Available online at: http://www.ijmtst.com/vol6issue03.html
International Journal for Modern Trends in Science and Technology
ISSN: 2455-3778 :: Volume: 06, Issue No: 03, March 2020

Techno-Economic Optimization of Grid Connected Distributed Energy Systems using HOMER

Vendoti Suresh[1] | K Sai Krishna Prasad[2] | P Venkateswarlu[2] | R Veera Raja Kumar[2]

[1]Assistant Professor, Department of Electrical and Electronics Engineering, Godavari Institute of Engineering and Technology (A), Rajahmundry, Andhra Pradesh, India.
[2]UG Students, Department of Electrical and Electronics Engineering, Godavari Institute of Engineering and Technology (A), Rajahmundry, Andhra Pradesh, India.

To Cite this Article
Vendoti Suresh, K Sai Krishna Prasad, P Venkateswarlu and R Veera Raja Kumar, "Techno-Economic Optimization of Grid Connected Distributed Energy Systems using HOMER", *International Journal for Modern Trends in Science and Technology*, Vol. 06, Issue 03, March 2020, pp.:191-202.

Article Info
Received on 25-February-2020, Revised on 01-March-2020, Accepted on 13-March-2020, Published on 18-March-2020.

ABSTRACT

This study presents the techno economic feasibility on grid connected distributed energy system or micro grid for a big technical institute. It is focused on how to minimize the electricity consumption from the grid by producing as much as possible renewable energy and in addition to that it integrates green vehicle transportation usage such as hydrogen gas, electric cars etc. which are necessary elements of a sustainability in the proposed system. The work is initiated collecting the institute monthly electrical load data, climate data and associated monetary data with the aim of investigating a renewable energy supply system feasibility study. Different scenarios are developed according to the project needs and the scenarios were modeled by HOMER software. The study concludes with a direct comparison of the economic feasibility, renewable energy fraction and emission among all system looks for appropriate sustainable solution. This study will provide helpful insights to the relevant stack holders and policy makers in the development of grid connected distributed energy systems.

KEYWORDS: *Distribution Energy System-Modeling of HRES-HOMER Software-Size and Cost Optimization*

I. INTRODUCTION

In present scenario, every country places considerable importance on sustainable development and energy security. Hence hybrid renewable becomes more significant sources. Energy requirement is an essential need to enhance the income, improved life quality of individuals. Developing countries on the way of growing their economies are in much demanding for electricity access to facilitate their economical and industrial growth.

Nowadays renewable energy resources are one of the promising ways to address many problems. Climate change, desertification, greenhouse effect, etc., lead the world towards sustainable energy era. Using natural and renewable resources such as wind, solar, geothermal, tidal, wave and hydroelectric offer clean alternatives for fossil fuel; in which they are omnipresent, abundant, free, clean and easily accessible even in isolated and undeveloped places.Sources of energy that can be repeatedly generated are of the challenges for the development for a system of energy i.e renewable with least socio-economic problems is to design a new form of fuel. This energy that can be generated repeatedly from the same source need to be appropriately designed and evaluated from beginning stages. Unreliable nature of these sources of energy is one of short comings in the process of their development, in particular as there of more reliable energy sources available to be replaced when it is essential to distribute the load. This inadequacy coupled with a huge expense at the beginning as well as depending heavily on conditions of weather and climate makes it essential to put together various Renewable resources to make up a fusion of different systems which can be used with more flexibility more cost effectively, reliably and efficiently. But planning assessing carefully should make sure effective carrying out of hybrid of this new power system. The thing the operators trained, getting the participation of the community on programs of electrification and supervising the setting up and commissioning having the maintenance structure, in force and following up the maintenance and reporting of essential for successful implementation of a hybrid power system.

