*0.23*	*0.20*	*0.20*	0.18	0.19	0.19	0.20	0.20	0.22	0.22	0.11	0.14	0.17
Kilis	Central	0.15	0.16	0.17	*0.24*	***0.25***	*0.22*	*0.21*	0.19	*0.21*	*0.21*	*0.22*	*0.22*	*0.24*	*0.23*	0.12	0.17	*0.21*

Table 5. Vertical axis wind turbine capacity factors

CITY	District	VA 300 W		VA 1000 W	
		Cf 10	Cf 12	Cf 10	Cf 12
Şırnak	Cizre	0.00	0.00	0.01	0.01
	Central	0.01	0.02	*0.05*	*0.06*
Siirt	Central	0.00	0.01	*0.03*	*0.04*
Batman	Central	0.00	0.01	*0.03*	*0.03*
Mardin	Central	*0.04*	*0.04*	***0.10***	***0.10***
	Nusaybin	*0.03*	*0.03*	***0.08***	***0.08***
Diyarbakır	Çermik	0.02	*0.03*	***0.07***	***0.07***
	Central	0.02	0.02	*0.06*	***0.07***
	Ergani	*0.06*	***0.07***	***0.13***	***0.13***
	Sur	*0.03*	*0.03*	***0.07***	***0.08***
Şanlıurfa	Akçakale	*0.03*	*0.03*	***0.07***	***0.07***
	Birecik	0.00	0.00	*0.02*	*0.03*
	Bozova	0.02	*0.03*	*0.06*	*0.06*
	Ceylanpınar	0.02	0.02	*0.06*	*0.06*
	Hilvan	0.00	0.01	*0.03*	*0.03*
	Siverek	0.01	0.01	*0.05*	*0.05*
	Central	0.01	0.01	*0.04*	*0.04*
Adıyaman	Central	0.00	0.00	0.02	0.02
	Gölbaşı	0.01	0.01	*0.05*	*0.05*
	Kahta	0.01	0.01	*0.05*	*0.05*
	Samsat	0.02	0.02	*0.06*	*0.06*
Gaziantep	Central	0.02	*0.03*	*0.06*	***0.07***
	İslâhiye	***0.07***	***0.08***	***0.13***	***0.13***
Kilis	Central	***0.07***	***0.07***	***0.13***	***0.13***

Table 6. Horizontal axis wind turbine energy price ($) per kWh (1 kW)

CITY	District	Cost 10	Grant 50	Grant 55	Grant 65	Cost 12	Grant 50	Grant 55	Grant 65	Cost 15	Grant 50	Grant 55	Grant 65
Şırnak	Cizre	3.48	1.74	NA	NA	2.81	1.41	NA	NA	2.68	1.34	NA	NA
	Central	0.50	0.25	NA	NA	0.42	0.21	NA	NA	0.42	0.21	NA	NA
Siirt	Central	0.88	0.44	NA	NA	0.88	0.44	NA	NA	1.05	0.52	NA	NA
Batman	Central	0.86	0.43	NA	NA	0.86	0.43	NA	NA	1.02	0.51	NA	NA
Mardin	Central	0.21	0.10	0.09	0.07	0.20	0.10	0.09	0.07	0.23	0.12	0.10	0.08
	Nusaybin	0.25	0.12	0.11	0.09	0.24	0.12	0.11	0.08	0.26	0.13	0.12	0.09
Diyarbakır	Çermik	0.30	0.15	0.13	0.10	0.29	0.14	0.13	0.10	0.32	0.16	0.15	0.11
	Central	0.33	0.17	0.15	0.12	0.31	0.16	0.14	0.11	0.35	0.17	0.16	0.12
	Ergani	0.12	0.06	0.05	0.04	0.12	0.06	0.05	0.04	0.15	0.07	0.07	0.05
	Sur	0.26	0.13	0.12	0.09	0.26	0.13	0.12	0.09	0.32	0.16	0.14	0.11
Şanlıurfa	Akçakale	0.26	0.13	0.11	0.09	0.26	0.13	0.12	0.09	0.31	0.15	0.14	0.11
	Birecik	1.37	0.69	0.62	0.48	1.11	0.55	0.50	0.39	1.05	0.53	0.47	0.37
	Bozova	0.29	0.15	0.13	0.10	0.29	0.15	0.13	0.10	0.35	0.18	0.16	0.12
	Ceylanpınar	0.29	0.15	0.13	0.10	0.29	0.15	0.13	0.10	0.34	0.17	0.15	0.12
	Hilvan	1.03	0.51	0.46	0.36	0.95	0.48	0.43	0.33	1.04	0.52	0.47	0.36
	Siverek	0.65	0.32	0.29	0.23	0.53	0.26	0.24	0.19	0.51	0.26	0.23	0.18
	Central	0.73	0.36	0.33	0.25	0.57	0.29	0.26	0.20	0.54	0.27	0.24	0.19
Adıyaman	Central	1.58	0.79	NA	NA	1.27	0.63	NA	NA	1.20	0.60	NA	NA
	Gölbaşı	0.54	0.27	NA	NA	0.50	0.25	NA	NA	0.53	0.27	NA	NA
	Kahta	0.37	0.18	NA	NA	0.38	0.19	NA	NA	0.46	0.23	NA	NA
	Samsat	0.36	0.18	NA	NA	0.36	0.18	NA	NA	0.44	0.22	NA	NA
Gaziantep	Central	0.31	0.15	NA	NA	0.27	0.14	NA	NA	0.28	0.14	NA	NA
	İslâhiye	0.12	0.06	NA	NA	0.12	0.06	NA	NA	0.15	0.08	NA	NA
Kilis	Central	0.12	0.06	NA	NA	0.12	0.06	NA	NA	0.14	0.07	NA	NA

