PHYSICAL AND ECONOMIC ANALYSIS OF THE POTENTIAL WIND ENERGY PLANT IN SINOP/ TURKEY

Yalçın ALCAN

Vocational School, Department of Electric and Energy, Sinop Uni., 57000, Sinop, TURKEY

yalcinalcan@sinop.edu.tr

Abstract: The use of renewable energy sources is rapidly increasing in the world and in Turkey. Wind energy from these sources, is more attractive to investors when compared to other renewable energy sources due to the installation and operation costs. Electrical energy from wind sources in the coastal area usually has production potential. For instance, if the wind map of Turkey is examined it can be seen that electrical energy production from the wind sources in the coastal area has production potential. Sinop, which is located in the Black Sea coastline, is an efficient point for wind energy investment because of its geographical structure. In this study, in order to be a model, potential points for the electric power from wind sources in the Sinop have been identified. Then, the scale and size of a potential power plant from wind energy which can be installed in Sinop have been investigated. Lastly, its installation and operation costs have been calculated.

Key words: Sinop province, Wind power plant, Physical Analysis, Economic Analysis, Renewable Energy

Introduction

Today, electric power is a kind of energy needed continuously as well as being the main input for industry and is an indispensable factor for quality of life (Saidur et al., 2011). Need for electricity is increasing with each day due to the rapid growth of human population in the world (Hepbasli and Özgener, 2004). Due to many factors such as depletion of fossil fuel resources on Earth, the rising costs of energy production and environmental pollution, it has been increased the orientation for new sources (Kenisarina et al., 2006*)*. Renewable energy sources are defined as the kind of energy sources which present in the next day due to the nature of its cycle even if it is consumed every day. Solar, wind, hydroelectric, geothermal, wave, ocean, hydrogen and biomass energy are some forms of renewable energy in this class (Acaroğlu, 2013). Being in many parts of world, having low cost, being clean, not being harmful to the environment are the some important features of these resources (Köse et al., 2004). In many countries in the world, a growing orientation toward these sources are in existence (Bacak et al., 2009). In these resources, wind energy has the most convenient forms in terms of commercial and feasibility (Oner et al., 2009). Therefore, in recent years many studies on wind energy have been done. Studies have generally focused on the importance, the potential and the evaluation of wind energy (Hayli, 2001, Bilgili et al., 2004, Togrul and Ertekin, 2011, Genç and Gökçek, 2009, Güler, 2009). Sinop that is located in the Black Sea coastline is considered to have efficient points for wind energy investments because of its geographical structure. In this study, in order to be a model, potential points for the electric power from wind sources in the Sinop have been identified. Then, the sc
ale and size of a potential power plant from wind energy which can be installed in Sinop have been investigated. Lastly, its installation and operation costs have been calculated.

Materials and Method

Provincial Based Wind Energy Potential Atlas (REPA) is used as the main tool, in order to determine the place for the establishment of WPPs in our country (Anonim1, 2016). In Figure 1, shown the areas that are not suitable for HPP

 Copyright © The Online Journal of Science and Technology

investments in Sinop (gray). In determination of prohibited areas; Hunting and Wild Animals and Their Habitat Protection Implementing Regulation, Procedures and Principles of Pest Combating Implementing Regulation (Anonim2, 2016) the Environmental Noise Assessment and Management Regulation (Anonim3, 2016) the Military Forbidden Zones and Security Zones Regulation (Anonim4, 2016) have been used. As the material in study, REPA point source information is used, that was obtained from the Ministry of Energy and Natural Resources Renewable Energy the Directorate General dated 27/02/2013 (Anonim1, 2016). In information of point sources, primarily the coordinates of a point is determined from REPA. Average wind speed and wind directions is determined on specified point, at 30-50-70-100 meters (m) heights (Anonim1, 2016).