The hybrid regeneratable power generation is a system expected at the making and utilization of the electrical energy restricting from additional than one source, on condition that at least one of them is renewable. Renewable sources of energy such as wind and solar energy have involved developing consideration. Recently as alternatives source options for domestic energy requirements, however such regeneratable energy systems operate discontinuously. A hybrid renewable energy based combined heat and power (CHP) system, on-grid, in which useful heat and electricity are produced simultaneously, can be used to moderate this challenge and enhance reliability. The hybrid renewable energy-based CHP system considered here includes solar-thermal collector, solar photovoltaic (PV), wind turbine (WT) and hydrogen energy technologies.Despite the surveys of hybrid renewable energy systems, techno-economic analysis and optimization tools for grid connected, hybrid solar–wind–fuel cell combined heat and the power systems with solar-thermal collectors are not accessible and needed. In this study therefore, an optimization method is developed for a grid-connected hybrid system for domestic application, combining a solar–wind–fuel cell releases the combined heat, and power system integrated with solar-thermal collectors.

The optimization method uses economic parameters for system components. The electrical power making is determined by reducing cost, the independent function, while accounting for electrical and thermal power tariffs for buying and retailing. To incent the buying of electricity from the grid,purchasing tariffs aremeasured to exceed export tariffs for electricity. However, due to its lower charge, thermal energy is sold locally to fellow citizen rather than to the grid. In addition, the output power values of the PV and WT systems and solar-thermal collector are preserved as negative energy loads for the hybrid system, so they are added to the domestic load. In this optimization method, we consider the costs of electrical power discussion with the grid, supplying energy,wind power production, solar power generation, the solar-thermal collector, heat recovery from the fuel cell, and maintenance. We also suggest a modified particle group optimization algorithm for the optimization of the grid-connected hybrid solar/wind/fuel cell CHP system with a solar-thermal collector and considered thereidentical uses in the city. Hybrid Optimization Model for Electric Renewable (HOMER) software will be used to consider the data. The software is a micro-power optimization model for both off-grid and grid connected power systems in a selection of applications

Many authors have been suggested that to discover most possible configurations of renewable energy systems in many applications.

Suresh et al. [1] developed an off-grid system consists supplying power to SVCET of Chittoor, India and perform optimization simulation using HOMER Pro. The economic assessment process is adopted by renewable energy instead of using diesel generator to meet electricity demand implemented for off- grid power systems. The production of renewable energy is totally depending on weather conditions. Simulation scenarios are modeled by referring power system and simulation results support that appropriate economic assessment process with political issues, decision making process and so on.

Wattala Fernando et al. [2] presented a integrated renewable energy system analysis by using a tool, is called Homer pro. It consistsof solarPV, battery (lithium ion and lead-acid batteries) are modelled and simulated in grid- connected mode. The system was simulated in Matara, located at the south coast of Srilanka. Despite this, battery storage technology was a promising option to reduce the need for conventional power stations and reduced major environmental impacts that came with burning fossil fuels.

Vendoti et al. [3] described the Design of Hybrid Standalone Energy System. The system load consists of total three villages of408 households and 1686 populations. The pattern of load consumption of the rural households of the village was suitably modeled and different combinations of hybrid systems were simulated to identify the optimal system based on least life cycle cost. In addition to this sensitivity analyses using diesel prices, solar average radiation and wind speed as sensitivity input variables were also performed in this case. Different system configurations were simulated in homer. The optimum sizes of the components which meet the load demanded for the available dataset of site resources had been determined and the optimum system, which offers least net present cost, was identified. In addition to this sensitivity analysis using diesel price, solar radiation and wind speed as sensitivity variables was also done.

Hussam J. Khasawneh et al. [4] proposed a Techno-Economic Evaluation of On-Grid Battery Energy Storage System. It consists tool for comparing and optimizing different battery storage technologies used with large-scale renewable energy sources such as PV in ordered to help in decision-making for the required best size and to be able to calculate the associated costs for each typed of best technology. The resulted levelized cost of energy (LCOE) will helped in secured electricity for Jordan from solar PV plants, and to depend less on fossil fuel which had environmental impacts, fluctuated prices, and not indigenously available in Jordan. It was found that the energy storage shares of the daily PV production over 75% are not feasible for most of the best technologies.

S. Marais et al. [5] developed a grid-connected PV-battery based system. It draws attention to the optimal design and sizing by considered the techno-economic factors such as net present cost and cost of energy under time-of- used (TOU) and fit incentive. The annual real-time load demanded data from a typical residential consumer, had been used in this studied. The data was acquired using energy monitoring system. HOMER (hybrid optimization of multiple energy resources) Pro version 3. 6. 1 Software was employed to model the energy system. This limitation denoted that there was still lot of work to be done to optimally manage the proposed PV battery-based system under TOU and fit schemes. The model must also minimize the grid cost by using the stored energy to supply the load demanded whenever there was no sunlight.