Table 7. Horizontal axis wind turbine energy price ($) per kWh (3 kW)

CITY	District	Cost 10	Grant 50	Grant 55	Grant 65	Cost 12	Grant 50	Grant 55	Grant 65
Şırnak	Cizre	0.34	0.17	NA	NA	0.31	0.15	NA	NA
	Central	0.07	0.03	NA	NA	0.07	0.03	NA	NA
Siirt	Central	0.10	0.05	NA	NA	0.11	0.05	NA	NA
Batman	Central	0.10	0.05	NA	NA	0.11	0.06	NA	NA
Mardin	Central	0.05	0.02	0.02	0.02	0.05	0.02	0.02	0.02
	Nusaybin	0.05	0.03	0.02	0.02	0.06	0.03	0.03	0.02
Diyarbakır	Çermik	0.06	0.03	0.03	0.02	0.06	0.03	0.03	0.02
	Central	0.07	0.03	0.03	0.02	0.07	0.03	0.03	0.02
	Ergani	0.04	0.02	0.02	0.01	***0.04***	***0.02***	***0.02***	***0.01***
	Sur	0.06	0.03	0.03	0.02	0.06	0.03	0.03	0.02
Şanlıurfa	Akçakale	0.06	0.03	0.03	0.02	0.07	0.03	0.03	0.02
	Birecik	0.15	0.07	0.07	0.05	0.15	0.07	0.07	0.05
	Bozova	0.08	0.04	0.03	0.03	0.08	0.04	0.04	0.03
	Ceylanpınar	0.07	0.04	0.03	0.02	0.07	0.04	0.03	0.03
	Hilvan	0.14	0.07	0.06	0.05	0.14	0.07	0.06	0.05
	Siverek	0.08	0.04	0.03	0.03	0.08	0.04	0.04	0.03
	Central	0.11	0.05	0.05	0.04	0.10	0.05	0.05	0.04
Adıyaman	Central	0.17	0.08	NA	NA	0.16	0.08	NA	NA
	Gölbaşı	0.08	0.04	NA	NA	0.08	0.04	NA	NA
	Kahta	0.11	0.05	NA	NA	0.11	0.06	NA	NA
	Samsat	0.07	0.04	NA	NA	0.08	0.04	NA	NA
Gaziantep	Central	0.06	0.03	NA	NA	0.06	0.03	NA	NA
	İslâhiye	*0.04*	*0.02*	NA	NA	*0.04*	*0.02*	NA	NA
Kilis	Central	*0.04*	*0.02*	NA	NA	***0.04***	***0.02***	NA	NA