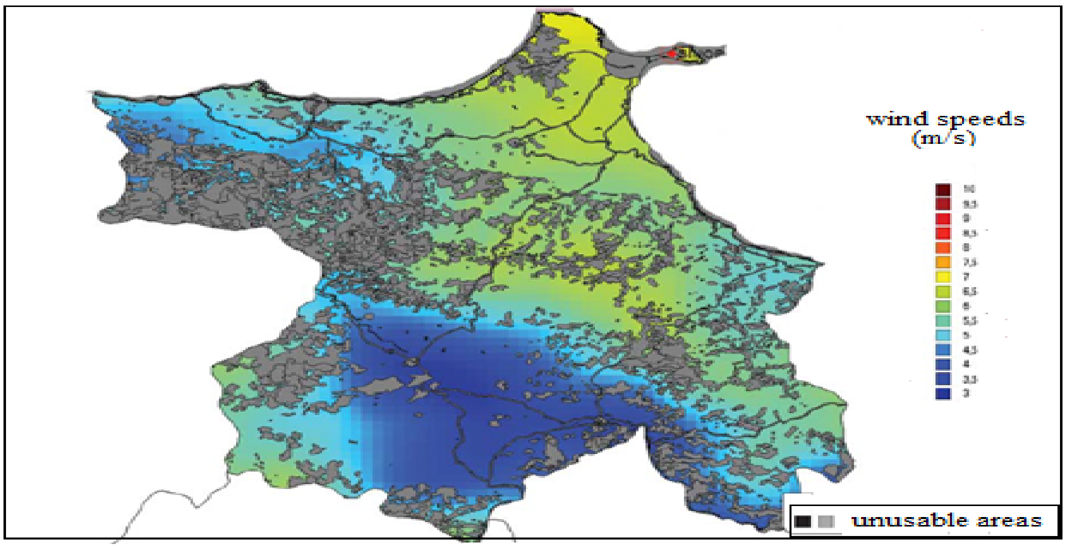

Figure 1: Wind Energy Potential Atlas (Anonim1, 2016).

In this height, the detected average wind speed and wind directions have been calculated with the Weibull distribution method (Anonim1, 2016). This distribution is composed with the scale and shape parameters is a two-parameter distribution (Anonim5, 2013). Weibull distribution function, which is in general form, is given in

$$f(v)=\left(\frac{k}{c}\right)\left(\frac{v}{c}\right)^{k-1}\exp\left[-\left(\frac{v}{c}\right)^{k}\right] \tag{1}$$

For wind speed. In this function, f (v), k and c shows the probability of observing wind speed v, Weibull shape parameter and reference value of wind speed respectively. C is also said Weibull scale parameter (Zeytinoğlu, 2009). Then the 50m and 100m annual power density (W / m^2) and annual capacity factors (%) are obtained. In line with these values, electricity production has been calculated by taking up reference Suzlon S64 / 1000 turbine model at 50m height (Anonim1, 2016).

While making an economic analysis, are taken into consideration of average investment cost which variable differ from as a nature of the establishment place, distance from the substation, pre-feasibility costs, and design costs etc. The average investment cost wind energy production is considered to be 1000-1200 US dollars / kW (Bayraç, 2011). If the number of turbines is less, the initial investment cost is more than about 10%
(Taşkın, 2013). Therefore, a 1 MW wind turbine has been recognized as a cost of US $ 1,320,000. The investment of working-life has estimated as a 25. year. Calculations have been made through two different funding models. Firstly, it has assumed invested as 100% elf-funded equity and calculations have been made. Secondly; it has been assumed invested 25% equity 75%. Credit and calculations have been made. Repayments totally 10 years, have been considered

as 2 years grace period and 8 years payback period, and calculations have been to be paid annually. Credit financing model is based on data of the Energy Market Regulatory Authority (EMRA) (Erdem et al., 2015). Operating costs have been determined as 1.2% (Anonim6, 2016). The corporate income tax has been taken as base 20% (Anonim7, 2016). If the electricity has been produced within the scope of renewable energy sources (RES), sales price is taken 7.3 US $ / kW, and sales revenues have been calculated annually.

Results

Sinop, in the middle of the Black Sea, is located between 41 ° 12 'and 42 ° 06' north latitude and 34 ° 14 'and 35 ° 26' east longitude (Anonim8, 2016). Altitude of the province from sea level is just 50m and longitude of province at Black Sea coastline is 175km long (Ceylan, 2010).

Sinop has been established between the two capes named Inceburun and Boztepe. Sinop as can be seen in Figure 2; is founded on a tombolo formed by a merging island and mainland (Ceylan, 2010). To as an example, suitable areas for installation of wind power plant in Sinop can be in figure 2.