Apart from wind/PV hybrid system sizing, different aspects like use of hydrogen storage along with or without fuel cell as a backup was also considered by [6 -20].

II. HOMER SOFTWARE

The HOMER Pro is micro-grid software and the HOMER Energy is the international standard for optimizing micro grid design in all areas, from community power and island benefits to grid-linked campuses and the military bases. Initially it will be developed at the National Regeneratable Energy Laboratory. This system can improve and distributed by HOMER Energy. HOMER (Hybrid Optimization Model for Multiple Energy Resources) nests 3 controlling tools in one software product, so that production and financial side work side by side are shown in figure1.

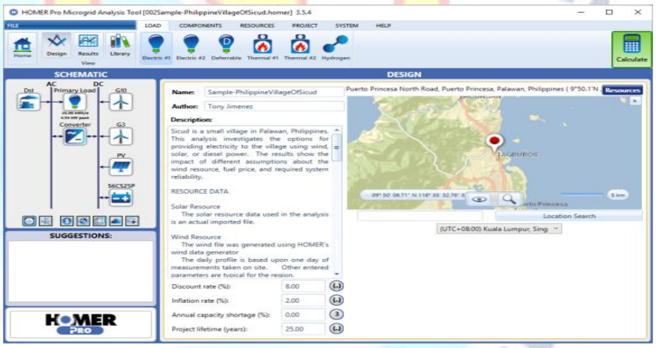


Fig 1.HOMER Pro screenshot

2.1. Simulation:

By the side of its essential, HOMER is a simulation model. It wills effort to simulate a feasible method for all possible arrangements of the tools that you hope to study. Dependent on how you complex your problem, HOMER software cansimulate a hundred or even thousands of methods.HOMER simulates the process of a hybrid micro-grid for a whole year, in time periods from one minute to one hour.

2.2. Optimization:

HOMER studies all conceivable combinations of arrangement types in a only single run, and then groups the systems according to the optimization flexible of optimal.HOMER Pro structures our original optimization process that considerably simplifies the strategy procedure for classifying least-price possibilities for micro-grids or other distributed generation of electrical power systems. HOMER Optimizer is a patented "derivative free" optimization process that was calculated specifically to effort in HOMER are shown in figure 2.

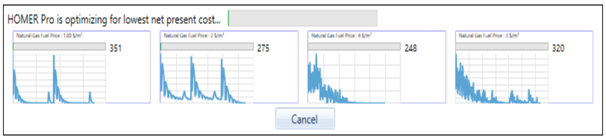


Fig 2. Optimization window.

2.3. Sensitivity Analysis:

HOMER agreements you ask as many "Whatever if?" questions as you'd comparable, as you can't control all features of a system, and also you cannot identify the importance of a exact variable or option without consecutively (running) hundreds or thousands of simulations and equating the results.HOMER makes very easy to equating thousands of possibilities in a single run. HOMER allows you to understand the control of variables that are further than your control, such as fuel cost, windspeed etc, and recognize how the optimum system changes with these differences

III. CASE STUDY

These case studies were developed to test the ability of the multilevel optimization method to analyse remote communities with different climate conditions. For this, we consider a GIET campus having two blocks (main block and VB block)which is located in Rajahmundry, East Godavari district, Andhra Pradesh (in fig. 3).

The college campus is selected as they exhibit distinct climate conditions in terms of solar energy and wind power availabilities. Table 1 and Table 2 show the mean horizontal insolation (fig. 5) and mean wind power at 30 m of height (fig. 6).

Since we are interested in analysing on the influence of climate conditions, we fixed the load profile for the campus. Consequently, for this case we used the sample load profile shown in fig.4, as it mimics the average electricity demand **(962.4kwh/day**) for campus.

