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FULL LENGTH ARTICLE **OPEN ACCESS**

Feasibility Study of Wind Power Plant Installation in MALAYER University, Using Approach of Annual Produced Energy

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ABSTRACT

Entering the distributed generation in the power distribution system has many benefits For example, losses reduction, voltage profile regulation, etc. DGs (Distributed Generations) that will be generated using clean sources, as compared to other energy resources, for the operation are priority.. Due to the high price of wind turbines, wind turbines must be installed in the Appropriate site. This site should be appropriate in terms of mean annual wind blowing. In this paper, feasibility study of wind power plant installation is done. Regarding the right place at the University of Malayer and located at the foot of the mountain, the site was studied. Annual energy produced was basis for calculating annual energy produced Power plant.

***Index Terms** : Wind Turbine, Feasibility Study, Economic Evaluation of Energy, Annual Energy Production*

Introduction

Wind energy is a clean and renewable energy from the ancient times until now, has helped many people to do things. Use of renewable resources as an alternative to fossil fuels is highly regarded in the recent years [1],[2]. Distribution systems are usually radial in nature for operational simplicity. The Radial Distribution Systems (RDS) are fed at only one point, which is the substation. The high R/X ratio of the distribution lines results in large voltage drops, low voltage stability and power losses. Under critical loading conditions in certain industrial areas, RDS experiences sudden voltage collapse due to low value of voltage stability index at most of its nodes [3].

placement of wind power plant in the distribution system, will be very useful to prevent voltage drop at the end of the feeder, reducing energy losses and etc. renewable energy sources are granted long-term contracts with predefined feed-in tariffs in order to reduce the risk for investors, and progressively phase out the existing coal-fired generators[9]. Policies have been developed to promote green-energy technologies, including feed-in tariffs, renewable portfolio standards, tradable green certificates, investment tax credits and capital subsidies, among others [4]. In Europe, the UK is aiming for 15% of its electricity to be generated from renewable energy sources by 2015/16, which represents an increase of around 10% compared to the existing share; Germany, with a more aggressive policy, targets a 25–30% share by 2020, and 50% by 2030 [5]. According to the trends observed in 2009 for the EU, nearly 55% of the new installed capacity based on renewable sources corresponds to wind and solar-Photovoltaic (PV) intermittent generation (39% and 16%, respectively) [5]. In the US, the state of California has set a target of 33%for the retail load to be served from renewable sources by 2020 [6], [7]. In Iran, there are policies that support the construction of wind power plants. Economic efficiency of wind energy depends on the following factors:

- Wind resources available
- Costs investment and capital value
- Operation and maintenance costs
- Connectivity of transmission line and network upgrade costs
- The amount of subsidies or incentives available
- Customers tend to pay a premium for wind energy [3]

- With regard to the mentioned above, in the some areas use of in terms of economy, wind turbines are still not affordable.

LOCATION AND SELECTING TYPE OF THE TURBINES

Malayer is located in the southeast of Hamedan province, in the west part of Iran. The site of the Malayer university is selected for the feasibility studies. After selecting the site, the next step is to find the appropriate model of turbine. For this purpose, authors have assisted two wind turbines S47-660KW and SN25KW. The most important and the main characteristics of these turbines are presented in the table 1 [10]:

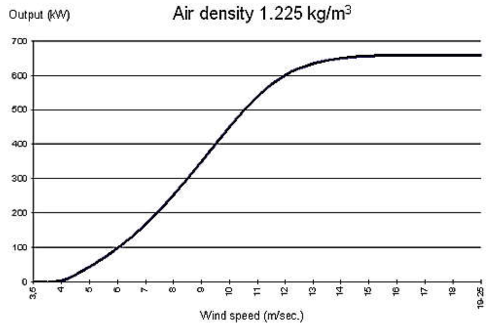

Figure 1. Produced Power of the 25KW Turbine in Different Speeds

Type Of Turbine	25KW	660KW
Rotor Diameter (m)	11.7	47
Number Of Blades	2	3
Swept Area (m^2)	108.4	1735
Tower Height (m)	24	40
Minimum Wind Speed Need To Produce Electricity (m/s)	2.5	4
Production Rate Of Numinal Power (m/s)	10	15
Maximum Permissible Speed (m/s)	25	25

