

Optimization of Hybrid Microgrid of Renewable Energy Efficiency Using Homer Software

A. Fayaz Ahamed¹; R.M. Rakesh Vibahar²; S. Purusothaman³; M. Gurudevan⁴; P. Ravivarma⁵

¹Assistant Professor, EEE, RMKEC, Kavaraipettai, India.

¹afd.eee@rmkec.ac.in

²EEE, RMKEC -Kavaraipettai, India.

²rake17232.ee@rmkec.ac.in

³EEE, RMKEC, Kavaraipettai, India.

³puru17228.ee@rmkec.ac.in

⁴EEE, RMKEC, Kavaraipettai, India.

⁴gurule181224.ee@rmkec.ac.in

⁵EEE, RMKEC, Kavaraipettai, India.

⁵ravi17233.ee@rmkec.ac.in

Abstract

This paper focuses on modelling an optimization of hybrid microgrid of renewable energy efficiency with HOMER software, using solar photovoltaic power (PV), wind power for a real time data of selected location which has future use in relation to increased demand for energy. The size of hybrid microgrid system components and factors like system cost, fuel cost, cash flow, and stability must all be optimized. The optimal sizing of Hybrid Microgrid system (PV/Wind) is conducted for our college campus. The cost of energy is based on peak load demand profiles considered for residential, industrial, commercial sectors and fuel cost, initial capital cost and operational and maintenance cost. It is also essential that hybrid system modules of optimal specifications be selected to ensure the minimal energy cost and efficiency of all load demands.

Key-words: HOMER Software, Hybrid Microgrid System, NREL (National Renewable Energy Laboratory).

1. Introduction

Modelling an optimization of hybrid microgrid with solar photovoltaic power (PV) and wind energy system. To assess device cost and reliability, it is critical to minimize the size of hybrid microgrid system modules, including storage. The optimum sizing of Hybrid Microgrid modules

(PV/Wind) for our college campus is investigated in this study. A hybrid microgrid structure is modelled using Homer Pro tools. The daily community load profile for a year (2019) was estimated based on report maintained by the college EB room. The total load demand in the substation as per the data collected from the college EB room for 8760 hours is considered as an input data. The input data collected is given as input to HOMER. The cost of energy is based on requirements of demand our college is taken into account. Furthermore, selecting optimally sized hybrid microgrid device components is critical to ensuring that all load demands are met with the least amount of energy and the high reliability. A single-purpose optimization technique is used to document a sizing solution for an isolated microgrid that significantly reduces the life cycle expense while reducing power loss. There have been several experiments using HOMER tools to determine the optimum sizes of different elements of energy systems for rural electrification using a real-time Energy Management System (EMS) has been reported. HOMER was included in a case study to assess the feasibility of using hybrid energy systems to meet electrical energy requirements by addressing technological and economic parameters. There has been a systematic analysis focusing on the use of HOMER tools and its use in the optimum planning of energy systems. It is planned to use a renewable energy solution that includes a PV system, a wind turbine, and the grid. A load tracking strategy is used to move electricity from the source to the load, and the fuel cell serves as a complement to the renewable energy grid. The energy storage unit will operate in charge-sustaining mode over a load cycle, taking into account the RET's peak power and an imposed SOC window. Some of the analysis proposed in the literature so far has ignored annual load growth when assessing sizing and energy management techniques. The control method depicted in various works has been checked for a year, and that too without taking into account load growth, which may lead to outcomes that are far from existence. Furthermore, instead of using a systematic approach or model, the most of researchers have actually selected energy alternatives expectations for modelling hybrid power sources, which can lead to errors and, in some situations, complete failure of the project in the real world. The sizing of a microgrid for a rural location with yearly load variation using HOMER PRO is presented in this paper. Two EMS load following controllers (LFC) based on HOMER and PSC developed with MATLAB and integrated with HOMER are used for expense energy monitoring between supply and consumption.

2. Introduction of Homer Software

The NREL (National Renewable Energy Laboratory) in the United States created the HOMER-Pro programme. It makes the complicated process of constructing the cheapest micro grid in a distributed energy system even easier. It produces credible and impartial performance. It also examines any potential combination to determine the most cost-effective method of integrating different device components and storage techniques. Various metallurgical data are needed to design the hybrid system, as well as to explain the possibilities. The HOMER-Pro work flow is a three-phase process that begins with project inputs, which include a load profile, site-specific tools, and system components; step 2 analyses the simulation, optimization, and responsive variables; and step 3 displays the outcome, which includes details on size of system, efficiency, and financial values.