Fig 3. Proposed location

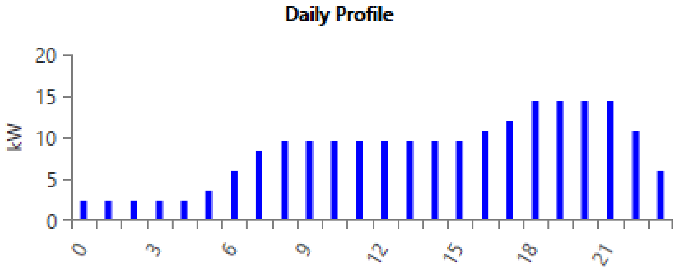


Fig 4. Power demand for a sample week of an average sized campus.

A. *3.1. Renewable Energy Resources*

1) 3.1.1. Solar resource

Data Solar resource input data for HOMER is made up of monthly averaged daily insolation incidents on a horizontal surface (kWh/m2 /day) from the NASA Surface Meteorology and Solar Energy (SSE) website. NASA gives monthly averaged values from 22 years of data. Due to the close distance, the location data of the city Rajahmundry is used as location data of the college Godavari Institute of Engineering in the study. The following location data is used to find the solar radiation data:

Latitude:17°3.6ꞌN

Longitude: 81°52.1ꞌE

Time Zone: Eastern Time Zone (UTC5:30) New Delhi

In Table1 he obtained solar radiation data for the campus Godavari Institute of Engineering and Technology is presented.

Table 1. Monthly average solar global horizontal irradiance.

Month	Clearness index	Daily radiation Kwh/m²/day
January	0.602	4.766
February	0.637	5.627
March	0.587	5.794
April	0.599	6.330
May	0.553	5.971
June	0.470	5.079
July	0.464	4.992
August	0.469	4.955
September	0.482	4.827
October	0.561	5.078
November	0.580	4.682
December	0.603	4.585

The solar resource raw data inputting to the software is the average global horizontal radiation measured in 10-minute time interval over the two years. On top of the solar resources data the latitude and longitude of this area would also be used as an input. The time zone is another parameter to be set. The college is at latitude: 17°3.6 N, longitude: 81°52.1 E, and with time zone of GMT +3:00. The annual solar radiation available within the study location as 5.22 kWh/m²/day using HOMER.

Similar to the solar sources data the wind speed was also measured at the same area in the same year. Wind speed was measured at 30 meter and 10-meter height wind mast but the data used in this paper took only the 30-meter height measured data. The time interval of data measurement was 10 minutes at both heights. Share of electricity generated by wind turbine is calculated by the software, thus 10-minute wind speed data was inputting into HOMER for the determination of energy production from wind sources. In addition to the wind speed resources the altitude above sea level, the anemometer height are the required inputs too.

HOMER evaluates PV array power for the year on an hourly basis, and uses latitude value to calculate the average daily radiation from the clearness index and vice versa. The annual averaged daily solar insolation in this area was found to be 5.33 kWh/m2 /day. The efficiency of the PV array is not a HOMER input, because the software does not designate the PV array size in terms of m2, but in kW of rated capacity. The rated capacity is the amount of power the PV module procures under STC and accounts for the panel efficiency. By managing rated capacity, HOMER has no need to deal with the efficiency, since two modules with different efficiencies (and the same area) would be set to different sizes.

Fig.5. Solar irradiance

Solar resource data was downloaded at 1/5/2020 11:57:02 from National Renewable Energy Lab data base

National Solar Radiation Data base:

Cell Number: 314081

- ✓ Cell Dimensions:40km*40km
- ✓ Cell Midpoint latitude:17.012
- ✓ Cell Midpoint Longitude:81.859
- ✓ Annual average radiation: 5.22 Kwh/m²/day

2) 3.1.2. Wind resource data

The average annual wind speed available within the study location as 4.23 m/s using HOMER based on the coordinate input of the project. The wind resource speed data found by HOMER is presented in table

Table2. Monthly Average Wind Data

Month	Average wind (m/s)
January	3.890
February	4.050
March	4.200
April	4.590
May	4.400
June	4.710
July	4.810
August	4.790
September	3.310
October	3.550
November	4.430
December	4.370