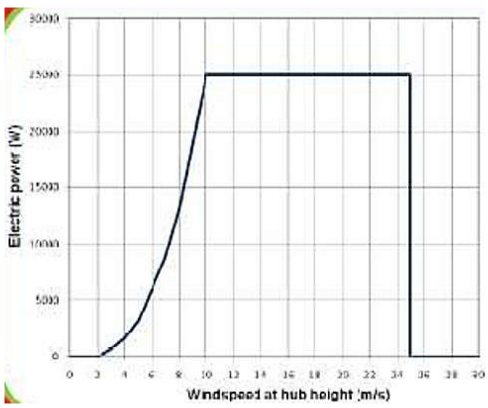

Figure 2. Produced Power of the 660KW Turbine in Different Speeds

WIND STUDY

In this phase of study, some data of the area's wind conditions are required such as wind speed, wind direction, etc. What is certain is that the characteristics of the local climate impact on the turbine's performance.

It is necessary that these studies be performed in some continues years, either to increase accuracy factor and to perform needful studies with comparing wind condition in sequential years. Wind data used for this project are according to the latest data obtained from the meteorological organization of the region and are recorded 8 times in each day in the height 10m, also, to increase accuracy and comparing, these data have been analyzed between 2009 to 2013 for 5 years. As the heights of selected turbines' tower are 24 and 40m, it is need to obtain wind data in these heights. This end is given as the Hellman equation in (1),

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Where h_1 and h_2 are height and v_1 and v_2 are, respectively, the wind speed in the height h_1 and h_2. A is the ratio that its amount is selected due to the region situation, wether desert or not, presence or absence of hills and vegetation type like presence of the dense trees or lack of it, scrub existence, etc., and naturally this ratio is different in various areas such as sea, mountains, deserts, etc. The α ratio in this area is considered 0.21 and has good precision [11].

In next step, to classify wind data, some intervals have been choose with respect to the turbine's type. Then, the data abundance in each interval and the percent of them have been determined. The diagrams of this step are shown in figures 3 to 12:

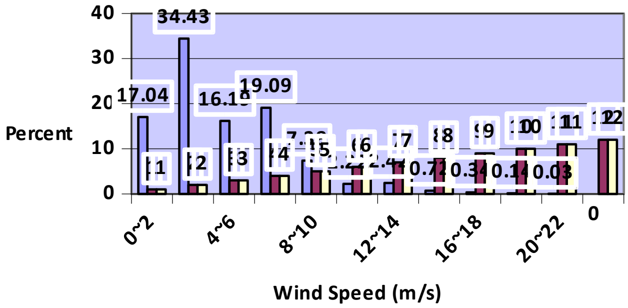


Figure 3. Percent of the Wind Speed in Each Interval for 2009 in the Height of 24m

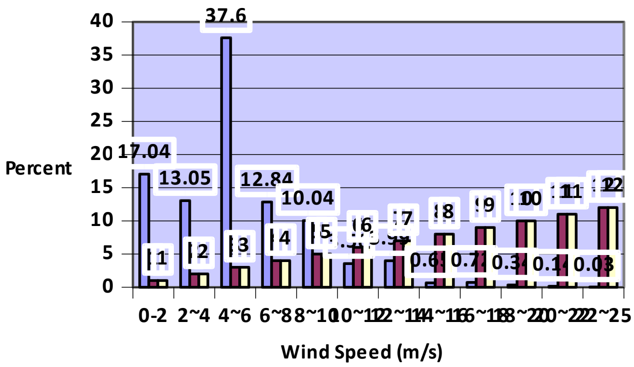
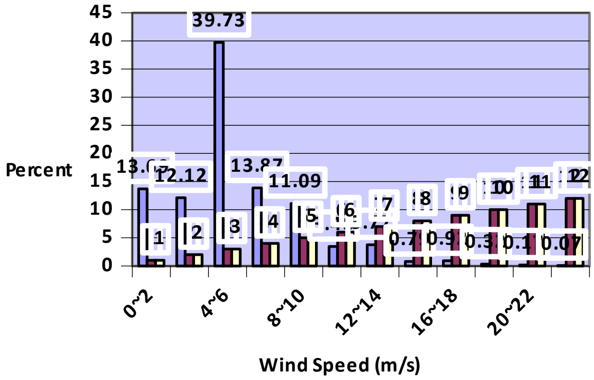