A. Simulation

HOMER-Pro decides various device configurations, the number of components available, sizes, and dispatch strategy by simulation. HOMER-Pro can simulate a variety of device setups that include PV modules, wind turbines, an ac–dc converter, and battery storage. The load-following and cycle-charging dispatch techniques are two separate dispatch techniques that HOMER-Pro can study. HOMER-Pro analyses two critical concepts during the simulation process: first, it evaluates the viability of the device design, and second, it calculates the model's Life cycle cost, which is the sum of both the installation and running costs.

B. Optimisation

The idea machine configuration is determined by the optimization procedure. It also determines the best optimal type system configuration that meets the specified load constraints. HOMER-Pro modifies a number of device configurations that do not function. Infeasible solutions do not meet the desired constraints. Methods are the possible architectures are defined by the lowest NPC and the minimum cost of energy (COE). The optimization process' goals are to determine the best value for each decision element. The meaning that the HOMER Pro user can monitor is referred to as a decision variable. The HOMER-Pro analyses these factors to identify the most practicable load-based design. The model parameters examined by the HOMER-Pro include generator size, the photovoltaic module, ac to dc transformer, amount of wind turbines, battery number and dispatch technique.

C. Sensitivity Analysis

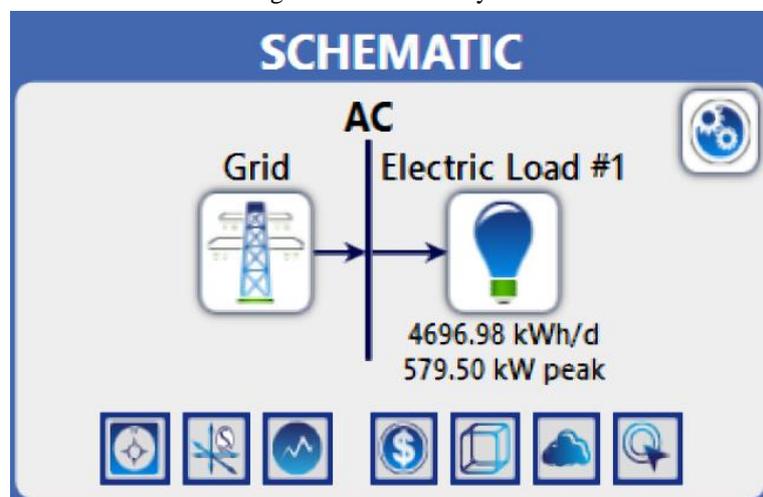
The Homer software will make certain assumptions that will impact the system configuration. The term "sensitivity variable" refers to these assumptions. Wind speed level, photovoltaic level, fuel price, interest rate, grid price, and other susceptibility variables are included. Under such assumptions, HOMER-Pro looks for various machine combinations that are feasible. A sensitivity analysis reveals how changes in inputs influence the results. The HOMER-Pro programme will evaluate a large number of sensitive values at once to determine the most cost-effective solution. Decision variables and sensitivity variables are two types of values that can be entered into HOMER-Pro. For research purposes, the user of HOMER-Pro may add many other responsive variables. The different cases of sensitivity are calculated by replacing the no vector of tolerance.

3. System Description

A. Load Profile

The optimal sizing of hybrid microgrid renewable energy efficiency system (PV/Wind) is designed for our college campus. As per the data collected, containing 8760 lines of hourly load data (resembling hours per year) is considered as an input data on electric load parameter. The normal intake of electricity amounts to 4696, 98 KW/day and the highest charge 579,50 KW. Grid alone as seen in Fig.1.

