

Hybrid Power System Design using Homer Pro

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Abstract--- The demand for commercial building increases day by day depending upon their requirements. In this paper, a standalone Hybrid Power system for an entire commercial classroom complex has been designed which includes general purpose classroom, labs with low power rating instruments, heavy load driving machines etc., The sizing of Hybrid system using HOMER software is illustrated in this paper. The designing of micro grid includes PV panel and Wind turbine installation and a converter which increases the installation cost but reduces the amount payable to grid.

I. INTRODUCTION

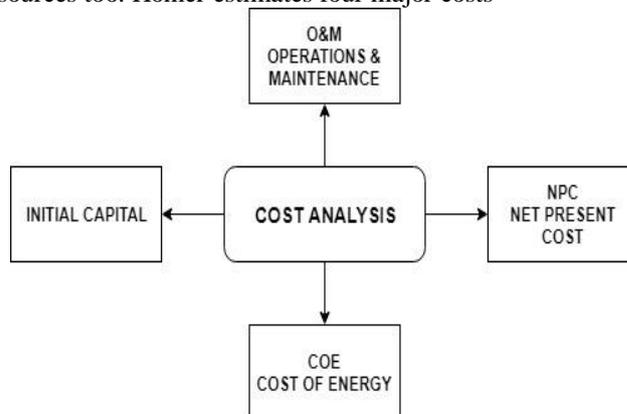
The usage of conventional energy sources increased globally, but we can't rely only on conventional source of energy which includes coal, petroleum and Gas which is the verge of depletion over the years. These sources tend to produce greenhouses gases which pollutes the air and land. To avoid these problems, we use alternate sources such as Solar, wind, thermal power etc., [1,2]. Over the years researches have proven that Hybrid system with grid connectivity has been more efficient than standalone system[3]. Here we use Homer software to design a microgrid to solve the energy crisis of a particular chosen area [4,5]. In [6] a micro grid was modeled for a milk factory in Arabian country, Iran. The case study showed that the COE(cost of energy) and CO₂ emissions were reduced in case of micro grid on comparing with conventional design. The cost of equipment for renewable energy sources is usually high. Hence, we use hybrid system which comprises of PV panels and Vertical axis wind turbine combined with the battery bank for sufficient energy supply without any interruption. A clear cost analysis has been done based on our requirements [7]. Various software's are available for designing and sizing hybrid energy system including HOMER, HOGA, ORIENTE, and HYBRID2 [8,9]. This paper mainly deals with the use of HOMER software to get an optimized result with cost efficiency and to overcome the energy crisis [10].

II. INTRODUCTION ABOUT HOMER PRO

HOMER (Hybrid Optimization Model for Multiple Energy Resources) is an optimization tool used for designing micro grid developed by National Renewable Energy Laboratory in

TheUSA. This software can be used to design micro grid for all sectors ranging from a small village to industries connected to grid. The various resources are available in this

utilization software mainly the seasonal and annual variation for each and every available Renewable sources of Energy including solar irradiation data, wind force at a particular location and its efficiency data's can be downloaded from a resources column and available for all other renewable sources too. Homer estimates four major costs



Homer helps to optimize for different load condition and the supply systems. Supply System includes PV, Wind, Biogas, Generator, Converter, Battery, Hydro power, Hydro kinetic and grid supply and net energy costs could be easily calculated.

HOMER tests various combinations for the given input, and then gives the optimized output. HOMER makes it possible to compare the various results obtained. This allows us to select the feasible design in terms of cost, space availability etc.

III. SYSTEM DESCRIPTION

On the basis of system design it is essential to optimize the size of the hybrid system to make it cost efficient. To start with System sizing we need to consider the energy usage and demand of the particular chosen commercial building (Load Profile). Therefore they are presented in the following sections,

Load Profile

The Fig.1 illustrates the load consumption data of the commercial building for a day. The readings are recorded in a periodic manner.

As a casestudy, the average energy consumption of the commercial classroom complex was scaled to 500 kWh/d with peak consumption of 270.09 kW in the present study.