Figure 4. Percent of the Wind Speed in Each Interval for 2009 in the Height of 40m



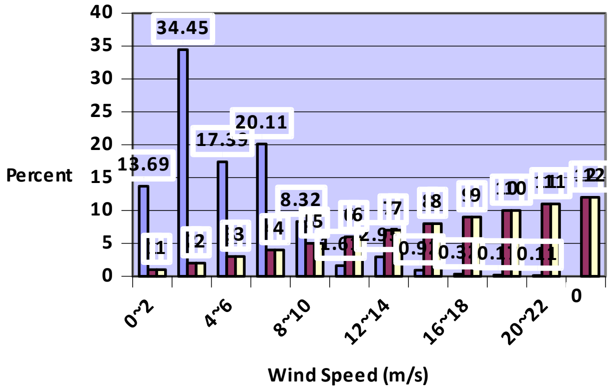


Figure 5. Percent of the Wind Speed in Each Interval for 2010 in the Height of 24m

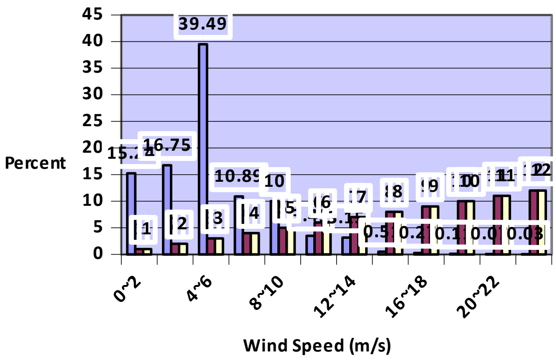


Figure 5. Percent of the Wind Speed in Each Interval for 2010 in the Height of 24m

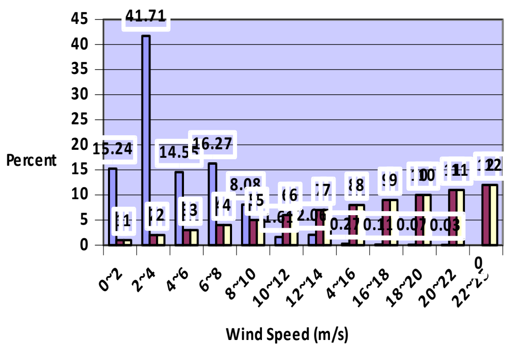


Figure 6. Percent of the Wind Speed in Each Interval for 2010 in the Height of 40m

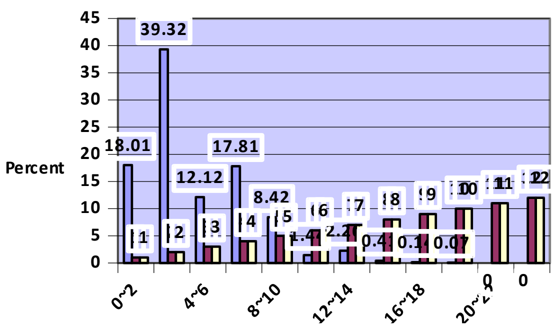


Figure 7. Percent of the Wind Speed in Each Interval for 2011 in the Height of 24m

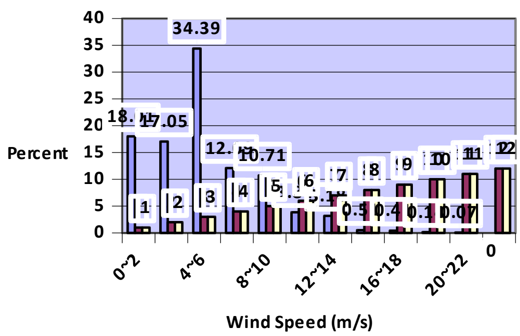


Figure 8. Percent of the Wind Speed in Each Interval for 2011 in the Height of 40m