Fig. 1 - Grid Alone System

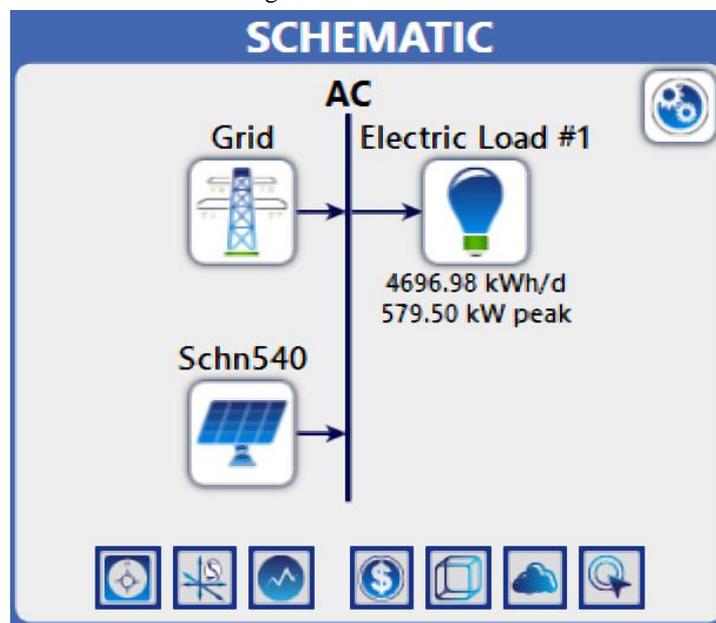


The various analyses and the different combination of power generation system using Renewable Energy system is studied.

1. PV Grid System

In PV Grid system, solar PV system is connected to the grid. The annual solar radiations should be above 4kwh/m²/d in order to have a reliable source of power coming from the photovoltaic panels. The name of the PV system is Schneider ConextCoreXC 540KW with Generic PV (Schn540). The Rated capacity (KW) is 540KW. The Temperature Coefficient (°C) is 45 and the Efficiency is 17.30%. From this analyse it has been found that the daily average mean output is 2,499kwh/day and the Total production is 912,196 kwh/yr. The PV-Grid connected model is shown in Fig.2.

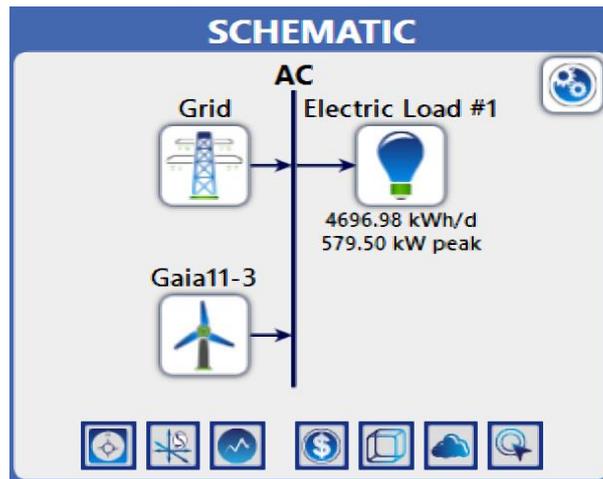
Fig. 2 - PV-Grid Model



2. Wind Turbine Grid System

In this analyse the wind turbine is connected to grid system. The Annual wind speed average could be a good indicator for the installation of wind turbine. Generally, values above 5m/s are considered as adequate for installation of wind turbine. The name of the wind turbine is Gaia-wind 11kw 3-phase (Gaia11-3). The Rated capacity (KW) of wind turbine is 11KW. The Wind-Grid Connected model is shown in Fig. 3.

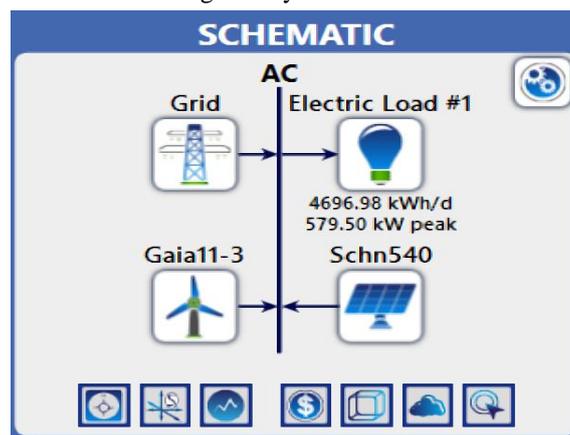
Fig. 3 - Wind Turbine Model



3. Hybrid System

Here, the analyse for all the possible combinations of power generations systems using Homer Software is studied. Homer Software provides the most optimized combinations of power generation system. Based on the location and certain criteria the Grid -PV-Wind Turbine model is designed. The Grid-PV-Wind Turbine (Hybrid System) Model is shown in Fig.4.

