Assessing the possibility and economical considerations of solar- wind based hybrid power generation in Green buildings

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Abstract - *The present power crisis and global scenario trend is favouring renewable energy sources like solar and wind power. Renewable energy technologies are clean sources of energy that have a much lower environmental impact than conventional energy technologies.*

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.

In this Paper a methodology has been developed to how to assist an existing Solar system with Wind power. This study will demonstrate the importance of Hybrid system applicable to a green building. A simulation analysis will identify the rating of the wind generator and its financial viability.

Key Words: *Solar, Wind, Hybrid systems, Homer Software, Simulation methodology*

1. INTRODUCTION

As convention fossil fuel energy sources diminish and the world's environmental concern about acid deposition and global warming increases, renewable energy sources (solar, wind, tidal, biomass and geothermal etc) are attracting more attention as alternative energy sources. These are all pollution free and one can say eco friendly. These are available at free of cost.

In India wind and solar energy sources are available all over the year at free of cost whereas tidal and wave are costal area. Geothermal is available at specific location. To meet the demand and for the sake of continuity of power supply, storing of energy is necessary.

The term hybrid power system is used to describe any power system combine two or more energy conversion devices, or two or more fuels for the same device, that when integrated, overcome limitations inherent in either.

1.1 Range and type of Hybrid systems:

Usually one of the energy sources is a conventional one (which necessarily does not depend on renewable energy resource) powered by a diesel engine, while the other(s) would be renewable viz. solar photovoltaic, wind or hydro. The design and structure of a hybrid energy system obviously take into account the types of renewable energy sources available locally, and the consumption the system supports. For example, the hybrid energy system presented here is a small-scale system and the consumption of power takes place during nights, so the wind energy component will make a more significant contribution in the hybrid system than solar energy. Although the energy produced by wind during night can be used directly without storage, a battery is needed to store solar and wind energy produced during the day.

In addition to the technical considerations, cost benefit is a factor that has to be incorporated into the process of optimizing a hybrid energy system. In general, the use of wind energy is cheaper than that of solar energy. In areas where there is a limited wind source, a wind system has to be over-dimensioned in order to produce the required power, and these results in higher plant costs.

It has been demonstrated that hybrid energy systems (renewable coupled with conventional energy source) can significantly reduce the total life cycle cost of a standalone power supplies in many off-grid situations, while at the same time providing a reliable supply of electricity using a combination of energy sources. Numerous hybrid systems can be integrated and these are as follows:

1. Diesel-PV,
2. Wind-PV,
3. Microhydel-PV,
4. Biomass-Diesel systems
5. Diesel-PV etc.,

1.2 Solar-wind Hybrid controller

Hybrid system is composed of two types of energy sources namely wind and the solar so we must be familiar with the parameters that it has to satisfy without any problems such as :-

- Large scale integration of wind energy into electricity grids.
- Predictability i.e. possibilities of wind & solar power generation for a particular area.

- Design and operation of power systems
- Grid infrastructure.
- Electrical energy storage system.

A large number of issued need to be addressed to faceplate large amount of wind energy successfully as wind power has some specific characteristic such as variability and geographical distribution. These issues includes: design and operation of the power system, grid infrastructure, storage option and manufacturing capacity ramp up.

2. Simulation results of Hybrid system

After careful study of the possibility of generation of solar and wind power; there is plenty of potential for wind power 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, a 400w wind turbine has selected with the following technical specifications.

A 1 kw solar PV power generation system has been installed in a green building 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, 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, project can be extended for a major wind turbine of 100kw to 250kw.

2.1 ENERGY AUDITING AND LOAD SURVEY PROCESS

For the installation of solar panel we took energy audit and details have taken 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 vacation. From May to June there is summer vacation, so at that time less power will be consumed. 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 2.1 will gives an estimation of the load which is connected to solar and wind hybrid system. These results are obtained by observing the load pattern of the system for one year. Hence, the data is a realistic one which will gives an exact solution to interconnect to the hybrid system.

Table 2.1: 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

2.2 Modeling hybrid system with Homer software

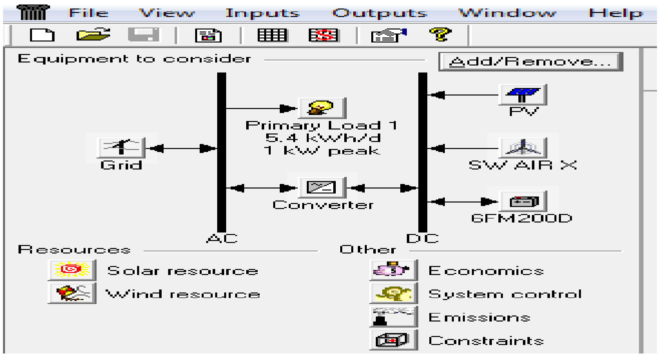


Fig. 2.1: Home page of homer

Home page of homer

To select the devices, click on the add or remove bar for choosing our equipment. According to our requirment choose the equipment with select option. As per the requirements; the selection is one primary load, one converter, one battery, one PV, wind and a Grid. The below Fig No. 6.2will shows how to add or remove equipment for simulating purposes.