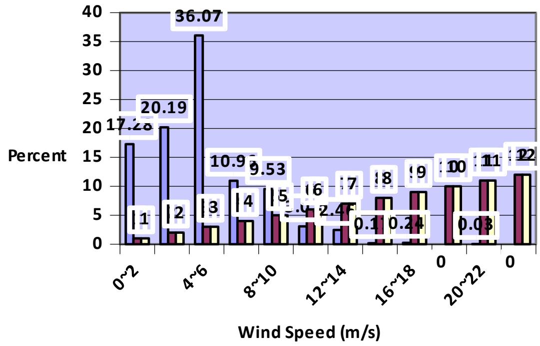


Figure 11. Percent of the Wind Speed in Each Interval for 2013 in the Height of 24m

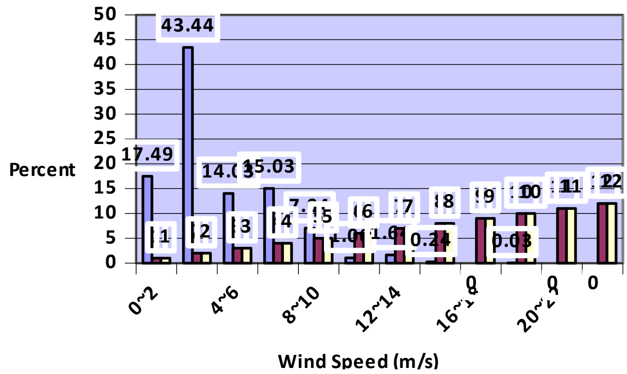
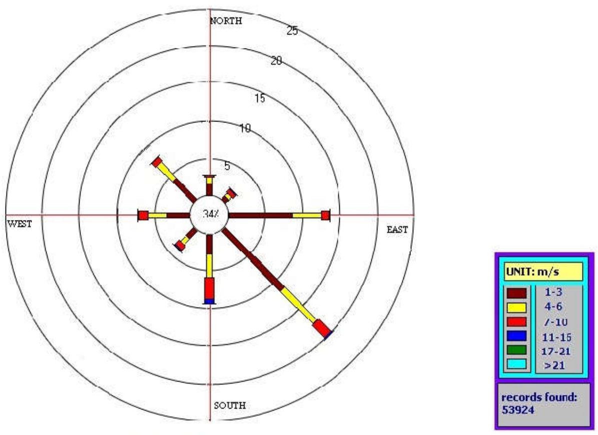


Figure 12. Percent of the Wind Speed in Each Interval for 2013 in

It should be noticed that besides wind speed, wind direction is also of high importance that figure (13) illustrates the wind direction distribution curve.



. Figure. 13. Wind Direction Distribution Curve in the Height of 10m

TURBINES PRODUCED POWER

It explained that The IRR(Rial) is equivalent to 1/30000 USD Or in other words: 1USD = 30000 Rials. By using Figures 3 to 12 and equation (2), the number of the hours in a year which in each interval wind had continued can be found,

$$H = \alpha \times T \qquad (2)$$

Where H is the number of hours in a year which wind continues in each interval, α is Frequency percentage of each interval according to Figures 3 to 12 and T is the total number of hours of the year. The amount of produced power by turbine at each interval can be found using the figures 1 and 2, and the energy produced by turbines at any interval can be obtained by equation (3),

$$E_i = H \times P \quad (3)$$

Where E_i is turbine's produced energy related to each interval in kWh, H is the number of hours in a year which wind continues in each interval in hour and P is the turbine's produced power in each interval of wind data in KW. Finally, by sum the total amount of energy in each period according to (4), Annual energy produced by each turbine can be achieved,

$$\sum E_i = E_{total} \quad (4)$$

The amount of annual energy produced at the height of 24m by 25 kW wind turbine and the amount of annual energy produced at the height of 40m by 660 kW wind turbine in different years is given in Tables 3 and 4 and in Figures 14 and 15.