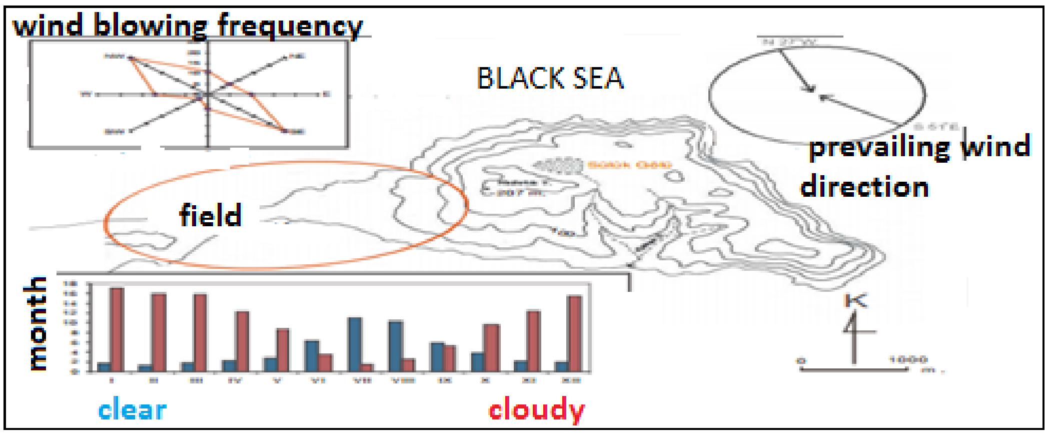

Figure 2: Sinop topography and wind direction (Şahin and Kaya , 2011).

Figure 3 illustrates the distribution of mean wind speeds of 50m. For economic investment, 7 m / s wind speed or over is required. Wind speed in areas with Yellow is 7 m / s. This rate is seen more dominant mostly in north-facing part of the Sinop coast.

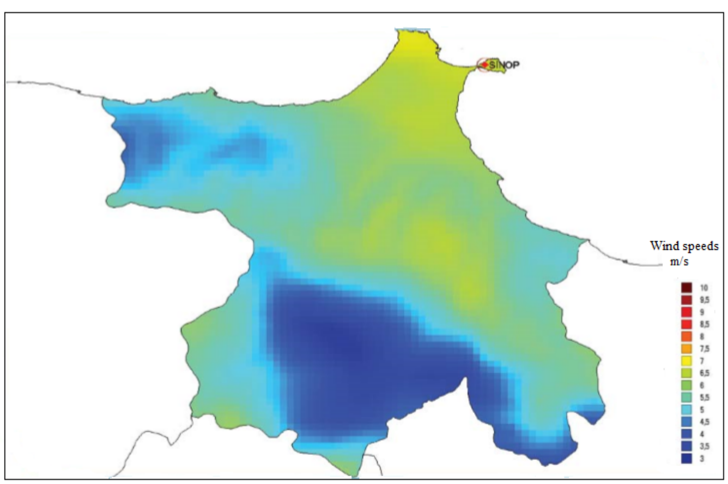

Figure 3: illustrates the distribution of mean wind speeds of 50m (Anonim1, 2016).

 Copyright © The Online Journal of Science and Technology

Although dominant direction is differ from seasons ,it's blows of annual average is northwest and %25.7 In Sinop, it was observed that dominant direction wind. Planning of the wind power plant depends mainly on the amount of energy that can be generated from the power plant site selected. In this study, a point has been determined in Sinop Dibekli village in North Latitude 42.0025513345238 Longitude 35.0127371674451 East coordinates. This point is at an altitude of 78m above sea level and the direction of the point is north-west (Anonim5, 2013).

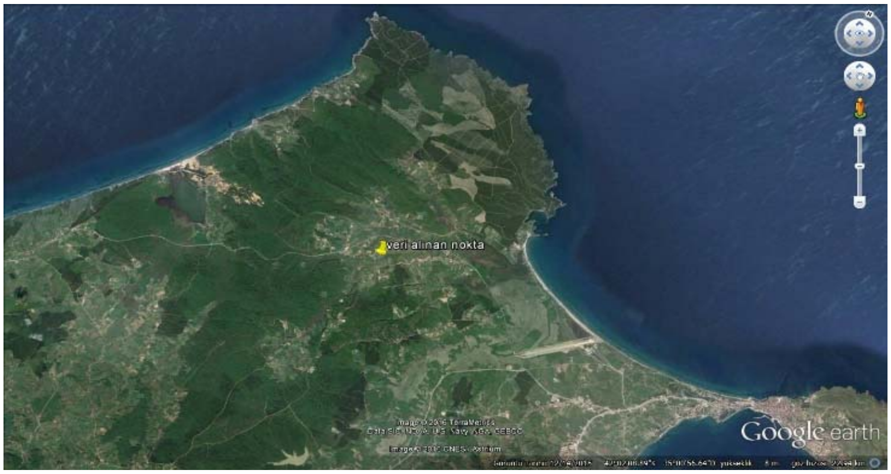

Figure 4: Is given the satellite view of point.

