

Statistical and Simulation analysis of Small Wind Power Forecasting for House hold applications – A Case Study

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Abstract –

The present global scenario is favouring towards renewable energy technologies due to the exhausting of fossil fuels, GHG emissions and global warming.

In this paper, a review has presented to how to plan a wind power technology for a building mounted wind turbines. Site measurement of wind speed requires time and money that often are not available for small micro-generation projects. Analysis of wind speed estimation for the selected area, local weather conditions can affect the planning of wind power plants in isolated areas.

To design wind turbines around numerous high-rise buildings with promising wind, this paper presents an integrated method of weather data and domain topography with technical analysis. This study demonstrates that how the wind power can be integrated in to Green buildings. Finally a study of feasibility of the wind turbine will be analyzed with technical parameters and its implementation.

Key Words: Green buildings, Homer software, Simulation, small wind turbines.

1. INTRODUCTION

To lead a luxurious life in the present era the educated minds in the society have started adopting certain measures which lead to climatic change ,forest fires which further leads to increase in the emission of CO₂ in the atmosphere . The rapid increase in the population worldwide adversely reports in increase in the power demand and it has also resulted in the fast rate of depletion of fossil fuel reserves .At the same time the awareness in environmental degradation has given rise to the use of alternative approach the renewable source of energy like solar, hydro, geothermal, tidal and bio-energy. Out of these above mentioned clean energy sources Wind energy conversion has emerged as a boon in the recent years. The harnessing or trapping of wind power has become easier due to the recent advancement in the technologies with a cost effective plan which challenges the traditional methods. The wind power utilization is the answer to all the problems which are being encountered

globally and it is in the limelight to conserve the conventional energy source[1].

Wind Power

Wind constitutes air which varies in its excited state due to the change in the pressure and other environmental factors and it also carries kinetic energy with it. This kinetic energy is converted into mechanical energy and further to electrical energy by generation. The air circulates in the atmosphere due to the phenomena of non-uniform heating of the earth's surface by the sun. The warm area where the air flows gets expanded and is forced upwards by the cool, denser air which flows in the surrounding area giving rise to wind [2]. The energy accessible in the wind varies as the cube of the wind speed; so it makes a challenging effort in understanding the characteristics of the wind resource and the prediction of the economical viability of wind projects by procuring the feasible wind turbines. The crystal clear fact is that there are many different climatic regions in the world and all the places have different wind variability. The topography has a major effect on the wind climate and it is obvious that more wind is experienced on the top of hills and mountains than in the bottom part .Moreover wind velocities significantly gets reduced by obstacles such as trees and buildings. As discussed earlier the power in the wind is proportional to the cube of the wind speed and is given by:-

$$P = \frac{1}{2} C_p A \rho V^3$$

Where: P = mechanical power

ρ = air density(kg/m³)

A = area swept by the rotor blade.

V = velocity in air(m/sec)

ρ is proportional to A and to the cube of the wind speed v. When we double (A) it may produce twice the power i.e doubling the wind speed produces eight times the power potential[3].

WIND POWER CONVERTORS

Wind power convertors are of two types:-

- Horizontal Axis Wind Turbine.
- Vertical Axis Wind Turbine.

Horizontal axis wind turbine can be of two types:-

Multi-blade type Wind Turbine

The rotor consists of multi blade and is fabricated from the blades that are curved in shape. From the center the width of the blade increases. In modern advancement of technology the rotor is used to drive the reciprocating pump which is usually placed over the well. Therefore the large number of blades provide a high torque which is further required for driving the centrifugal pump even at low speed of wind.

Propeller type Wind Turbine

There are two or three aerodynamic blades connected to the propeller type rotor which are made strong from light weight material. The aerodynamic theory which is used for designing purposes in aircraft is implemented in the design of blade slope [4].