Table 8. Horizontal axis wind turbine energy price ($) per kWh (5 kW)

CITY	District	Cost 10	Grant 50	Grant 55	Grant 65	Cost 12	Grant 50	Grant 55	Grant 65	Cost 18	Grant 50	Grant 55	Grant 65
Şırnak	Cizre	0.64	0.32	NA	NA	0.56	1.12	NA	NA	0.48	0.24	NA	NA
	Central	0.13	0.06	NA	NA	0.13	0.27	NA	NA	0.17	0.09	NA	NA
Siirt	Central	0.19	0.10	NA	NA	0.20	0.39	NA	NA	0.24	0.12	NA	NA
Batman	Central	0.19	0.10	NA	NA	0.20	0.40	NA	NA	0.24	0.12	NA	NA
Mardin	Central	0.08	0.04	0.04	0.03	0.09	0.18	0.04	0.03	0.13	0.06	0.06	0.04
	Nusaybin	0.10	0.05	0.05	0.04	0.11	0.21	0.05	0.04	0.15	0.07	0.07	0.05
Diyarbakır	Çermik	0.11	0.05	0.05	0.04	0.12	0.23	0.05	0.04	0.16	0.08	0.07	0.05
	Central	0.12	0.06	0.05	0.04	0.13	0.26	0.06	0.04	0.17	0.08	0.08	0.06
	Ergani	0.06	0.03	0.03	0.02	0.07	0.14	0.03	0.02	0.10	0.05	0.05	0.04
	Sur	0.11	0.05	0.05	0.04	0.11	0.23	0.05	0.04	0.15	0.08	0.07	0.05
Şanlıurfa	Akçakale	0.11	0.06	0.05	0.04	0.12	0.24	0.05	0.04	0.16	0.08	0.07	0.06
	Birecik	0.28	0.14	0.13	0.10	0.28	0.55	0.12	0.10	0.30	0.15	0.13	0.10
	Bozova	0.14	0.07	0.06	0.05	0.14	0.29	0.06	0.05	0.18	0.09	0.08	0.06
	Ceylanpınar	0.13	0.06	0.06	0.05	0.14	0.27	0.06	0.05	0.18	0.09	0.08	0.06
	Hilvan	0.26	0.13	0.12	0.09	0.26	0.52	0.12	0.09	0.28	0.14	0.13	0.10
	Siverek	0.14	0.07	0.06	0.05	0.15	0.30	0.07	0.05	0.19	0.10	0.09	0.07
	Central	0.20	0.10	0.09	0.07	0.20	0.40	0.09	0.07	0.24	0.12	0.11	0.08
Adıyaman	Central	0.31	0.15	NA	NA	0.30	0.60	NA	NA	0.31	0.16	NA	NA
	Gölbaşı	0.14	0.07	NA	NA	0.15	0.30	NA	NA	0.19	0.09	NA	NA
	Kahta	0.21	0.11	NA	NA	0.21	0.43	NA	NA	0.25	0.12	NA	NA
	Samsat	0.13	0.07	NA	NA	0.14	0.27	NA	NA	0.18	0.09	NA	NA
Gaziantep	Central	0.12	0.06	NA	NA	0.13	0.25	NA	NA	0.17	0.08	NA	NA
	İslâhiye	*0.06*	*0.03*	NA	NA	*0.07*	*0.14*	NA	NA	0.10	0.05	NA	NA
Kilis	Central	*0.06*	*0.03*	NA	NA	*0.06*	*0.13*	NA	NA	0.09	0.05	NA	NA

Table 9. Horizontal axis wind turbine energy price ($) per kWh (10 kW)