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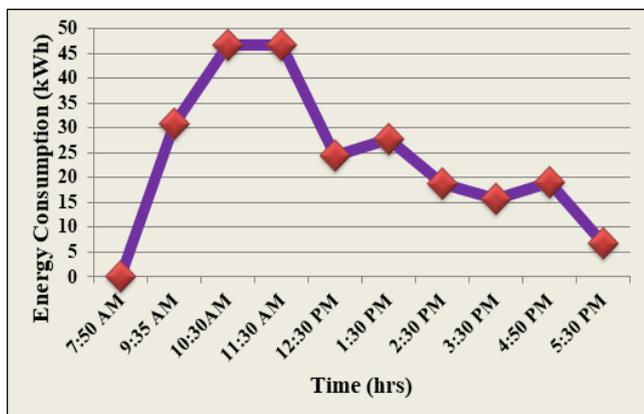


Fig.1: Hourly load data

Solar Radiation and Wind Speed Data

The resources for the selected renewable sources were collected using the Homer resources tool for the location Potheri, Thailavaram, Tamil Nadu 603203, India (12°49.6'N, 80°2.4'E). The above collected data is used to estimate the performance of various components used in the designed hybrid Power system to fulfill the load requirements of a commercial classroom complex. As shown in Fig.2 the average solar radiation ranges from 4.988 kWh/m²/d to 6.609kWh/m²/d over a year. Fig.3 depicts the monthly average wind speed ranging from 3.660 to 4.680 (m²/s).

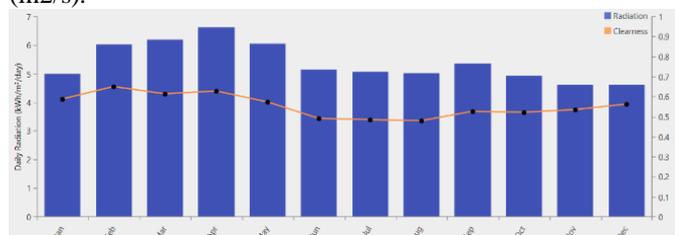
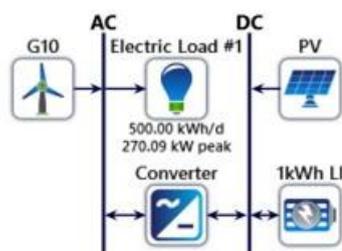


Fig.2: Solar Radiation Data



Fig.3: Wind Speed Data)

Description of System Components



PV Panels -PV panels are of mono-crystalline silicon flat plate type with the life time around 20 years and maximum efficiency of 17% .The Purchase price of 1kWh panel is about 48,000 without including the battery and a converter as the estimation of which will be provided in the upcoming sections. The replacement cost is about14,000;The maintenace price is reduced at 4,800/year.The output of pv graph is shown in Fig.4

Vertical Axis Wind Turbine -Usually the commercial building will have more than 4 floors such that the wind speed will be more in the ground level.So we prefer Vertical Axis Wind Turbine(VAWT) considering its efficiency and its operation,Then the notable thing is that it operates for any wind direction provided in a area.Here we add a generic 10kW Wind turbine of cost 4,00,000 and the operating and maintenance costs add up to 4,000/year;The replacement cost for a wind turbine will be around 1,20,000.Fig.5depicts wind energy output andFig.6 illustrates the windturbine power curve.

Battery –For this hybrid system we use lithium ion type battery and their characteristics are 1000Ah with a nominal voltage of 12v capacity. The purchase price is of 4500/battery ,the initial state of charge is considered to be 100%.The replacement cost will be around 1000/battery;The O&M cost includes 3000/year.The output of battery is given in Fig.7

Converter – The basic converter is of 300kW as our peak demand is around 270kW.The Single converter of 300kW is used in this hybrid system having the purchase cost of 1,40,000 and their lifetime is around 20years.The converter output is shown in Fig.8.