Vertical axes Wind Turbines are of two types:-

Savonius Rotor

It consists of two hollow semi-cylinder fixed to a vertical axis. The cylinders are so placed that they look like in a "S" type structure. The rotor rotates due to pressure difference between the two sides even if the wind flows in the opposite direction.

Darrieus Rotor

Thin curved blades of flexible metal stripes are arranged in such a way that it looks like an egg beater and it will operate with wind coming from any direction.

1.1 Site Selection Process

A comprehensive set of factors and balancing of multiple objectives are considered for site selection of large wind turbine. A complex array of critical factors drawing from physical, demographical, economic, policies and environment disciplines Geographic Information System (GIS) is considered as useful computer based tools for spatial description and manipulation .GIS forms the basis of decision support system.

Multi Criteria Decision Methods (MCDM) is the techniques adopted in the various approaches of decision analysis. These are represented by various quantities, weighting scheme, constraints, goals, utilities and other parameters MCDM results are used to map the spatial extent of the best areas or index of land suitability [5].

1.2 Selection of Wind Turbine Generator

The limiting factor in wind turbine lies in their generator technology. There are mainly 3 types of wind turbine generators which are DC, AC Synchronous and AC asynchronous. All these can be run at fixed or variable speed. As we know that wind power is fluctuating in nature so it is advantageous to operate the generator at variable speed which will reduce the physical stress on the blades of the turbine, which will improve the aerodynamic efficiency.

After careful study of the possibility of wind generation in the locality with the use of NASA website the exact wind turbine can be procured this will be the most suitable one.

After careful study of the possibility of generation of solar and wind power; there is plenty of potential is there in GIET campus. For this a proto type solar-wind hybrid system is planned and analyzed with simulation approach. With some basic research on best suitable wind turbine to our project model we have selected a 400w with the following technical specifications

A 1 kw solar PV power generation system has been installed in administration block with the following specifications. A complete load survey also conducted to know the load pattern of 1 kw solar PV system. After collecting the data from various sources we have calculated and analyzed the load pattern and load curves of various rooms and checked with HOMER software for accuracy. To check the validity of wind power in GIET campus a 400 W of wind turbine has to be erected for experimental purpose. After observing one year data a decision has to be taken for the installation of 100 kw wind power plant in GIET campus.

1.3 ENERGY AUDITING AND LOAD SURVEY PROCESS

For the installation of solar panel we took energy audit and details have taken by batch No. 10 in order to calculate the number of loads and its power consumption. Here we considered all types of loads such as lights, fans etc. in administration block.

By taking the account of monthly wise we observe that there is more power consumption in between February to May due to summer season. From august to December there is moderate power consumption due to winter season and puja vacation. From May to June there is summer vacation, so at that time we consume less power. January, June and July are the months in which exams take place, so less power consumption take place than other months. By analyzing and taking the above data we simulate it through HOMER software.

Table 1: Daily load pattern at administration block

Hour	Load (kW)	Hour	Load (kW)
00:00 - 01:00	0.000	12:00 - 13:00	0.560
01:00 - 02:00	0.000	13:00 - 14:00	0.100
02:00 - 03:00	0.000	14:00 - 15:00	0.100
03:00 - 04:00	0.000	15:00 - 16:00	0.100
04:00 - 05:00	0.000	16:00 - 17:00	0.560
05:00 - 06:00	0.000	17:00 - 18:00	0.560

06:00 - 07:00	0.000	18:00 - 19:00	0.560
07:00 - 08:00	0.000	19:00 - 20:00	0.300
08:00 - 09:00	0.100	20:00 - 21:00	0.300
09:00 - 10:00	0.560	21:00 - 22:00	0.100
10:00 - 11:00	0.560	22:00 - 23:00	0.000
11:00 - 12:00	0.560	23:00 - 00:00	0.000

Primary load input

Here we have to first choose type of load. The load type is AC. After that 24 hourly values entered in the load table of every month. Each of 24 values in the load table is the average electric demand for a single hour of the day. The above Fig No. 6.3 show how the primary load gives result.