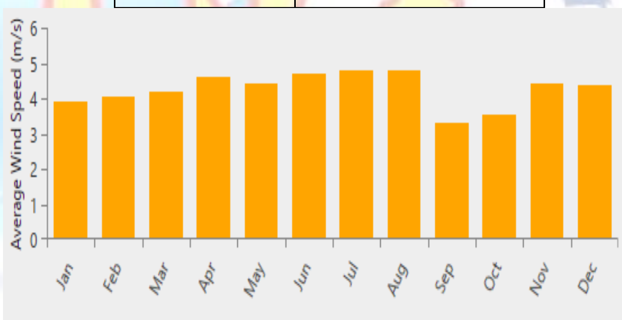


Fig.6. Average Monthly Wind Speed

National wind data database:

Wind energy resource data was downloaded at 1/5/2020 11:57:02 from NASA Surface Meteorology and Solar Energy Database

- ✓ Cell Number :107261
- ✓ Cell Dimensions:1degree x 1 degree
- ✓ Cell midpoint latitude: 17.5
- ✓ Cell midpoint longitude :81.5
- ✓ Anemometer height: 17m

B. 3.2. Electricity demand

In addition, we developed a case study with the objective of evaluating how the DES performance varies according to the energy demand of the campus. To classify the campus based on electricity demand, we made use of the annualized electricity consumption. A case study was created rescaling the electricity profile shown in fig.8to match an annualized electricity demand that ranges from 351.276Mwh/year. The climate conditions for all the cases are taken as those of region, because it represents community with an average-solar and average-wind power availability The average overall consumption power per day is calculated as 962.4 kWh/day as shown in table 3.

Table 3: Load consuming data of the campus

Consuming blocks	Lights and fans (Kw)	Air coolers (Kw)	Printers and projectors (Kw)	Ups and laboratories	xerox machines, mixers	Motors (Kw)	Total load in Kw	Total consumption per day Kwh
Shops/gate/data center	5	3.5	2	9	1	0	20.5	59.7
Ground floor	10.6	55	77.7	117.5	1	0	262.6	449.3
First floor	10.5	26	13.1	30.9	8	0	88.5	172.16
Second floor	10.5	1.5	5	22.5	0	0	39.5	66.56
Third floor	11.2	0	5.4	0	0	0	16.6	39.8
Machines lab	0	0	0	0	0	32.44	32.44	175
TOTAL	47.8	86	103.2	179.9	10	32.44	460.14	**962.4Kwh**

IV. DESCRIPTION OF HYBRIDRENEWABLE ENERGY SYSTEM

The energy system that is proposed is expected to meet the demand of the load of electricity of the community that will also include classrooms. The source of renewable energy considered here are mainly of solar and wind due to the unstable nature of renewable energy battery bank is employed as storage system. Though AC type voltage is produced by wind turbine while PV panels produce DC type of power. In this configuration a two-way converter is inserted. This is used to change the battery power in terms of AC type voltage into DC type voltage. It supplies AC type power back from battery to AC type load to consumers. AC type power is required by all the consumers, part of the input values into the software are given according to size and quantity. Wind turbines and batteries are the components which will vary in quantity. The other components are solar PV and converter; these two are also vary in size. This chapter attempts to illustrate the variable of input which will help in the optimization and modeling of the system. It will brief some values evaluated to its inputs. We have already explained in the previous chapters in detailed the components of the power generating system and their electricity loads. The schematic representation of HOMER simulated model of the hybrid architecture considered in this project is presented in fig. 7

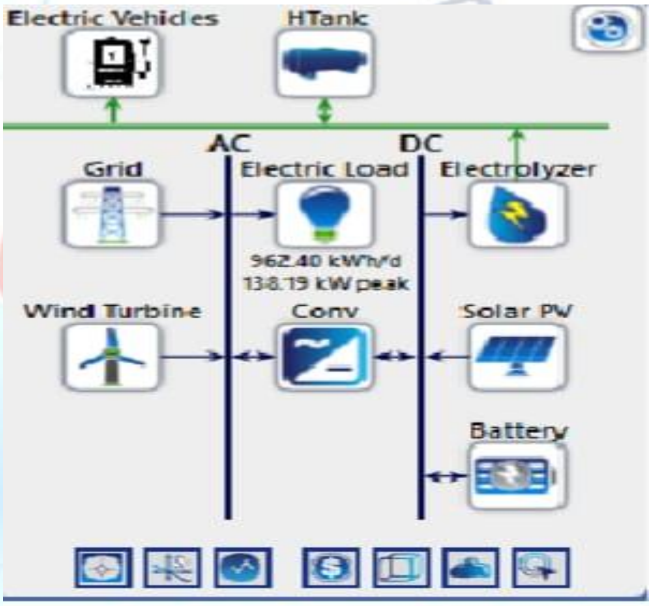


Fig. 7. Architecture of the Selected Technologies of the Hybrid System Produced by HOMER.