CITY	District	Cost 12	Grant 50	Grant 55	Grant 65	Cost 15	Grant 50	Grant 55	Grant 65	Cost 18	Grant 50	Grant 55	Grant 65
Şırnak	Cizre	0.53	0.26	NA	NA	0.49	0.25	NA	NA	0.47	0.23	NA	NA
	Central	0.10	0.05	NA	NA	0.11	0.05	NA	NA	0.11	0.06	NA	NA
Siirt	Central	0.17	0.08	NA	NA	0.18	0.09	NA	NA	0.20	0.10	NA	NA
Batman	Central	0.17	0.09	NA	NA	0.18	0.09	NA	NA	0.20	0.10	NA	NA
Mardin	Central	0.06	0.03	0.03	0.02	0.07	0.03	0.03	0.02	0.07	0.04	0.03	0.03
	Nusaybin	0.08	0.04	0.03	0.03	0.08	0.04	0.04	0.03	0.09	0.04	0.04	0.03
Diyarbakır	Çermik	0.09	0.04	0.04	0.03	0.09	0.05	0.04	0.03	0.10	0.05	0.04	0.03
	Central	0.10	0.05	0.04	0.03	0.10	0.05	0.05	0.04	0.11	0.05	0.05	0.04
	Ergani	*0.05*	*0.02*	*0.02*	*0.02*	*0.05*	*0.03*	*0.02*	*0.02*	*0.06*	*0.03*	*0.03*	*0.02*
	Sur	0.08	0.04	0.04	0.03	0.09	0.05	0.04	0.03	0.10	0.05	0.05	0.04
Şanlıurfa	Akçakale	0.09	0.05	0.04	0.03	0.10	0.05	0.04	0.03	0.10	0.05	0.05	0.04
	Birecik	0.23	0.12	0.11	0.08	0.23	0.12	0.11	0.08	0.23	0.12	0.11	0.08
	Bozova	0.11	0.05	0.05	0.04	0.12	0.06	0.05	0.04	0.12	0.06	0.06	0.04
	Ceylanpınar	0.10	0.05	0.05	0.04	0.11	0.05	0.05	0.04	0.12	0.06	0.05	0.04
	Hilvan	0.22	0.11	0.10	0.08	0.23	0.11	0.10	0.08	0.24	0.12	0.11	0.08
	Siverek	0.12	0.06	0.05	0.04	0.13	0.06	0.06	0.04	0.13	0.06	0.06	0.05
	Central	0.15	0.08	0.07	0.05	0.15	0.08	0.07	0.05	0.15	0.07	0.07	0.05
Adıyaman	Central	0.26	0.13	NA	NA	0.26	0.13	NA	NA	0.25	0.13	NA	NA
	Gölbaşı	0.12	0.06	NA	NA	0.12	0.06	NA	NA	0.13	0.07	NA	NA
	Kahta	0.17	0.09	NA	NA	0.19	0.09	NA	NA	0.20	0.10	NA	NA
	Samsat	0.11	0.05	NA	NA	0.12	0.06	NA	NA	0.13	0.06	NA	NA
Gaziantep	Central	0.09	0.04	NA	NA	0.09	0.04	NA	NA	0.09	0.05	NA	NA
	İslâhiye	*0.05*	*0.03*	NA	NA	*0.06*	*0.03*	NA	NA	*0.06*	*0.03*	NA	NA
Kilis	Central	*0.05*	*0.02*	NA	NA	*0.05*	*0.03*	NA	NA	*0.06*	*0.03*	NA	NA

Table 10. Horizontal axis wind turbine energy price ($) per kWh (10 kW)