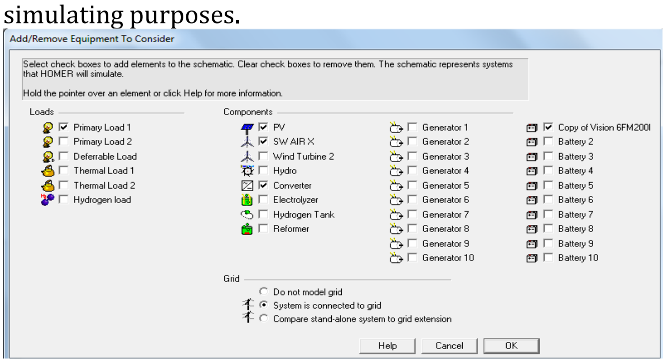


Fig No. 2.2: equipments for simulating purposes

Primary load input

By choosing the type of load; load pattern has to be entered in to the baseline data. Each of 24 values in the load table is the average electric demand for a single hour of the day. The Fig No. 3.3 show how the primary load gives result.

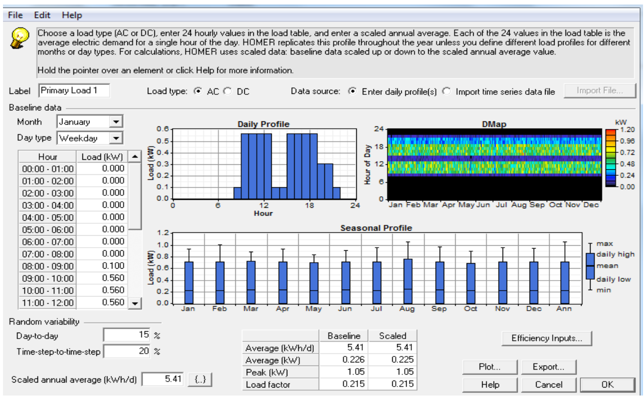


Fig No. 3.3 Primary load input

PV input

By entering the size of the PV 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. 3.4 shows that, its life time is 20 years.

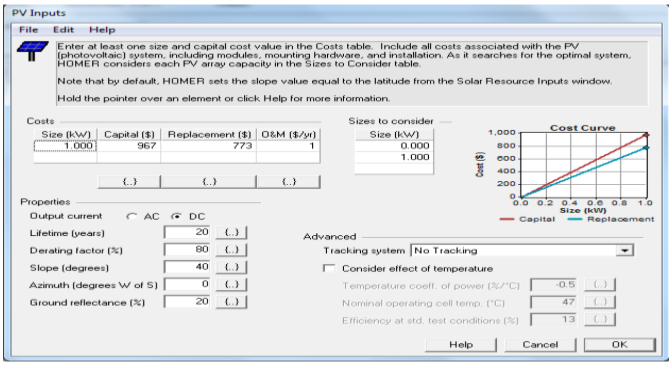
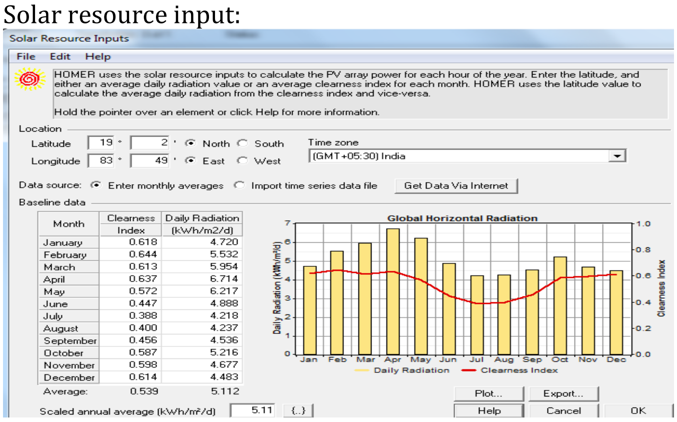


Fig No. 3.4 PV input

Solar resource input:



Month	Clearness Index	Daily Radiation (kWh/m2/d)
January	0.618	4.720
February	0.644	5.532
March	0.613	5.954
April	0.637	6.714
May	0.572	6.217
June	0.447	4.888
July	0.388	4.218
August	0.400	4.237
September	0.456	4.536
October	0.587	5.216
November	0.598	4.677
December	0.614	4.483
Average:	0.539	5.112