Fig. 4 - Hybrid Model



B. System Components

1. Solar PV Panel

When solar radiation strikes it, HOMER-Pro creates a PV module that generates dc electricity. When diesel prices are high and wind speeds are slow, solar power is the best option.

The output of the PV array is calculated using the equation

$$P_{pv} = C_{pv} P_{pv} I_r / I_s \quad (2)$$

Where,

C_{PV}: PV de rating factor,

PPV: rated capacity of PV (kW),

IT: The solar radiation values on the PV Array's surface (kW/m²)

IS: Standard solar radiation value, 1kw/m²

2. Wind Turbine

For the specific power curve, the wind turbine transforms the kinetic wind energy into ac or dc electricity. A graph between output power and wind speed is the power curve. Conditions of temperature and pressure. In a four-step procedure, every hour, HOMER-Pro calculates the output power of the turbine. First, it uses the wind resource data to calculate the average wind speed for the hour at the Anemometer height. Second, it uses either the logarithmic or power laws to measure the corresponding wind speed at the turbine's hub height. Third, it refers to the turbine's power curve, which is used to measure the turbine's power output at a given wind speed using normal air density assumptions. Fourth, by means of the air density ratio, the current air density proportion to the standard air density multiplies the current power output value. The air density ratio of HOMER-Pro is assumed to be constant throughout the year. The cost of capital of the 1kw wind turbine is around ₹100,000. The costs of substitution and repair service are 1,00,000 rupees and, respectively, 45,000 rupees. The turbine has a lifetime of 25 years and a hub height of 18 metres. Wind turbines are commonly determined by their electrical generation capability.

3. Grid

Grid is the main electrical energy system part from which electric power may be borrowed or sold. If renewable energy sources are incapable of delivering acres in the night time, then we can buy energy from the grids and excess energy is generated by renewable energy sources, which are charged by net metering for sales to the grid and bill. These are technically known as grid power prices, demand rates and sales rates. Grid power prices are the ones that we can buy at grid rates, and the High grid demand is a fee. Selling back rate refers to the price we receive by trying to sell grid

power. HOMER-Pro also supplies to the grid the emissions of toxic elements connected to the spending power of a system.

4. Economic Analysis

Natural resources are expensive in operation and maintenance but have lower capital costs, but other renewable energies have high costs of capital, but lower maintenance and operation costs. The price of every part of a life cycle is the amount of both the cost of capital and the cost of operations. In calculating the salvage value of various materials, HOMER-Pro includes the following equations.

$$S = C$$

Where,

S = Salvage value

Crep = Substitution cost of the component

Rrem = Remaining life of the component

Rcom = Life time of the component

The system's total net present cost(NPC) is estimated using the following equations

$$CNPC = C_{\text{annual, total}} / \text{CRF}(j, R_{\text{project}})$$

Where,

CNPC = Cumulative Net Present Cost

Cannual, total= Total annualized cost

Levelized cost of energy is calculated by the following equation

$$COE = C_{\text{annual, total}} / E_{\text{primary}} + E_{\text{def}} + E_{\text{grid, sell}}$$

Where,

Cannual, total = annualized cost of total.