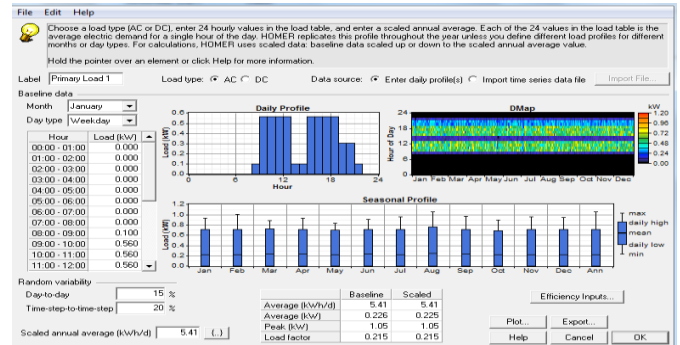


Fig No. 3 Primary load input

2. Modeling hybrid system with Homer software

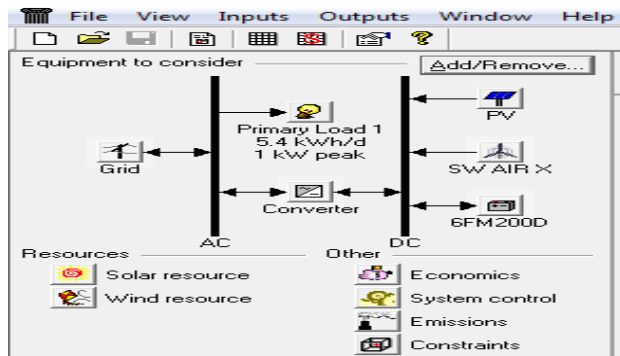


Fig No. 1 Home page of homer

Home page of homer

At first we have to click on the add or remove bar for choosing our equipment. A lot of equipment are shown in a window which is appeared like Fig No: 1. We have to choose equipment according to our requirements. As per our requirements we take one primary load, one converter, one battery, one PV, wind and a Grid. The below Fig No. 6.2 will shows how to add or remove equipment for simulating purposes.

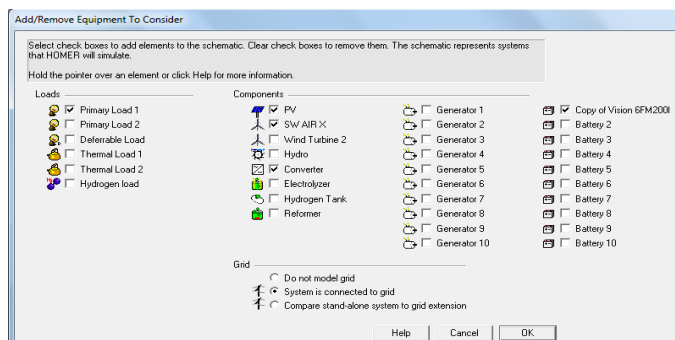


Fig No. 2 Add or remove equipments for simulating purposes

PV input

PV is one of the equipments we select. Here we have to put size of the PV according to peak load. We have to also enter the cost and replacement value according to the size of PV. Here we got the curve between cost and size. The above Fig No. 5.4 shows that, its life time is 20 years.

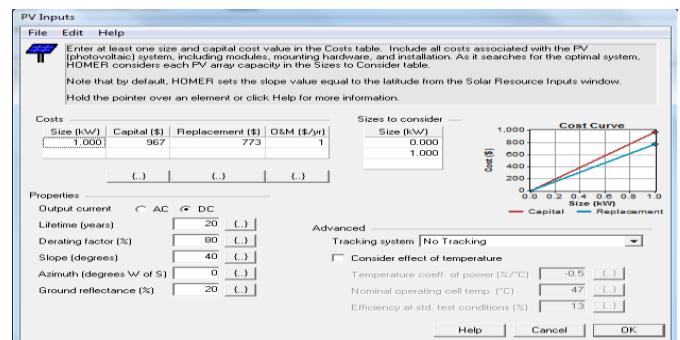


Fig No. 4 PV input

Solar resource input:

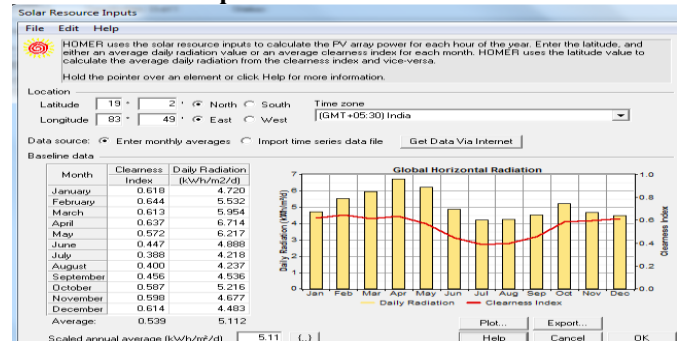


Fig. 5 Solar Resource at Gunupur

Using this window will specify the latitude and the amount of solar radiation available to the photovoltaic (PV) array throughout the year. HOMER uses this data to calculate the output of the PV array each hour of the year.

Latitude

The latitude specifies your location on the earth's surface. it is an important variable in solar calculations. it is used when calculating radiation values from clearness indices, and vice versa. it is also used to calculate the radiation incident on a tilted surface.

Baseline data

The baseline data is the set of 8,760 values representing the average global solar radiation on the horizontal surface, expressed in kwh/m², for each hour of the year. Homer displays the monthly average radiation and clearness index of the baseline data in the solar resource table and graph.

There are two ways to create baseline data: you can use homer to synthesize data, or you can import hourly radiation data from a file.

Wind turbine input

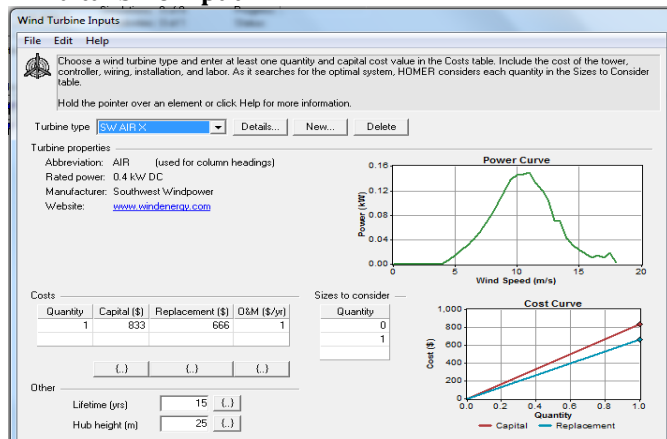


Fig. 6: wind turbine input

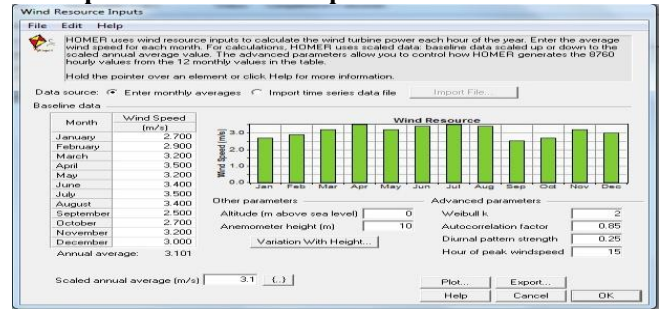
Wind turbine model has selected according to the company's quotation. A 400 w wind turbine has selected for the experimental purpose.

NASA website database of Gunupur area will provide exact information on wind speed. Table 2 shows the monthly wise data of wind speed in Gunupur.