V. SIZE AND COSTOPTIMIZATION

Immediately after selecting the components technology from the library of HOMER software, we should enter the electricity load into the modeling tool. The primary load input, determined in section 3.2 is entered on a 24 hours data basis and thereafter the software models a peak load. It also synthesizes the monthly load from a 24-hour input data. This project describes a primary electricity load and its inputs. it groups a weekend load and for august, January and further rest of the months generated by HOMER after inserting the 24 hrs load data depicts the diurnal variation of the[primary load profile of the college Fig. 4 indicates the primary load demand and shows that load profile changes during the day. The load is about to zero from midnight to 6:00 clock in the morning. The load is about to raises the demand from 6:00 to 9:00 O clock. Around lunch time i.e. from 12:00AM to 2:00PM there is a greater demand in power. There is a greater demand for power around dinner time, however peak hour is from6:00 PM to 12:00PM midnight. This schematic clearly demonstrates that electricity id consumed most for lightening purpose. The hourly load profile of the study area is shown in figure 8.

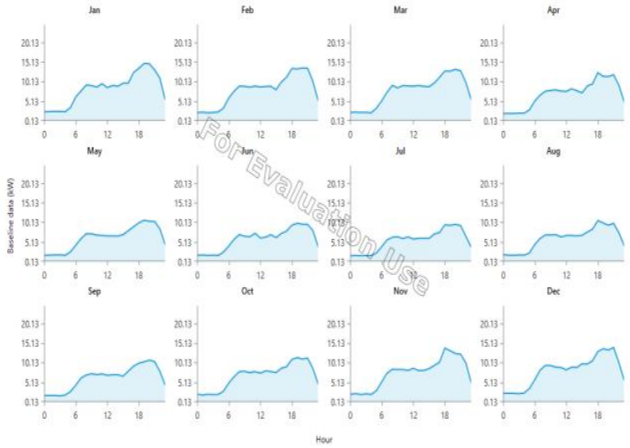


Fig.8. Hourly diurnal variation of primary load profile and hourly variation of load profile.

5.1.Resources Input

Sunlight based crude information contribution to the program is the run of the mill horizontal radiation around the world measured in 10-minute time interval over the two years. Over the sun-oriented assets information the scope and longitude of this territory would likewise be utilized as info. Another parameter was time zone is to be set. The campus is located at latitude: 17°3.6 N, longitude: 81°52.1E, and with time zone of GMT 5:30. So as to get how much power is created by the sun powered PV it requires contributing estimated sunlight-based assets information in units of kW/m² into HOMER software.Like the sun-based sources information the breeze speed was likewise estimated at a similar zone around the same time. Wind speed was estimated at 30 meter and 10 meter stature wind pole yet the information utilized right now just the 30 meter tallness estimated information. The time interim of information estimation was 10 minutes at the two heights. Portion of power created by wind turbine is determined by the product; hence brief wind speed information was contributing into HOMER for the assurance of vitality generation from wind sources. Notwithstanding the wind speed assets, the elevation above ocean level, the anemometer heights are the necessary sources of info as well.

5.2. Grid inputs

Since an eventual surplus of produced electricity at the college can be sold to the grid, a grid is modeled in HOMER. The profit for sold electricity is 0.15 $. Using electricity from the grid is not an option for the college, so the annual purchase capacity, which is the maximal amount of electricity that the system can purchase from the utility grid, is set to zero. The sale capacity, which is the maximal power amount the system can sell to the grid, is set to 100 kW. The emission factor for the electricity of the Indian utility grid used in the modeling is 1037.620796 g CO_2/kWh. Figures 9 and 10 shows the energy purchase from grid and energy sold to grid.