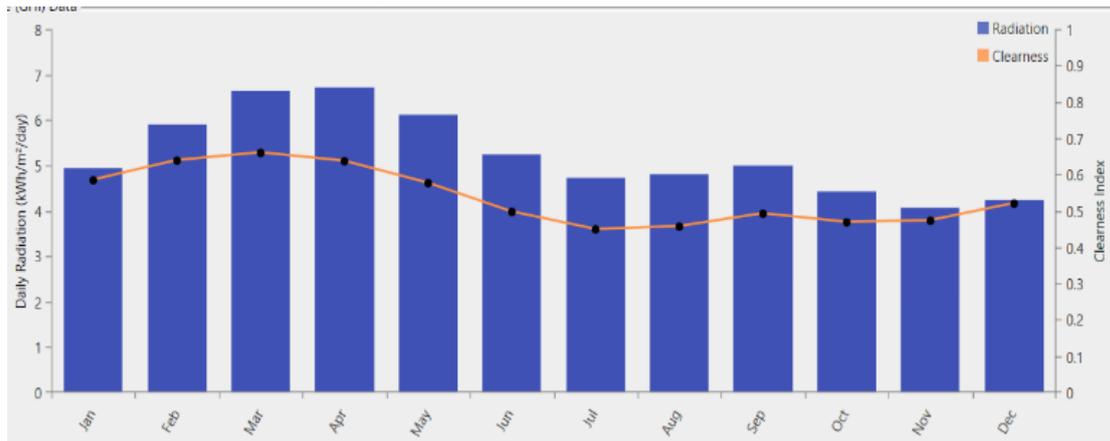
Eprimary = Number of primary load

Edef = Number of deferrable load

5. Results

The estimated area has a latitude of 13°21.47'N and 80°08 00.15'E. Figure 1 displays the monthly solar radiation and clarity index values for every day. The solar radiation intensity annually amounts to 5.23 kWh/m²/day.

Fig. 1 - Monthly Solar Radiation Level



The NREL database was collected with the wind source data from a hub height of anemometer of 15 metres for the test area of 13°21.47'N and 80°08 00.15'E longitude. Mean wind speed Curve of 5.51 m/s as indicated in Figure 2 above.

Fig. 2 - Monthly Wind Speed Level



1. Grid Alone System

Case 1, In the Grid alone system, the monthly average energy consumption is shown in Fig.3. The components name and size of the system is shown in the table 1. the energy Purchased from the grid and the Emission due to grid alone system is shown in the Table 2 and Table 3 respectively.

Table 1 - Electric Load

Components	Name	Size
GRID	GRID	999,999 KW
LOAD	ELECTRIC LOAD	4696.98 kwh/day

Fig. 3 - Monthly Energy Consumption

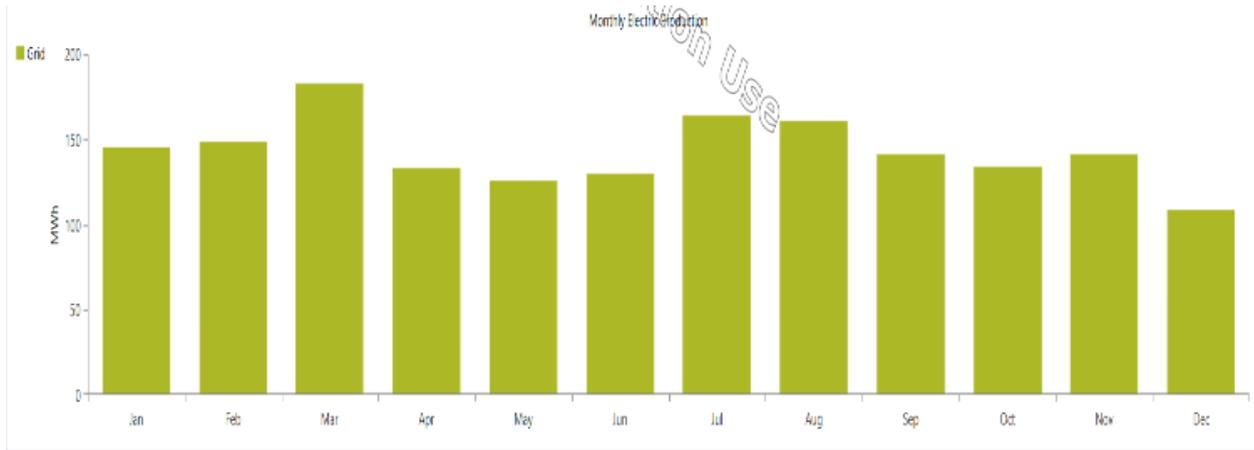


Table 2 - Total Energy Purchased

Production	Kwh/yr	Percentage
Grid purchases	1,714,451	100
Total	1,714,451	100

Table 3 - Emission

Quantity	values	units
CO2	1,083,533	Kg/year
SO2	4,698	Kg/year
NO2	2,297	Kg/year

2. PV-Grid Alone System

Case 2, In the PV- Grid system, the monthly average energy consumption is shown in Fig.4. The components, name and size of the system is shown in the table 4.the energy Purchased from the grid and the Emission due to grid alone system is shown in the Table 5 and 6 respectively.