CITY	**District**	**Cost 24**	**Grant 50**	**Grant 55**	**Grant 65**	**Cost 30**	**Grant 50**	**Grant 55**	**Grant 65**	**Cost 36**	**Grant 50**	**Grant 55**	**Grant 65**
Şırnak	Cizre	0.46	0.23	NA	NA	0.32	0.16	NA	NA	0.43	0.21	NA	NA
	Central	0.12	0.06	NA	NA	0.11	0.06	NA	NA	0.14	0.07	NA	NA
Siirt	Central	0.24	0.12	NA	NA	0.26	0.13	NA	NA	0.30	0.15	NA	NA
Batman	Central	0.24	0.12	NA	NA	0.26	0.13	NA	NA	0.30	0.15	NA	NA
Mardin	Central	0.09	0.04	0.04	0.03	0.10	0.05	0.04	0.03	0.11	0.06	0.05	0.04
	Nusaybin	0.10	0.05	0.04	0.03	0.09	0.05	0.04	0.03	0.11	0.06	0.05	0.04
Diyarbakır	Çermik	0.11	0.06	0.05	0.04	0.12	0.06	0.05	0.04	0.14	0.07	0.06	0.05
	Central	0.12	0.06	0.05	0.04	0.12	0.06	0.05	0.04	0.14	0.07	0.06	0.05
	Ergani	*0.07*	*0.03*	*0.03*	*0.02*	*0.07*	*0.04*	*0.03*	*0.03*	*0.09*	*0.04*	*0.04*	*0.03*
	Sur	0.12	0.06	0.06	0.04	0.15	0.07	0.07	0.05	0.16	0.08	0.07	0.06
Şanlıurfa	Akçakale	0.12	0.06	0.06	0.04	0.13	0.06	0.06	0.04	0.15	0.07	0.07	0.05
	Birecik	0.25	0.12	0.11	0.09	0.20	0.10	0.09	0.07	0.26	0.13	0.12	0.09
	Bozova	0.15	0.07	0.07	0.05	0.15	0.08	0.07	0.05	0.18	0.09	0.08	0.06
	Ceylanpınar	0.14	0.07	0.06	0.05	0.14	0.07	0.06	0.05	0.16	0.08	0.07	0.06
	Hilvan	0.27	0.14	0.12	0.10	0.26	0.13	0.12	0.09	0.31	0.16	0.14	0.11
	Siverek	0.14	0.07	0.06	0.05	0.13	0.06	0.06	0.04	0.16	0.08	0.07	0.06
	Central	0.15	0.08	0.07	0.05	0.12	0.06	0.05	0.04	0.15	0.08	0.07	0.05
Adıyaman	Central	0.26	0.13	NA	NA	0.20	0.10	NA	NA	0.26	0.13	NA	NA
	Gölbaşı	0.15	0.08	NA	NA	0.15	0.07	NA	NA	0.18	0.09	NA	NA
	Kahta	0.25	0.12	NA	NA	0.28	0.14	NA	NA	0.32	0.16	NA	NA
	Samsat	0.15	0.08	NA	NA	0.18	0.09	NA	NA	0.20	0.10	NA	NA
Gaziantep	Central	0.10	0.05	NA	NA	0.08	0.04	NA	NA	0.10	0.05	NA	NA
	İslâhiye	*0.07*	*0.04*	NA	NA	*0.08*	*0.04*	NA	NA	0.09	0.04	NA	NA
Kilis	Central	*0.07*	*0.03*	NA	NA	*0.07*	*0.04*	NA	NA	0.08	0.04	NA	NA

Table 11. Horizontal axis wind turbine energy price ($) per kWh (20 kW)

CITY	**District**	**Cost 18**	**Grant 50**	**Grant 55**	**Grant 65**	**Cost 24**	**Grant 50**	**Grant 55**	**Grant 65**	**Cost 30**	**Grant 50**	**Grant 55**	**Grant 65**
Şırnak	Cizre	0.52	0.26	NA	NA	0.34	0.17	NA	NA	0.27	0.13	NA	NA
	Central	0.18	0.09	NA	NA	0.12	0.06	NA	NA	0.10	0.05	NA	NA
Siirt	Central	0.45	0.23	NA	NA	0.30	0.15	NA	NA	0.24	0.12	NA	NA
Batman	Central	0.44	0.22	NA	NA	0.30	0.15	NA	NA	0.24	0.12	NA	NA
Mardin	Central	0.13	0.06	0.06	0.05	0.10	0.05	0.04	0.03	0.08	0.04	0.04	0.03
	Nusaybin	0.13	0.07	0.06	0.05	0.10	0.05	0.04	0.03	0.08	0.04	0.04	0.03
Diyarbakır	Çermik	0.17	0.08	0.07	0.06	0.12	0.06	0.05	0.04	0.10	0.05	0.05	0.04
	Central	0.17	0.08	0.08	0.06	0.12	0.06	0.05	0.04	0.10	0.05	0.05	0.04
	Ergani	0.09	0.04	0.04	0.03	0.07	0.04	0.03	0.03	*0.07*	*0.03*	*0.03*	*0.02*
	Sur	0.18	0.09	0.08	0.06	0.14	0.07	0.06	0.05	0.13	0.06	0.06	0.04
Şanlıurfa	Akçakale	0.16	0.08	0.07	0.06	0.13	0.07	0.06	0.05	0.11	0.06	0.05	0.04
	Birecik	0.34	0.17	0.15	0.12	0.22	0.11	0.10	0.08	0.17	0.09	0.08	0.06
	Bozova	0.20	0.10	0.09	0.07	0.16	0.08	0.07	0.05	0.14	0.07	0.06	0.05
	Ceylanpınar	0.18	0.09	0.08	0.06	0.14	0.07	0.06	0.05	0.12	0.06	0.05	0.04
	Hilvan	0.41	0.21	0.19	0.14	0.28	0.14	0.12	0.10	0.23	0.11	0.10	0.08
	Siverek	0.21	0.11	0.09	0.07	0.14	0.07	0.06	0.05	0.11	0.06	0.05	0.04
	Central	0.20	0.10	0.09	0.07	0.13	0.07	0.06	0.05	0.11	0.05	0.05	0.04
Adıyaman	Central	0.34	0.17	NA	NA	0.22	0.11	NA	NA	0.18	0.09	NA	NA
	Gölbaşı	0.24	0.12	NA	NA	0.16	0.08	NA	NA	0.13	0.07	NA	NA
	Kahta	0.36	0.18	NA	NA	0.28	0.14	NA	NA	0.24	0.12	NA	NA
	Samsat	0.24	0.12	NA	NA	0.18	0.09	NA	NA	0.16	0.08	NA	NA
Gaziantep	Central	0.12	0.06	NA	NA	0.09	0.04	NA	NA	0.07	0.04	NA	NA
	İslâhiye	0.09	0.05	NA	NA	0.08	0.04	NA	NA	0.08	0.04	NA	NA
Kilis	Central	0.09	0.04	NA	NA	0.07	0.04	NA	NA	*0.06*	*0.03*	NA	NA