The construction of WPP, wind capacity factor is an effective distribution parameter as well as the wind speed distribution in Sinop, wind capacity factor distributions are shown in Figure 5.

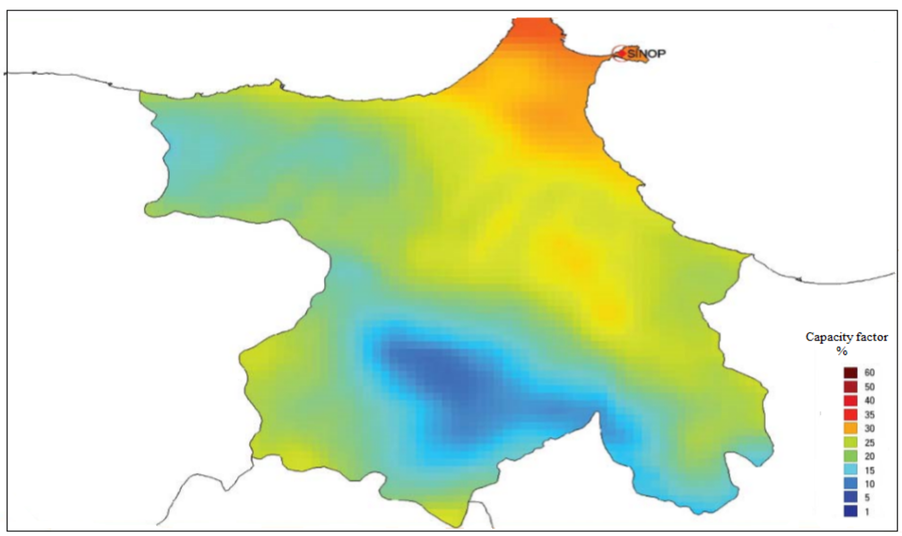

Figure 5: capacity factor distribution in 50m height (Anonim1, 2016).

The average wind speed of Sinop has been calculated as; 5.84 m / s at 30m, 6.42 m / s at 50m, 6,69 m / s at 70m, 6.99 m / s at 100m. With the rise from sea level, wind speed has increased directly proportional. In Figure 6, the prevailing wind direction and frequency information is shown for the relevant point.. In Figure 6, red color shows wind power and the blue color shows the wind blowing frequency. Prior to the installation of wind turbines, one of the important steps is to determine the prevailing wind direction. It is shown in Figure 6 that the prevailing wind direction for the province of Sinop is northwest (NW) and southeast (SE).

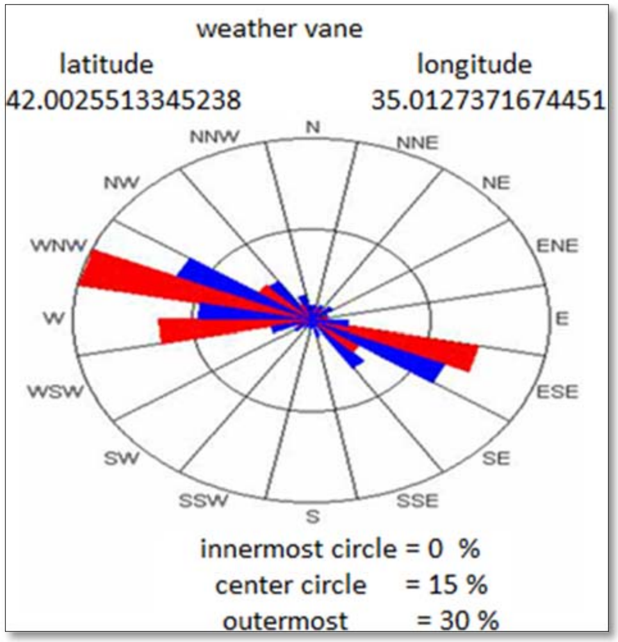

Figure 6: Dominant wind intensity of getting data (Anonim5, 2013).