Table 4 - Electric Load and PV Size

Components	Name	Size
GRID	GRID	999,999 KW
PV	Schn540	540 KW
LOAD	ELECTRIC LOAD	4696.98 kwh/day

Fig. 4 - Monthly Average Energy Consumption

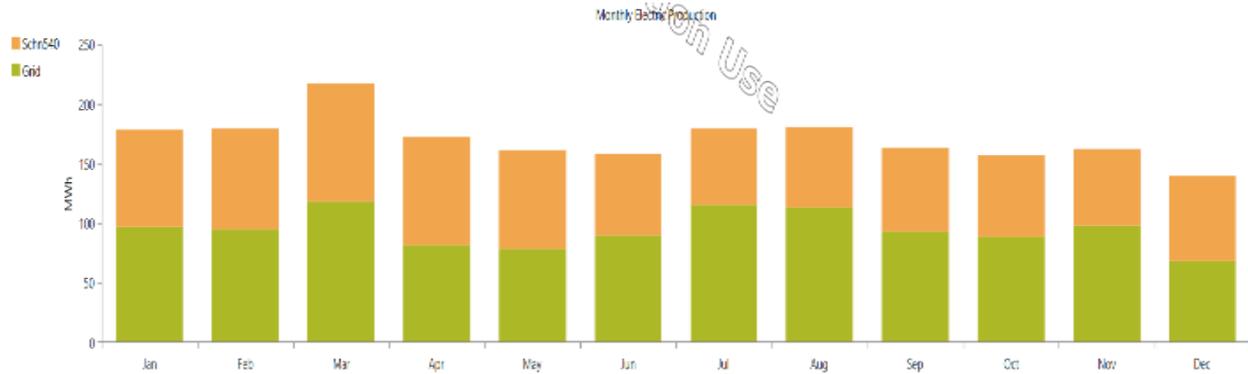


Table 5 - Production

Production	Kwh/yr	Percentage
Schn540KW (PV)	912,196	44.5%
Grid purchases	1,137,069	55.5%
Total	2,049,265	100%

Table 6 - Emission

Quantity	Values	units
CO2	718,628	Kg/year
SO2	3,116	Kg/year
NO2	1,524	Kg/year

3. Wind Turbine-Grid Alone System

Case 3, In the Wind Turbine- Grid system, the monthly average energy consumption is shown in Fig. 5. The components, name and size of the system is shown in the table 7. The energy bought from the grid and the Emission due to grid alone system is shown in the Table 8 and Table 9 respectively.

Fig. 5 - Monthly Energy Consumption

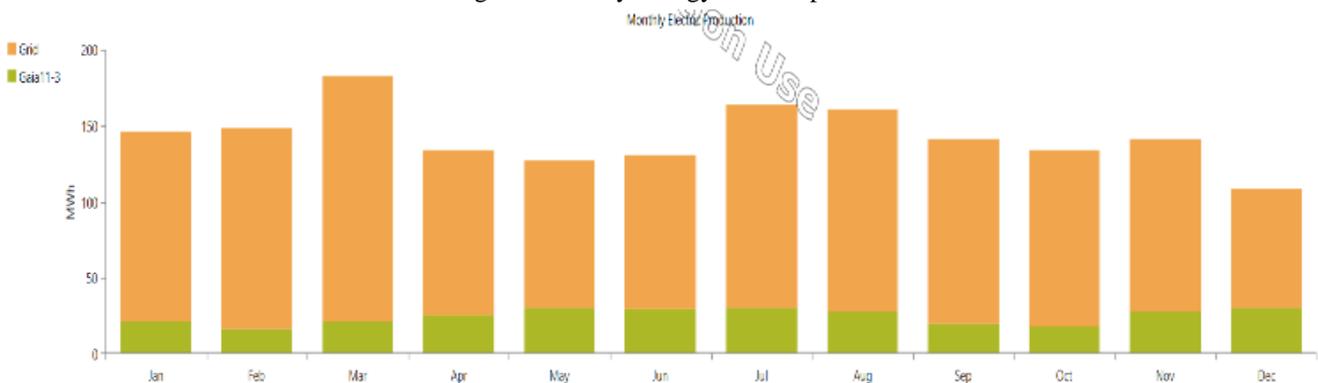


Table 7 - Electric Load and Wind Turbine Size

Components	Name	Size
GRID	GRID	999,999 KW
WIND TURBINE	Gaia11 -3	11 KW
LOAD	ELECTRIC LOAD	4696.98 kwh/day