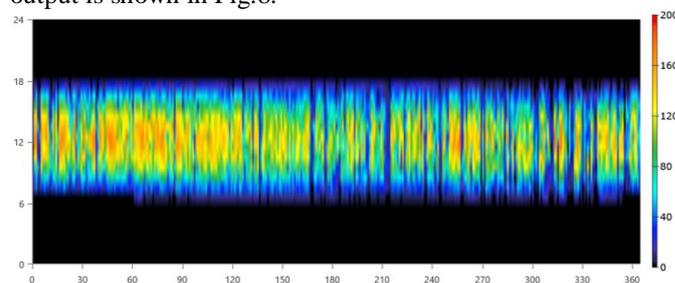


Fig.4: Generic flat plate PV output

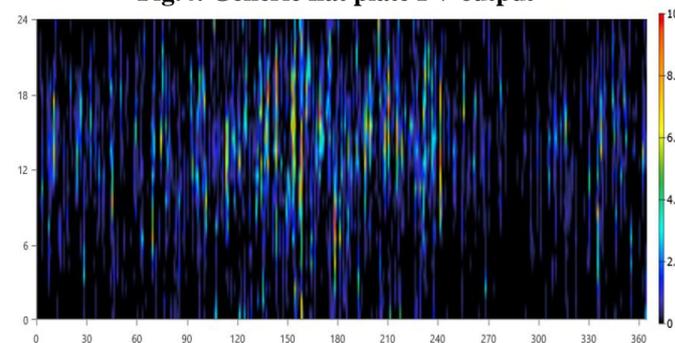


Fig.5: Generic 10kW VAWT output

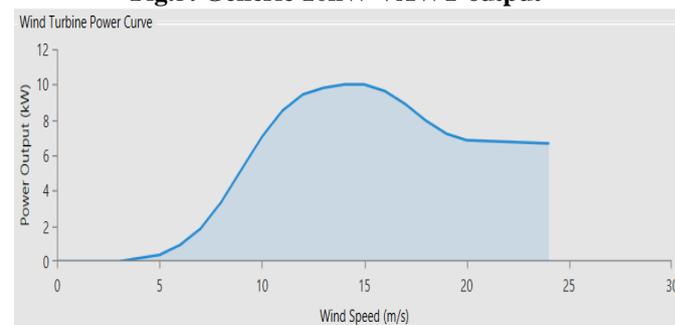


Fig.6: Wind turbine power curve

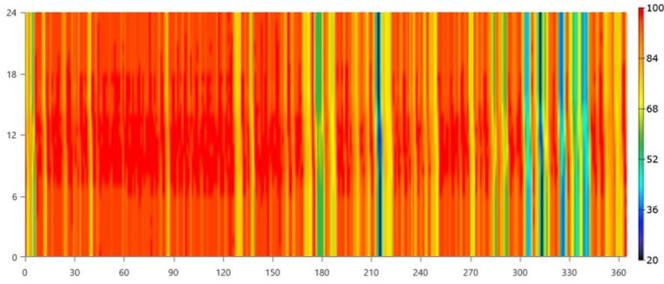


Fig.7: Li-ion State of charge

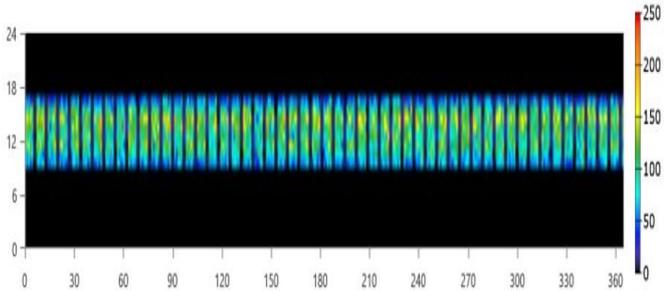


Fig.8: System Converter Output

IV. SIZING OF SYSTEM

The designing of Hybrid system was done using the simulation tool i.e., Homer Pro. In Homer Pro it simulates for different type of configuration according to the given load data and the additional system. From different simulated results we chose the best one which suits to our cost and space for the entire system to be placed. The suitable System configuration is shown in Table 1.

Table 1

| COMPONENT | NAME | SIZE | UNIT |
|------------------|-----------------------|------|---------|
| PV PANELS | Generic Flat plate PV | 192 | kW |
| WIND TURBINE | Generic 10kW | 1 | 10kW |
| STORAGE | Generic 1kW li-ion | 42 | Strings |
| SYSTEM CONVERTER | Inverter | 300 | kW |

The sizing of each system is done by comparing all the system configuration made by the simulation tool. The sizing of an solar panel lists up-to 192kW, the wind turbine of 10kW and their energy is backed up in a battery having a storage of 262500Ah packed in 42 strings such that each string has 75 batteries accounting to have no interrupted supply for the taken commercial building. The building is fully operated in this renewable sources without taking the power from the grid.

The annual AC primary load is accounted to 2,18,928kWh/year, this load is managed by the designed hybrid system's Annual output. The production summary for the load is given in Table2. The annual electricity production of generic flat plate PV is of 3,06,033 and for wind power generation is 4,046kW/year and it leads to excess production of 91,484kW/year. These lists are shown in following table (Table3).

Table 2: Consumption Summary

| COMPONENT | CONSUMPTION(kWh/yr) | PERCENT |
|-----------------|---------------------|---------|
| AC primary load | 2,18,928 | 100 |
| DC primary load | 0 | 0 |
| Deferrable load | 0 | 0 |
| Total | 2,18,928 | 100 |

Table 3

| COMPONENT | PRODUCTION(kWh/yr) | CONSUMPTION(kWh/yr) | EXCESS(kWh/yr) |
|---------------|--------------------|---------------------|----------------|
| Generic 10kW | 3,06,366 | 0 | 0 |
| Flat plate PV | 4,046 | 0 | 0 |
| Total | 3,10,412 | 2,18,928 | 91,484 |

These Excess power generated can be utilized in different possible ways such as supplying back to the grid and this reduces the cost of electricity production as the Govt. of India has a regulatory plan such as payback cost will be rewarded back to the supplier.

