Installation Of 2MW Wind Power Plant In Northern Cyprus: Technical, Economical And Environmental Analysis

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Abstract: The impetus for the work presented here arose from the fact that the demand for renewable energy grows, and the supply of the non-renewable energy is at the decreasing level. An increasing percentage of total energy produced globally is moving to renewable forms. Wind energy enjoys increasing deployment for power generation due to the economic benefits associated with it.Turkish Republic of Northern Cyprus (TRNC) has abundance of renewable energy; it has an average wind speed of 4.30m/s and 5.04m/s at 10m and 50m respectively. The economic analysis of is plant shows that the wind farm has an investment cost of $2300000 with $333217.8 as annual savings. The simple payback was calculated to be 7 years, the savings to investment ratio was found to be 3.62, the net present value turn to be positive while the return on investment was 14.48%.

Keyword: wind plant, economic analysis, turbine, greenhouse gases, renewable energy

1 INTRODUCTION

With the rapid development of the global economy, energy requirements have increased remarkably, especially in emergent countries. The realization that fossil fuel resources required for the generation of energy are becoming scarce and that climate change is related to carbon emissions to the atmosphere has increased interest in utilization of renewable energy [1]. It is imperative to develop a renewable wind system that is free from pollution. Cyprus is the third largest island in the Mediterranean at a latitude of 35 degree, 33 degree longitude with an area of 9251$\mathbf{km^2}$, it has a population of about 750000 inhabitants, with an average wind speed of 4.30m/s and 5.04m/sat 10m and 50m respectively. This wind speed is suitable for powering a wind turbine. Hence, the need of decreasing global warming as well as pollutants associated with energy use, it is imperative to develop a new and incredibly impressive technological innovation industry. However, wind technology is progressively appealing. The output from wind energy sources fluctuate on an hourly, daily, and seasonal basis. As a result, the wind turbines are not well suited for directly powering loads that require a uniform and uninterrupted supply of input energy.

1.1 Energy policy of North Cyprus

Northern Cyprus energy sector depend more on imported fossil fuel. It has an installed capacity of 347MW [6] with 1.2MW coming from renewable (PV plant) source. Unpredicted cost of this fuel coupled with increase in global warming associated with thermal plant pose a great danger in the energy sector. To complement this, renewable energy sources of energy need to be harness for electricity generation.

2 WIND TURBINE PARAMETERS

In order to map the wind resource of any region successfully, there are few main aspects of the wind that need to be quantified. First and most importantly, the speed at which the wind blows needs to be accurately measured over the course of one full year at a minimum. Second, the direction the wind is blowing from needs to be examined. Last, the change in wind speed as a function of height off the ground needs to be explored to give an idea of how the wind speed measurements will scale when interpolating to the wind turbine hub height [4].

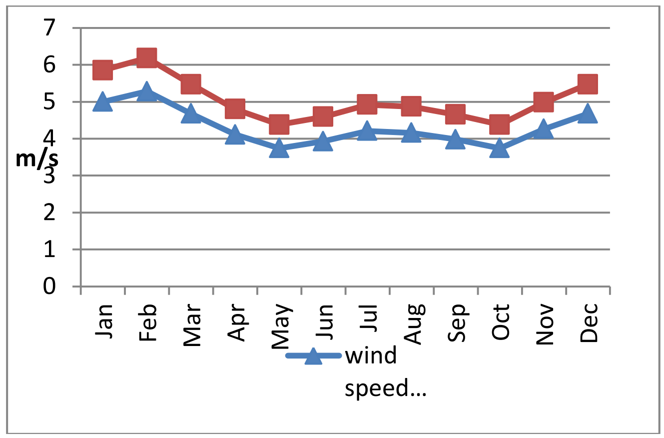

Fig. 1 *Northern Cyprus monthly average wind speed at 10 m and 50m [5]*

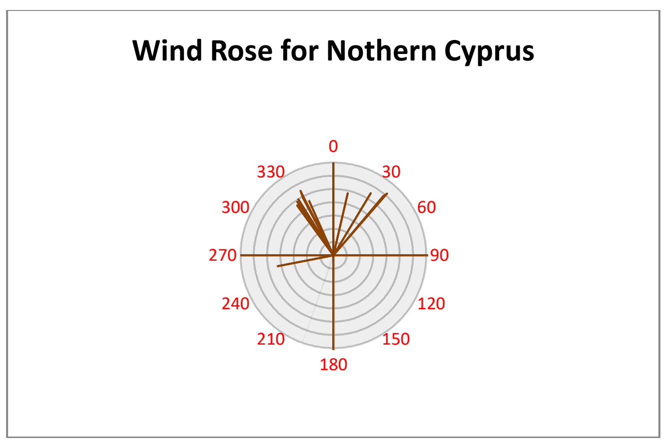

Fig. 2 *Wind rose diagram [5]*

As shown, the prevailing winds are from the north-western directions. It is also shown that these winds are more oriented towards the west (more dense brown lines) than toward the north. In addition, the wind rose also clearly shows that the predominant wind speeds are in the order between 4 m/s to 5 m/s, 6 m/s wind speeds are shown to be rare. Wind turbine selection