Table 12. Vertical axis wind turbine energy price ($) per kWh (300 W)

CITY	District	Cost 10	Grant 50	Grant 55	Grant 65	Cost 12	Grant 50	Grant 55	Grant 65
Şırnak	Cizre	NA	NA	NA	NA	NA	52.20	NA	NA
	Central	2.82	1.41	NA	NA	4.38	2.19	NA	NA
Siirt	Central	7.19	3.59	NA	NA	12.97	6.48	NA	NA
Batman	Central	7.11	3.55	NA	NA	13.05	6.53	NA	NA
Mardin	Central	*0.85*	*0.43*	*0.38*	*0.30*	*1.65*	*0.83*	*0.74*	*0.58*
	Nusaybin	*1.13*	*0.56*	*0.51*	*0.39*	*2.08*	*1.04*	*0.94*	*0.73*
Diyarbakır	Çermik	1.36	0.68	0.61	0.48	2.56	*1.28*	*1.15*	*0.90*
	Central	1.62	0.81	0.73	0.57	2.95	1.47	1.33	1.03
	Ergani	*0.50*	*0.25*	*0.22*	*0.17*	**1.00**	**0.50**	**0.45**	**0.35**
	Sur	*1.11*	*0.56*	*0.50*	*0.39*	*2.25*	*1.12*	*1.01*	*0.79*
Şanlıurfa	Akçakale	*1.07*	*0.54*	*0.48*	*0.38*	*2.12*	*1.06*	*0.95*	*0.74*
	Birecik	19.85	9.93	8.93	6.95	19.31	9.65	8.69	6.76
	Bozova	1.29	0.64	0.58	0.45	*2.55*	*1.28*	*1.15*	*0.89*
	Ceylanpınar	1.39	0.69	0.63	0.49	2.71	1.35	1.22	0.95
	Hilvan	6.62	3.31	2.98	2.32	11.46	5.73	5.16	4.01
	Siverek	5.41	2.71	2.44	1.90	7.03	3.52	3.17	2.46
	Central	3.76	1.88	1.69	1.31	5.45	2.72	2.45	1.91
Adıyaman	Central	34.74	17.37	NA	NA	25.75	12.88	NA	NA
	Gölbaşı	3.18	1.59	NA	NA	5.42	2.71	NA	NA
	Kahta	2.47	1.23	NA	NA	5.11	2.55	NA	NA
	Samsat	1.67	0.84	NA	NA	3.35	1.68	NA	NA
Gaziantep	Central	1.47	0.74	NA	NA	*2.43*	*1.22*	NA	NA
	İslâhiye	***0.43***	***0.21***	NA	NA	***0.88***	***0.44***	NA	NA
Kilis	Central	***0.47***	***0.23***	NA	NA	***0.94***	***0.47***	NA	NA