Fig. 3.5 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

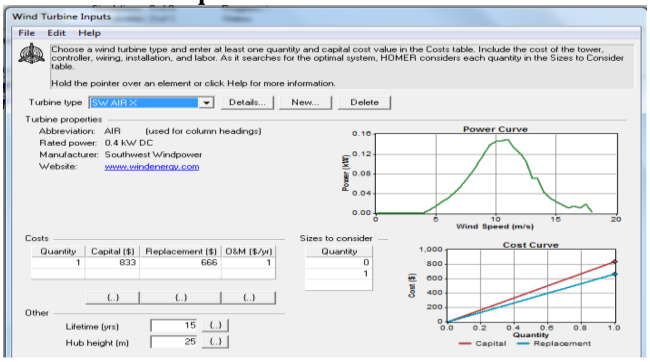
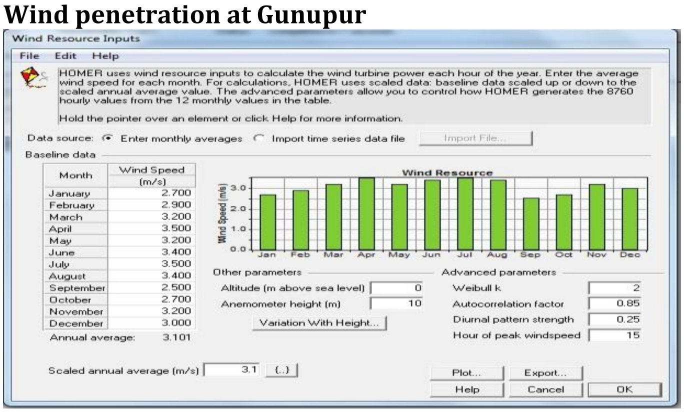


Fig. No. 3.6: Wind turbine input

Wind turbine model has selected according to the turbine specfications. A 400 w wind turbine has selected for the experimental purpose.

Wind penetration at Gunupur



Month	Wind Speed (m/s)
January	2.700
February	2.900
March	3.200
April	3.500
May	3.200
June	3.400
July	3.500
August	3.400
September	2.500
October	2.700
November	3.200
December	3.000
Annual average:	3.101

Fig. No 3.7: Wind avialbility in Gunupur

Fig, 3.7 will indiactes the wind avialbity in Gunupur. By entering the data in the table it will anlyze the wind aviablity for the given period.

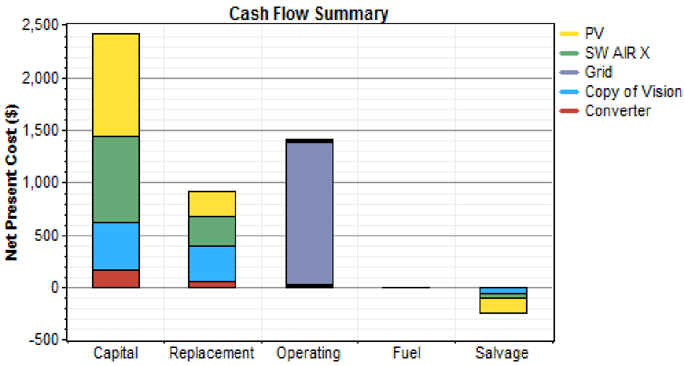
Wind density is an important parameter for the generation of power. Average power denisty will gives clear idea about the power genration.

4 SIMULATION OUTPUT REPORT

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

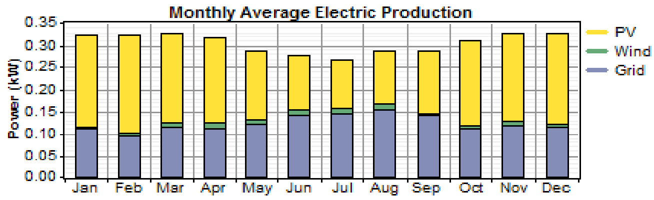
Electrical power production and consumption

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.

Electrical

Component	Production (kWh/yr)	Fraction
PV array	1,527	57%
Wind turbine	85	3%
Grid purchases	1,066	40%
Total	2,677	100%



PV output

PV

Quantity	Value	Units
Rated capacity	1.00	kW
Mean output	0.174	kW
Mean output	4.18	kWh/d
Capacity factor	17.4	%
Total production	1,527	kWh/yr

Quantity	Value	Units
Minimum output	0.00	kW
Maximum output	1.05	kW
PV penetration	77.3	%
Hours of operation	4,355	hr/yr
Levelized cost	0.0556	$/kWh

Wind Out put:

DC Wind Turbine: SW AIR X

Variable	Value	Units
Total rated capacity	0.400	kW
Mean output	0.00965	kW
Capacity factor	2.41	%
Total production	84.5	kWh/yr

Variable	Value	Units
Minimum output	0.00	kW
Maximum output	0.149	kW
Wind penetration	4.28	%
Hours of operation	3,966	hr/yr
Levelized cost	0.992	$/kWh

6.5 Payback analysis:

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 × 9 = 14508 Rs/- year
Payback period	10 years

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.

3. CONCLUSIONS

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 installed in a Green building. 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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