Weibull C-parameter is; 6.80532 at 30m, 7.24459 at 50m, 7.54666 at 70m and 7.87815 at 100m. Weibull scale parameter (c)'s, is observed to be high similar to the average wind speed at the same height. Weibull k-parameter is 2,12802 at 30m, 2,01701 at 50m, 1,94953 at 70m and 1,88172 at 100m.When the Weibull's parameter is high without too many changes at wind speed shows that the wind blows as a fixed. In wind's force line with the changes occurring in the day, the change in the average power density occur. For Sinop the annual power density 50m and 100m was recorded as 305.12 W / m², 421.27 W / m² respectively. Annual capacity factor; for 50m was realized as 32.471% (Anonim1, 2016). This value is an acceptable level for sustainable Economic WPP investment. For Sinop, energy production based on wind data taken at 50m height is calculated 2,844,492 kWh / year (Anonim5, 2013). Total paid corporation tax realized as 1.038.240 US dollars and it has been reduced from gross income. The net income has been calculated as USD 4,152,598 of WPP considered for establishment in Sinop.

Discussion

In this study, a point has been determined in Sinop Dibekli village in North Latitude 42.0025513345238 Longitude 35.0127371674451 East coordinates. It has been taken annual with speed and direction information of this point. With received data; average speed, direction and energy calculations were performed. It has been investigated as a sample can be installed in a wind power plant in Sinop installation and operating costs have been calculated. Resource (Anonim5, 2013) has been used for place selection of WPP which considered to be established in Sinop. While doing cost analysis at economic analysis are taken into consideration of the nature of the place was founded,distance from the substation,pre-feasibility costs,design costs and so on.It is assumed two different financing models as 100% equity and 25% equity - 75% investment credit would be done and calculations have been made.

In 100% self-owned investment; it has been estimated that fixed investment costs are $ 52,800 per year while annual operating costs are $ 15.840. Annual net profit after expenses are expected to be 97 478 USD. Total profit for 25 years for $ 2,436,958 is to occur, breakeven point will be the 9th year. In 25% equity,75% investment credit model, investment cost varies according to year, realizes as $ 195,360 annually between 3th and 12th years, other years realizes $ 13,200. The net profit calculated on the total income is estimated to be $ 1,605,358, excluding capital increase. The breakeven point is envisaged at 14. years, excluding the capital increase.

Conclusions

As a result of the study, it can be said making an investment using 100% equity would be more profitable WPP investment determined at the point of in Sinop Dibekli village, than 75% credit-based financing model.
For Sinop, energy production based on wind data taken at 50 m height, is calculated 2,844,492 kWh / year.
With the installation of wind power plants; they will reduce dependence on foreign sources to meet Turkey's energy needs and are expected to contribute to increased energy diversity.