Table 13. Vertical axis wind turbine energy price ($) per kWh (1 kW)

CITY	District	Cost 10	Grant 50	Grant 55	Grant 65	Cost 12	Grant 50	Grant 55	Grant 65
Şırnak	Cizre	3.23	1.61	NA	NA	2.85	1.42	NA	NA
	Central	0.53	0.26	NA	NA	0.54	0.27	NA	NA
Siirt	Central	0.86	0.43	NA	NA	0.92	0.46	NA	NA
Batman	Central	0.87	0.44	NA	NA	0.93	0.47	NA	NA
Mardin	Central	*0.30*	*0.15*	*0.14*	*0.11*	*0.32*	*0.16*	*0.15*	*0.11*
	Nusaybin	*0.38*	*0.19*	*0.17*	*0.13*	*0.39*	*0.20*	*0.18*	*0.14*
Diyarbakır	Çermik	0.41	0.21	0.19	0.14	0.44	*0.22*	*0.20*	*0.15*
	Central	0.47	0.24	0.21	0.16	0.49	0.25	0.22	0.17
	Ergani	*0.23*	*0.12*	*0.10*	*0.08*	**0.25**	**0.12**	**0.11**	**0.09**
	Sur	*0.39*	*0.19*	*0.18*	*0.14*	*0.43*	*0.21*	*0.19*	*0.15*
Şanlıurfa	Akçakale	*0.42*	*0.21*	*0.19*	*0.15*	*0.45*	*0.22*	*0.20*	*0.16*
	Birecik	1.31	0.65	0.59	0.46	1.27	0.63	0.57	0.44
	Bozova	0.51	0.26	0.23	0.18	*0.55*	*0.27*	*0.25*	*0.19*
	Ceylanpınar	0.49	0.24	0.22	0.17	0.52	0.26	0.23	0.18
	Hilvan	1.12	0.56	0.50	0.39	1.16	0.58	0.52	0.40
	Siverek	0.64	0.32	0.29	0.22	0.65	0.32	0.29	0.23
	Central	0.80	0.40	0.36	0.28	0.78	0.39	0.35	0.27
Adıyaman	Central	1.49	0.74	NA	NA	1.41	0.70	NA	NA
	Gölbaşı	0.59	0.30	NA	NA	0.62	0.31	NA	NA
	Kahta	0.60	0.30	NA	NA	0.67	0.33	NA	NA
	Samsat	0.51	0.25	NA	NA	0.55	0.28	NA	NA
Gaziantep	Central	0.45	0.23	NA	NA	*0.45*	*0.22*	NA	NA
	İslâhiye	***0.22***	***0.11***	NA	NA	***0.24***	***0.12***	NA	NA
Kilis	Central	***0.23***	***0.11***	NA	NA	***0.24***	***0.12***	NA	NA

Discussion

With the Atatürk Dam built under the GAP project, it allowed the development of water resources in Northern Mesopotamia. However, salinity problem occurred in the region due to uncontrolled irrigation. In order for the continuity and existence of agricultural production to continue in the Southeastern Anatolia Region, desalination should be applied to agricultural areas or new irrigation techniques should be applied. Agricultural activities will only be sustainable under these conditions. Energy is needed for these methods.

In this study, wind energy potential research was carried out for agricultural activities in the Southeastern Anatolia Region. Small capacity wind turbines were selected as examples to support agricultural production and to eliminate the possible grid shortage of farming areas. In the study, the capacity factors obtained in line with the station data of the selected turbines have been determined as the analysis criterion, and economic and technic installability situations have been revealed.

Capacity factors in the range of 20% to 35% for horizontal axis wind turbines and capacity factors in the range of 1.6-13.6% are considered appropriate for vertical axis wind turbines (Anonymous 2006). In this study, capacity factors of up to 25% for horizontal axis wind turbines and up to 13% for vertical axis wind turbines were obtained. As a result, it is possible to benefit from wind energy in many areas represented by the stations.