Table 2: NASA data base of Gunupur wind speeds

Month	Air temperature	Relative humidity	Wind speed
	°C	%	m/s
January	21.7	56.7%	2.8
February	24.0	60.4%	3.0
March	26.9	58.8%	3.6
April	28.2	64.5%	3.9
May	28.8	70.0%	3.6
June	28.3	78.0%	3.8
July	27.4	81.0%	4.0
August	27.1	81.4%	3.8
September	26.8	80.5%	2.9
October	25.7	74.9%	2.9
November	24.0	60.3%	3.5
December	22.0	52.5%	3.2
Average	25.9	68.3%	3.4

Wind penetration at Gunupur



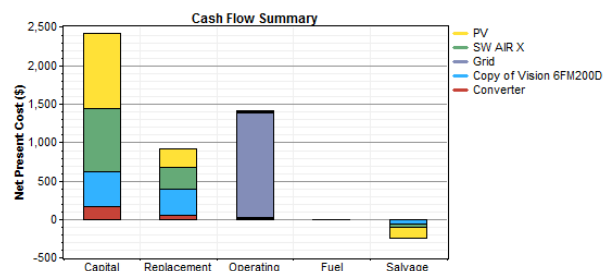
3. SIMULATION OUTPUT REPORT

System architecture

System architecture

PV Array	1 kW
Wind turbine 1 SW AIR X	
Grid	1,000 kW
Battery	2 Copy of Vision 6FM200D
Inverter	1.5 kW
Rectifier	1.5 kW

Cost summary includes all the expenditure throughout the project. It includes total net present cost; cost of energy and Operating cost details is given. Cost summary also includes cash flow summary which gives detail information about PV, grid, battery and converter net present cost. Here different color shows different net present cost of PV, grid, battery and converter which includes capital, replacement, and operating, fuel and salvage cash flow.



Net Present Costs

Component	Capital (\$)	Replacement (\$)	O&M (\$)	Fuel (\$)	Salvage (\$)	Total (\$)
PV	967	241	13	0	-135	1,086
SW AIR X	833	278	13	0	-52	1,072
Grid	0	0	1,363	0	0	1,363
Copy of Vision 6FM200D	451	337	13	0	-45	755
Converter	161	53	13	0	-10	217
System	2,412	909	1,414	0	-242	4,493

Electrical power production and consumption

Every year we got maximum electrical power from PV array and purchased moderate power from grid to fulfill our load profile. Detail information is given.

Below result shows monthly average electric power production in a year. Here PV is represented in yellow color and grid is represented in gray color. Here colors represent PV and grid power consumption in kw every month.

Particulars	Cost
Total system cost	1,48,000 Rs/-
After subsidy	1,03,600 Rs/-
No. of units generated from solar panel	1527 kwh
No. of units generated from wind turbine	84.5 kwh
Each unit rate by considering maximum demand rate and diesel generator option.	9 Rs/-
Total revenue from solar power	$1612 \times 9 = 14508$ Rs/- year
Payback period	10 years (without considering net metering option)

Here, the wind turbine power generation is very low comparing to its cost. If the wind turbine capacity is more the number of units generated will be more. As a rule of thumb; If a 5kw wind turbine preferred; then the number of specific units generated will be much more than the 400 w unit. Hence they pay back period will be less.

4. Conclusion

The accurate assessment of solar and wind potential for an area requires both the knowledge of probability density function and the power density of both solar and wind. For this purpose, for the area of interest are required databases that to contain direct measurements of solar and wind parameters recorded during at least one year. But, Site measurement of these information requires time and money that often are not available for small micro-generation projects. Analysis of solar power availability and wind speed estimation for the selected area, local weather conditions can affect the planning of hybrid systems. This multiplicity of factors makes it difficult to generalize a wind resource estimation methodology for the solar assisted hybrid system which is integrated with wind.

In this paper an analysis has being carried out with a 1 kW solar PV system and 400 w wind turbine is going to be installed at GIET campus. By analyzing all factors with simulation software called Homer a complete economic analysis methodology has been suggested. The results obtained are very encourageable to plan for further future projects.

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