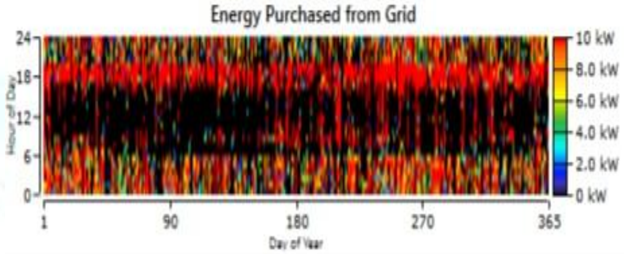


Fig.9.Energy purchase from grid.

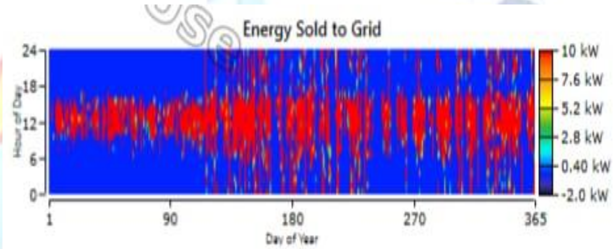


Fig. 10. Energy sold to grid

5.3 Cost Data and Size Specifications of Each Component

The cost of the components as chief purpose of the work is investigating the best power system configuration which would meet the requirements with minimum NPC and COE, is the basic criteria relevant to the selection of the power system components in this thesis. The cost of equipment was estimated on the basis of a current cost available in the market.

Initial capital cost:

The total installed cost used in purchasing and installing components in the beginning of the project.

O&M cost:

The cost of maintaining and operating of the system is the O&M cost. All the components related to this scheme considered in this project as variable operational cost and maintenance cost. Miscellaneous O&M cost mentioned by HOMER are emission penalties, capacity shortage, and penalty and fixed operational and maintenance cost.

Replacement cost:

it is required to change wear out components at the end of its lifetime initial cost of components is

different from this because of all the spaces of the components are not necessary to be replaced at the end of the life cycle .and cost born by donors may make up or reduce the initial cost . However, replacement cost may not be considered as travel cost.
cost.

5.4 Solar PV Size and Cost

The following panel was chosen. The reason for choosing after considering different products regarding the cost provided them with 4 modules having product was chosen from the stated company because of its low cost. This is expected to give an efficient service for a considerable long time. We considered a 50KW solar panel
250W capacity delivered by Generic PV Company. The panel known as Generic Flat Plate PV built with mono-crystalline silicon we have efficiency of 20.4% and price range from $1.16 to $1.31/watt. The insulation cost is taken as 60% of PV price. The operation and maintenance would expected to 1%per year and other details found in table 4.

Table 4: SizeandCostof PV Panel

Size of PV(kW)	Capital cost($)	O&M cost($/year)	Life span of PV (year)	considered Sizes(kW)
1	450	250	25	0, 100,200

Thesystem is a fixed tracking mount on the ground. Derating factor is applied both PU system efficiency and charge controller efficacy as charge controller is not defined by HOMER. This factor is discounted for dust, high temperature shading, wiring losses and so o. in HOMER the size of the PV panel imported is calculated in Kw not in m^2.so we do not detect the consideration. Its efficiency is not considered as an input. Solar system design takes into consideration the azimuth angle or orientation angle of inclination of the PV panel as two important factors. For optimum generation of electricity, the best orientation of solar PV is to the south. But it may also face south east or south west. However, there are could be in small loss of electricity due to the shift of a west or east of south. The following considerations (were made for modeling the power system) like the derating factor at 85%, ground reflectance at 20%, slopes 11^{O}3.6$^{!}$ (Latitude of the location) and azimuth 0 (south orientation)

5.5 Wind Turbine Size and Cost

According to the wind speed sources the turbine has to generate large amount of energy. To provide significant, renewable fraction and we can perform this using a single large wind turbine or number of smaller turbines. Wind turbine is selected on the restrive values such as number of turbines, the service time taken, hub height, price and cost of the components, type of electricity produced and cut in wind speed. So here to cater for Ac load consumer appliances the selected turbines must be AC generating type. The selected for this thesis for 10kw power rated turbine manufactures by the BERGER EXCEL10 company.O&M cost of wind was suggested to being about 2% of its initial capital cost. The total initial cost of these turbines was estimated according to the restored wind turbines in Europe and china since 2011. The installed capital cost of averaged between $ 950/kw to$ 1050/kw in china. In Europe it was $ 1000/kw to $ 1050 /kw.In this thesis the installed cost is taken to be around $950/kw of the wind turbine is considered to be 70% of the capital cost after 20 years of service life.Table 5 represents the parametric inputs of wind turbine into HOMER are inserted.