V.COMPARISON WITH GRID

The primary load for a commercial building is usually supplied from the grid. As per TNEB(Tamil Nadu Electricity Board)there are several tariff rate varies according to the consumer demand. The following table depicts the tariff for Private institutions.

Table 4

| CONSUMPTION | CC Charges per Unit | Fixed Charges for 2 Months |
|----------------------------------|---------------------|----------------------------|
| Private educational institutions | 6.50 | 100/kW |

On comparing Grid system with Hybrid system for a period of 15 years, It was found that the COE was higher for Hybrid system. The excess energy generated (91,484 kWh/yr.) was given back to the grid for which TNEB pays a Payback amount of 5,94,646/yr. Which sums up to 89,19,690 for 15 years. This amount gets reduced from the overall cost thereby reducing it to 63,33,690 from 1,52,53,680.

Table 5

| COST | GRID SYTEM | HYBRID SYSTEM |
|-----------------------------|-------------|---------------|
| COE(cost of energy) | 6.05/kWh | 13.03/kWh |
| Overall cost (for 15 years) | 1,31,61,774 | 1,52,53,680 |
| Payback from TNEB | 0 | 89,19,690 |

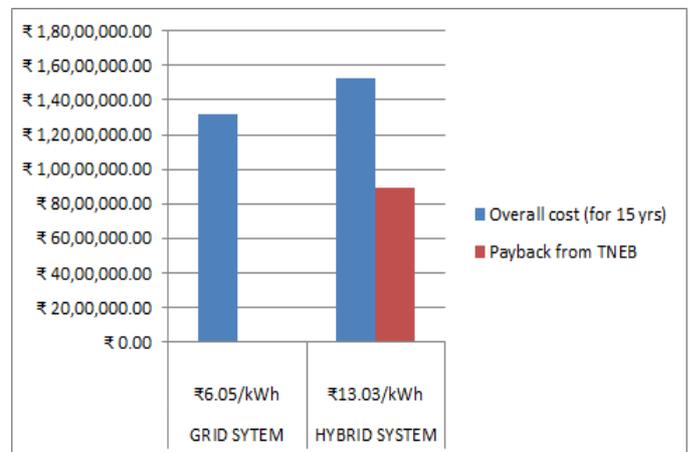


Fig.9: Cost analysis for a period of 15 years

VI. RESULTS & DISCUSSIONS

The total cost analysis includes the following quantities,

- Capital cost
- Replacement cost
- Operating & Maintenance cost
- Salvage

These cost calculations are done by the simulation tool and the cash flow graph will be generated for easy understanding by Homer Pro. The NPC denotes the total cost for the proposed design for the period of 15 years as mentioned for the life time of the equipment. The cost data is given in the following Table 6. The NPC graph is shown below in Fig.10. The Cost of the design is calculated and sorted accordingly.

Table 6: Net Present Cost

| NAME | CAPITAL | OPERATING | REPLACEMENT | TOTAL |
|---------------------------|---------------|-------------|-------------|---------------|
| Generic 10kW wind turbine | ₹ 4,00,000 | ₹ 4,000 | ₹ 1,20,000 | ₹ 5,24,000 |
| Generic 1kWh | | | | |
| Li-Ion | ₹ 11,34,000 | ₹ 1,13,400 | ₹ 3,40,000 | ₹ 15,87,400 |
| Generic flat plate PV | ₹ 92,16,000 | ₹ 9,21,600 | ₹ 27,64,800 | ₹ 1,29,02,400 |
| System | | | | |
| Converter | ₹ 1,48,000 | ₹ 11,480 | ₹ 44,400 | ₹ 2,03,880 |
| System | ₹ 1,08,98,000 | ₹ 10,50,480 | ₹ 32,69,200 | ₹ 1,52,53,680 |

