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

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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 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.

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
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

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

(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 / m²) 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).
Although dominant direction is different 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).
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 higher 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 3rd 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 compared to a 75% credit-based financing model for Sinop. Energy production based on wind data taken at 50 m height, is calculated to be 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