TABLE 1: *WIND TURBINE SPECIFICATIONS [3]*

Type	3 blade, horizontal axix
Cut-in speed	3m/s
Cut-out speed	11m/s
Survival wind speed	45m/s
Rated power output	1.3kW
Swept area	6.8m2
Blade diameter	2.9m

Wind turbine with different specification are available in the market. Raum energy wind turbine was selected for this study. The specifications of this turbine are shown in the table above.

2.1 Analysis of the wind farm

TABLE 2: *POWER OUTPUT FROM A SINGLE TURBINE*

Month	Power delivered by the wind turbine in watts at 50m, Cp=0.3	Power delivered by the wind turbine (kWh)
January	243.8	181.4
February	287.5	193.2
March	199.3	143.5
April	134.7	96.9
May	102.3	76.1
June	117.8	84.8
July	145	107.9
August	140.7	104.7
September	122.5	88.2
October	102.3	76.1
November	150.4	108.3
December	199.3	148.3

From the results obtained above, each wind turbine can produce an expected total energy of 1409.4kWh. However, for a wind turbine of 2Mw, 1540 wind turbines are required. Land requirement The expected land area for the installation of the wind turbine can be calculated as follows

Power output = 1540 (1408.4) 0.85 = 1843595.6kWh/year

P_{av}/m^2 = power density/320 = 76.43/320 = 0.2388

0.2388×8760 = 2.092kWh/m^2/year

Land requirement = 1844904.6/2.092 = 881885m^2

3 ECONOMIC ANALYSIS

Investment cost of wind farm varies with the size of the turbine and other cost associated with the project. It is estimated to vary from 900$/kW to 1150$/kW [4]. Other sources shows that the cost can be as high as 1308$/kW to 1400$/kW. 1100$/kW was assumed for this paper. Also, the generation cost of 18 cent/kWh is assumed since the generation cost per kWh of an onshore wind farm ranges from 14 to 18 cent/kWh [4]. The discount rate for the analysis is assumed at 12% and the project lifetime at 25 years. Investment cost = 2000×1150 = $2300000. Cost for generation per annum is calculated as $333217.8.

3.1 Simple payback

This measure is used in calculating how long it will take to recover the initial investment in a cost saving measure.

$$\text{SPP} = \frac{\text{Investment}}{\text{Savings}} = \frac{2300000}{333217.8} = 7 \text{ years}$$

3.2 Present value

Of the project after 25 years can be estimated as

P= A × [P/A, I, N], Where A= Annual savings, P=Present value, I= Discount rate, N= Number of year.

P=333217.8 × [7.8431] =2613460.5

3.3 Net present value (NPV)

NPV=A × [P/A, I, N] – present value cost

NPV= 2613460.5-2300000=313460.5

Saving to investment ratio (SIR): This calculate the present worth of all benefits, then calculate worth of all costs and takes the ratio of the two sums.

$$\text{SIR}=\frac{\text{Lifetime savings}}{\text{Investment cost}}$$

$$\text{SIR}=\frac{333217.8\times 25}{2300000} = 3.62$$

3.4 Return on investment (ROI)

It is the reciprocal of simple payback expressed as percentage. It gives the percentage of investment cost that will be returned annually by savings

$$\frac{\text{savings}}{\text{Investment}} \times 100 = \frac{333217.8}{2300000} \times 100 = 14.48\%$$

4 ENVIRONMENTAL ANALYSIS

As the propellers of the wind turbine rotate, noise is produce which may disturb the people residing around the wind farm. Also, the propeller may kill the birds that may fly around. However, the power plant will reduce greenhouse emission associated with thermal plant.

5 CONCLUSION

This paper describes a 2MW wind farm in Northern Cyprus. The economic analysis shows that the wind farm has an investment cost of $2300000 with $333217.8 as annual savings. The simple payback was calculated to be 7 years, the savings to investment ratio was found to be 3.62, the net present value turn to be positive while the return on investment was 14.48%. From the results obtained, it can be concluded that wind farm is feasible in Northern Cyprus with appreciable annual savings and payback period. Also, it was shown that the plant will reduce the emission of greenhouse gases.

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