Table 8 - Production

Production	Kwh/yr	Percentage
Gaia-wind 11kw 3-phase	2,97,207	17.3%
Grid purchases	1,420,826	82.7%
Total	1,718,034	100%

Table 9 - Emission

Quantity	Values	units
CO2	897,962	Kg/year
SO2	3,893	Kg/year
NO2	1,904	Kg/year

4. Hybrid System

Case 4, In the Hybrid optimization system, the monthly average energy consumption is shown in Fig. 6. The components, name and size of the system is shown in the table 10. the energy bought from the grid and the Emission due to grid alone system is shown in the Table 11 and Table 12 respectively.

Table 10 - Components in Hybrid System

Components	Name	Size
GRID	GRID	999,999 KW
PV	Schn540	540 KW
WIND TURBINE	Gaia11 -3	11 KW
LOAD	ELECTRIC LOAD	4696.98 kwh/day

Fig. 6 - Monthly Energy Consumption

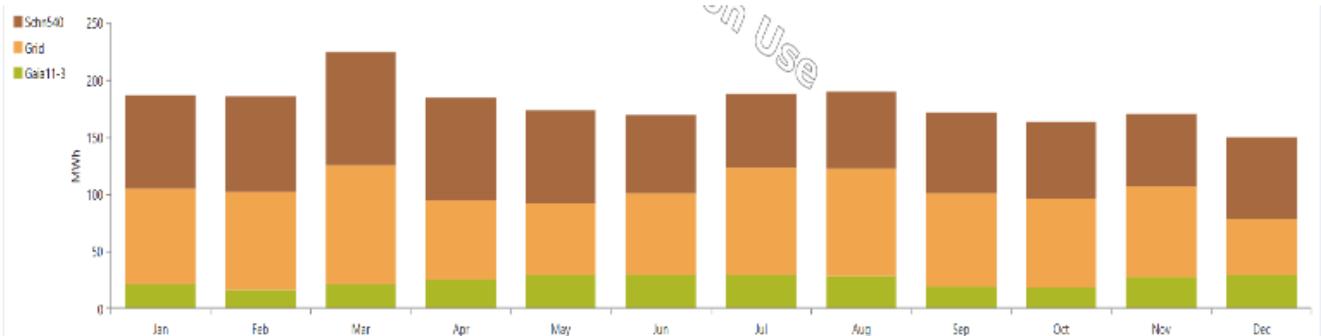


Table 11 - Production

Production	Kwh/yr	Percentage
Schn540 (PV)	912,196	42.2%
Gaia-wind 11kw 3-phase	2,97,207	13.8%
Grid purchases	1,420,826	44.0%
Total	1,718,034	100%

Table 12 - Emission

Quantity	values	units
CO2	600,239	Kg/year
SO2	2,602	Kg/year
NO2	1,273	Kg/yr

6. Conclusion

Using the HOMER software different cases were analysed for the load data of our college.

In **Case 1** the load of the college was met only with the electricity which is obtained from the **Grid alone** here in this system the electricity is entirely obtained from the Electricity board. The total cost paid for by the college for **a year** is **1.08 crores** with a **COE of Rupees 6.35** and for **25 years** it would cost around **27 Crores**.

In **Case 2** the load of the college was met only with the electricity which is obtained from the **Grid and PV system**. The total cost paid for by the college for a year is **62 lakhs** with a **COE of Rupees 5.57** and for **25 years** it would cost around **15.5 Crores**.

In **Case 3** the load of the college was met only with the electricity which is obtained from the **Grid and Wind Turbine system**. The total cost paid for by the college for a year is **90 lakhs** with a **COE of Rupees 5.40** and for **25 years** it would cost around **22.52 Crores**.

In **Case 4** the load of the college was met only with the electricity which is obtained from the **Grid, PV system and Wind Turbine** here in this system the electricity is entirely obtained from the Electricity Board. The total cost paid for by the college for a year is **47 lakhs** with a **COE of Rupees 4.71** and for **25 years** it would cost around **11.75 Crores**.

Hence **Case 4** is the **most optimised system** which can be implemented for our college which involves PV system, Wind turbine system along with the grid the system has two renewable sources of energy which has lowest COE and less emission of gases. The **profit** is around **15.25 crores**.

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