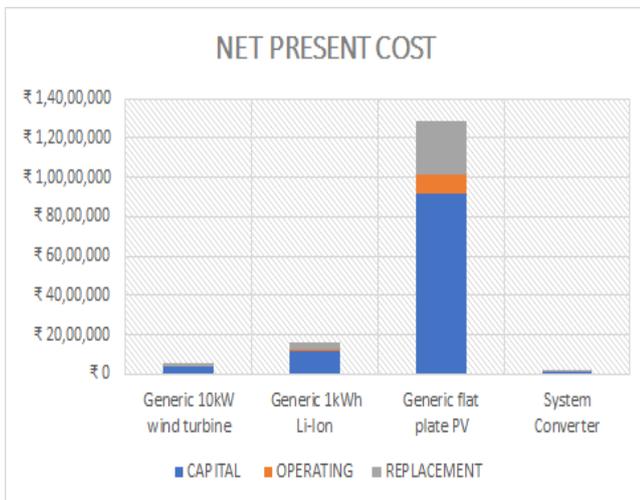


Fig.10: Graph for NPE

The following figures illustrate load details for entire commercial classroom complex

STAFF ROOM LOAD

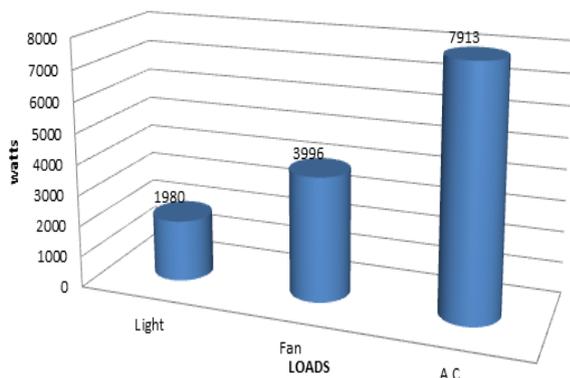


Fig.11: Staffroom Load

Load Distribution for Labs

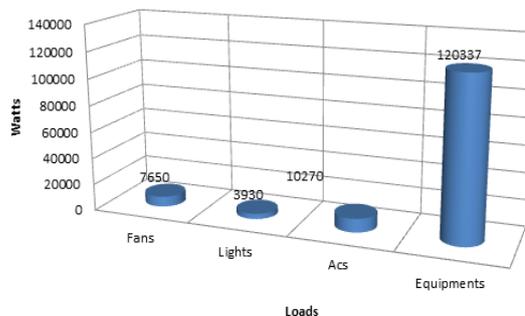


Fig.12: Lab Load Distribution

CLASS ROOM LOAD

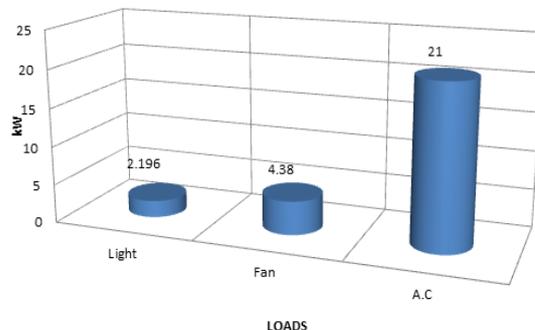


Fig.13: Classroom Load

MISCELLANEOUS

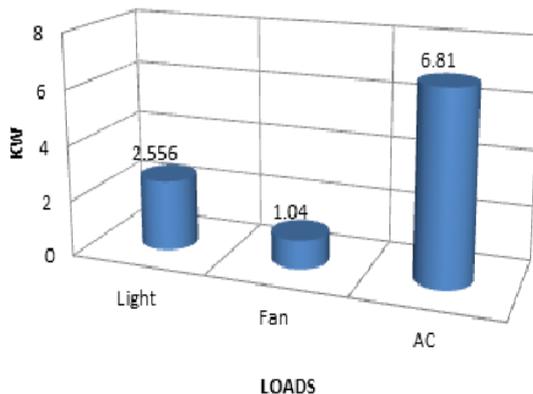


Fig.14: Miscellaneous Load

VII. CONCLUSION

Microgrid for the hybrid Powersystem is designed using Homer Pro. By initializing the Input load data, Sizing of system, Cost analysis and the respective output efficiency and the detailed output data is collected from the simulation tool. The following are the specification of the designed micro grid: a flat plate PV of size 192kW, Generic 10kW wind turbine, 42 strings of 1000Ah, 12v Lithium Ion battery and a 300kW Inverter to convert the DC power to AC load demand. A clear comparison was done with Grid for a period of 15 years. Even though the COE is higher for hybrid system than the Grid, Due to the excess energy produced which we give back to grid we get payback from government which benefits us by reducing the overall cost. The main drawback for this system it requires lot of spaces and proper maintenance periodically.



The cost of operation and maintenance are included in the above section.

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