Table (3): Annual Energy Produced by 25 kW Turbine in Different Years.

year	2009	2010	2011	2012	2013
Annual energy production (kwh)	55998.31	59336.71	50789.93	51624.89	45419.97

Table (4): Annual Energy produced by 660 kW Turbine in Different Years.

year	2009	2010	2011	2012	2013
Annual energy production (kwh)	1130418.2	1189088.6	1006504.8	1036300.2	894719.95

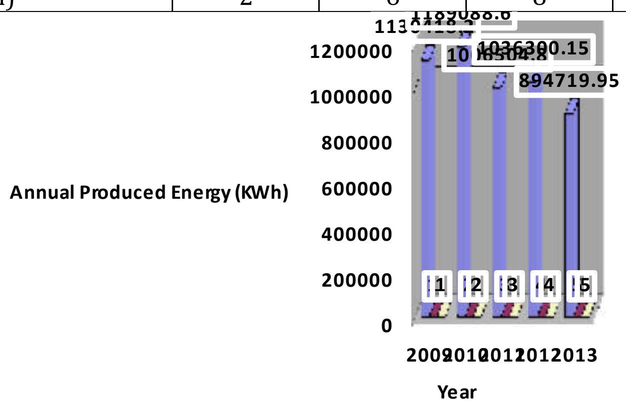


Figure 14. Annual Energy Produced by 25KW Turbine in Different Years

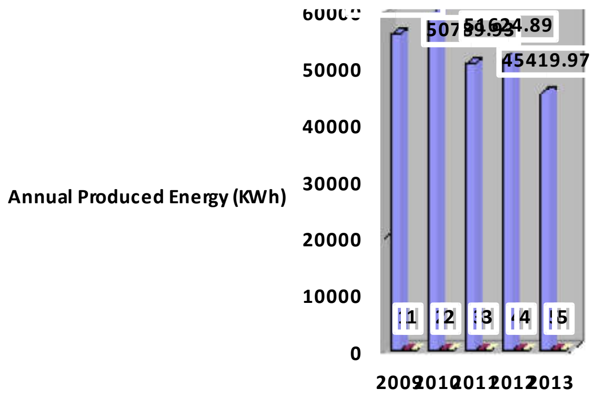


Figure 15. Annual Energy Produced by 660KW Turbine in Different Years

FINANCIAL ASPECTS

EXPENSES

The data obtained from SABA NIROO (Manufacturer of wind turbines in Iran) in the fields of selling equipments, transportation, installation and operation of wind turbine in the years 2013-2014 is shown in table 5.

Table (5): Wind turbine's Buying, Transportation and Operation Expenses in 2013-2014

Columns	Turbine Type	Selling Equipments (Million Rials)	Rent of Crane (Million Rials)	Installation and Operation (Million Rials)
1	25KW	1200	10	100
2	660KW	25000	550	300

As it can be seen, the total expense that should be payed till installation and operation of 25KW and 660KW wind turbines, respectively, equal to 1310 and 25850 million Rials.

REVENUE FROM SELLING ENERGY

According to data published by the Central Bank and the Statistical Center of Iran, the average inflation rate in years 2013 and 2014, respectively, is 25.4% and 31% [12]. Because the inflation rate and the growth amount of inflation rate depends on several factors such as government policies and local conditions; We suggest a 1.5 percent rate of inflation in the last five years to be considered. For the works that will be done in the future, according to the situation and the declared information, economic studies can be repeated at any arbitrary time.

By averaging the energy produced by wind turbines in this period, we can airn the amount of annual energy that could be achieved from wind in this area. Average energy for 25 kW and 660 kW wind turbines, is 52633.962 kWh and 1,051,406.35 kWh, respectively.

Since the purchase price of wind power plants electricity for each kWh in 2013 was 1320 Rials, Due to the growing inflation rate of 1.5 percent purchase produced electricity, the amount of revenue over the 20 years lifetime for 25 kW and 660 kW wind turbines, is 1606472,734.58 and 32090604052.16 , Rials, respectively.

CONCLUSION

Today, in many countries, the public interest in the use of renewable resources and the replacement of fossil fuels with clean energy such as wind, solar, geothermal, hydro, etc has increased. According to this, the increasing use of renewable energy resource in the electricity industry is a long-term agenda for most programs [13]. Before the construction of a wind plant, economic and financial evaluation and also estimation of project costs and revenues, is necessary [2]. Economic analysis on the feasibility step demonstrated that Malayer university wind plant site from economic standpoint is affordable; but we can increase the amount of revenues with using some following suggestion.

To increase the amount of revenues and make the project more economic, following suggestions can be considered.

- Executing supportive policies of wind plant and assign publish penalties to thermal units [14]
- Use of wind turbines with up to date technology and high efficiency with low prices.

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