References

Acaroğlu M. (2013). *Alternatif Enerji Kaynakları.* Ankara: Nobel Akademik Yayıncılık.
Anonim1 (2016). Enerji Bakanlığı Yenilenebilir Enerji Genel Müdürlüğü, *http://www.eie.gov.tr/YEKrepa/SINOP-REPA.pdf,* (Erişim tarihi: 15.05).
Anonim2 (2016). Av ve Yaban Hayvanlarının ve Yaşam Alanlarının Korunması, Zararlılarıyla Mücadele Usul ve Esasları Hakkında Yönetmelik, *http://www.resmigazete.gov.tr/eskiler/2005/10/20051024-2.htm,* (Erişim Tarihi:15.05).
Anonim3 (2016). Çevresel Gürültünün Değerlendirilmesi ve Yönetimi Yönetmeliği, *http://www.resmigazete.gov.tr/eskiler/2015/11/20151118-4.htm* (Erişim tarihi: 15.05).
Anonim4 (2016). Askeri Yasak Bölgeler ve Güvenlik Bölgeleri Yönetmeliği, *http://www.mevzuat.gov.tr/MevzuatMetin/3.5.835949.pdf* (Erişim tarihi: 15.05).
Anonim5 (2013). *İl Bazlı Rüzgar Enerjisi Potansiyeli Atlası (REPA) noktasal kaynak bilgisi,* Enerji ve Tabii Kaynaklar Bakanlığı EİE Yenilenebilir Enerji Genel Müdürlüğü, Belge tarihi: 27.02.
Anonim6 (2016). Enerji ve Tabii Kaynaklar Bakanlığı EİE Yenilenebilir Enerji Genel Müdürlüğü, *http://www.eie.gov.tr/eie-web/turkce/YEK/ruzgar/ruzgar_turbin.html* ;(Erişim tarihi: 15.05)
Anonim7 (2016). Maliye Bakanlığı Kurumlar Vergisi Genel Tebliği *http://www.gib.gov.tr/fileadmin/user_upload/Tebligler/5520/5520_genteb1_tum.pdf,* (Erişim tarihi: 15.05).
Anonim8 (2016). *Sinop Valiliği.* Sinop Valiliği İnternet Sitesi: www.sinop.gov.tr, (Erişim tarihi: 15.05).
Bacak S, Külcü R, Ekinci K. (2009*). Türkiye ve AB ülkelerinde Yenilenebilir Enerji Kaynakalrı Politikaları ve Hedefler.* Journal of Agricultrucal Machinery Science. 5(1):9-14.
Bayraç HN.(2011*). Küresel Rüzgar Enerjisi Politikaları ve Uygulamaları.* Uludağ Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi. 1:37-57.
Bilgili M, Şahin B, Kahraman A. (2004). *Wind energy potential in Antakya and İskenderun regions, Turkey*. Renewable Energy. 29:1733–1745.
Ceylan MA.(2010). *Türkiye Kıyılarında Tombololarıın Oluşumu Dağılışı ve Fonksiyonel Özellikleri Konusunda Bir Araştırma. Marmara*. Coğrafya Dergisi. 22:205-232.
Erdem O, Batur B, Bilge ZD, Temir G. (2015). *Bozcaada'da Kurulacak Olan Bir Rüzgâr Enerjisi Santralinin Ekonomik Analizi*. Tesisat Mühendisliği Dergisi. 148:22-27.
Genç M, Gökçek M. (2009). *Evaluation of Wind Characteristics and Energy Potential in Kayseri, Turkey.* Journal of Energy Engineering. 135(2):33-43.
Güler, Ö.(2009). *Wind energy status in electrical energy production of Turkey.* Renewable and Sustainable Energy Reviews. 13(2):473–478.
Hayli S. (2001). Rüzgar Enerjisinin Önemi, Dünyada ve Türkiye'deki Durumu. Fırat Üniversitesi Sosyal Bilimler Dergisi Sayı. 11(1):1-26.
Hepbasli A, Özgener O. (2004). *A review on the development of wind energy in Turkey.* Renewable and Sustainable Energy Reviews. 8:257–276.
Kenisarina M, Karslı, V. M., Çağlar, M. (2006*). Wind power engineering in the world and perspectives of its development in Turkey.* Renewable and Sustainable Energy Reviews. 10(4):341–369.
Köse R, Özgür ME, Arif O, Tuğcu A. (2004). *The analysis of wind data and wind energy potential in Kutahya/ Turkey.* Renewable and Sustainable Energy Reviews . 8:277–288.
Oner Y, Ozcira S, Bekiroğlu N. (2009). *Prediction Wind Energy Potential Using by Wind Data Analysis in Bababurnu-Turkey*. IEEE 2nd International Conference on Clean Electrical Power. 232-235.

Saidur R, Rahim NA, Solangi KH. (2011). *Environmental impact of wind energy.* Renewable and Sustainable Energy Reviews. 15:2423–2430.

Şahin K, Kaya M. (2011). *Yerleşimler Üzerinde Bakı Faktörünün Etkisi: Sinop Şehri Örneği.* The Journal of International Social Research. 4(19)382.

Togrul İT, Ertekin C. (2011). *A Statistical Investigation on the Wind Energy Potential of Turkey's Geographical Regions*. Energy Source Part A: Recovery, Utilization, and Environmental Effects. 33(15):1399-1421.

Taşkın B. (2013). *Niğde İlinde Kurulabilecek Rüzgâr Enerjisi Santralinin Fiziksel ve Ekonomik Analizi,* Yüksek Lisans Tezi, Niğde Üniversitesi Fen Bilimleri Enstitüsü.

Zeytinoğlu FÇ.(2009). *Weibull Dağılımının Ölçek ve Biçim Parametreleri İçin İstatistiksel Tahmin Yöntemlerinin Karşılaştırılması.*İstanbul Ticaret Üniversitesi Sosyal Bilimler Dergisi. 73-87.

 Copyright © The Online Journal of Science and Technology