In our study, although the result of the efficient capacity factor for Adıyaman wind energy has been obtained, there is a wind power plant operated in the region, this difference is due to the location of the meteorological station (Kapluhan, 2017).

Republic of Turkey Ministry of Energy support is provided to that meet 25% and above capacity factor condition for Wind Power Plant's. Agricultural and Rural Development Support Institution (TKDK) provides 55% up to 65% support geat for Diyarbakır, Mardin and for Şanlıurfa in the establishment of a 1MW facility within the scope of the Instrument for Pre-Accession Assistance-IPA (IPARD) projects within the range of € 54000000 (Anonymous, 2020c). According to the communiqué (communiqué no: 2019/30) on the support of agricultural investments within the scope of the 13th stage of rural development supports and the communiqué (communiqué no: 2017/22) on the support of agricultural investments within the scope of rural development supports (50%) (Anonymous, 2019; Anonymous, 2017). Also, according to the communiqué on the electrical energy support used in agricultural irrigation (communiqué no: 2005/22); 0,017 Turkish Lira support payment is made per kilowatt of active electrical energy consumed in agricultural irrigation (Anonymous, 2005b). The law numbered 5346 "Electricity Law on Utilization of Renewable Energy Resources for the Purpose of Production" is in force in Turkey. In his scope, the electricity obtained from wind energy is pricing as 7.3 c$/kWh. Also, if components are domestic production, there is additional support for the price, it is reported that this pricing will be adjusted every ten years (Anonymous, 2005a).

Since our research is aimed at providing energy to increase their production range, quality and quantity in agricultural enterprises in areas without grids, 5346 "Electricity Law on Utilization of Renewable Energy Resources for the Purpose of Production"support for 7.3 c$/kWh (Anonymous 2005a) and communiqué on the electrical energy support used in agricultural irrigation (communiqué no: 2005/22) support for 0.017 Turkish Lira were not included to the calculations (Anonymous, 2005b).

The kWh price included in the electricity energy tariffs of the energy supervisory board for single term tariff for low voltage is 66,7215 Kurush for agricultural irrigation (Anonymous 2020g). This value does not include funds, shares, taxes and similar legal obligations. When these items are added, the kWh cost of energy on average is 85 Kurush. As this current value, according to Central Bank of Republic of Turkey’s data is $ 0.17 or € 0.156 (Anonymous, 2020h).

Even if the electricity is supplied from the grid, the stations that have competitive power for electricity generation from wind energy have been determined with the turbines we have selected. The above mentioned supports also make a difference under the condition that the electricity grid exists and the cost of the energy obtained in this way is quite profitable.

These supports are scientifically lacking for vertical axis wind turbines. Because the economical installability capacity factor of vertical axis turbines can be considered as an average of 6.4%. These supports should be evaluated in order to meet the energy need for agricultural activity by considering the critical energy need of the region and by considering the economic benefit calculation and by staying away from the energy line.

Cost analysis in the study reveals the economics of horizontal axis turbines. However, as a response to low wind speeds, vertical axis turbines are more functional despite being high in cost (see Table 12). For this reason, the 25% capacity factor criterion determined by law (Anonymous, 2005a) is scientifically insufficient. Especially in non-grid areas, these laws should be revised by supplementing with annexes. It should pave the way for system installations where technical potential can also be evaluated and vertical axis turbines will also be covered.

These supports should also be provided to meet the energy need for agricultural activity, which is away from the grid. Wind Power Plant investments; In addition to factors such as capacity factor and payback period, hidden costs should also be examined in particular, Wind Power Plant s to be designed as hybrid should be encouraged as they will reduce discontinuity. As the Wind Power Plant’s is environmentally friendly will provide the potential to speed up very important issues for Turkey as organic product manufacturing and accelerate critical production procedures such as domestic seed. In all agricultural activities that can be done before and after the product vegetation, the necessary energy requirement can be provided by wind energy.

Acknowledgments

The authors wish to acknowledge the Turkish State Meteorological Service for providing data for this research.

This study was produced from Roza Gül BENCUYA İPEKÇİOĞLU's Master Thesis.

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Research and Publication Ethics were followed in this study.

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