Table 5: The Wind Turbine Parametric Inputs

Capital cost ($)	Replacement cost ($)	O&M cost ($/year)	Life span (years)	height of the Tower (m)	Considered Quantity
950	800	100	20	30	1 to 8

5.6 Cost and Size of Batteries

As seen other components in the power generating system, input criteria inserting into the software are cost and number of batteries. Please note to the following definitions: the battery rated nominal capacity is _ the quantity of energy discharge from the battery. Minimum state of charge of batteries _ a state of charge below which the battery is never discharge to prevent from damage. The recommended minimum state of charge is 30%_50%. Round trip battery efficiency_ the energy flow into the battery that can preserve for later use. Life time throughput_ the energy quantity that circulated in the battery through its life time. The storage type battery chosen is Trojan SAGM 12 205 manufactured by the Trojan TECHNOLOGIES which is given in HOMER tool library. The chosen battery has the following characteristics obtained from the modeling tool. The selected battery has a nominal capacity of 1156AH (5.06) and has a nominal voltage of 12V for single battery. A single battery can store 5.068Kwh, a maximum charge current is 885A, life time charge of 9108kwh is considered and minimum state of charge is respective at 40%, round trip battery efficiency is 80%. A 70% of a capital cost is expected as replacement cost. Quantities of batteries are considered as 1, 50,150,200,300,400. Therefore, capital cost of batteries is $1200/battery. Replacement cost: $1000/battery. Operating and maintaining cost $12/year are shown in table 6.

Table 6: Size and cost of Battery

Costs ($)			Life span (years)	Throughoutput (Kwh)	Considered quantity
Capital	Replacement	O&M			
1200	1000	12	20	30	100,300

5.7 Power Converter Size and Cost

A Generic large free converter is required to keep the flow of energy between the AC and DC power system components. The standard power of the inverter should be equal to or larger than the peak load. Even below the peak capacity would be installed. Operating and maintenance cost in this case is not conserved converter sizes 1,100,150,200,300kw capital cost of converter is taken as $300 replacement cost is $300. And it is 70% of the capital cost, efficiency of converter is around 90% and life time of the converter will be 15 years are shown in table 7.

Table 7. Size and Cost of Power Converter

Costs ($)			Life span (years)	Considered quantity (Kw)
Capital	Replacement	O&M		
300	200	50	15	50&100

5.8 Electrolyzer size and specifications

Fuel cells are electrochemical devices that convert chemical energy of a fuel, usually hydrogen or hydrocarbon directly into electricity. Fuel cells consist of an anode, electrolyte, and cathode; and by varying the materials used for each component a different fuel cell type is obtained. However, the most common type is the Proton Exchange Membrane Fuel Cells (PEMFC). The main characteristics of PEMFC are quick start-up, low operating temperatures, and low corrosion. This makes PEMFC practical for distributed generation applications. Hydrogen is produced in place with a complementary device called electrolyser. The latter uses the reverse operating principle of fuel cells and produces hydrogen using electricity, allowing the system to utilize the excess electricity from intermittent components. Hydrogen consumption of fuel cells is estimated as follows:

$$H_{2FC} = H_{2c}\, P_{FC}$$

Where H_{2FC} is the fuel cell hydrogen consumption, H_{2c} is the hydrogen consumption constant, and P_{FC} is the required power output of the fuel cell. The table 8 shows sizes considered of electrolyzer.

Table 8. Size and Cost of Electrolyzer

Costs ($)			Life span (years)	Considered quantity
Capital	Replacement	O&M		
1000	800	10	5	50&100

5.9 Hydrogen Tank size and specifications

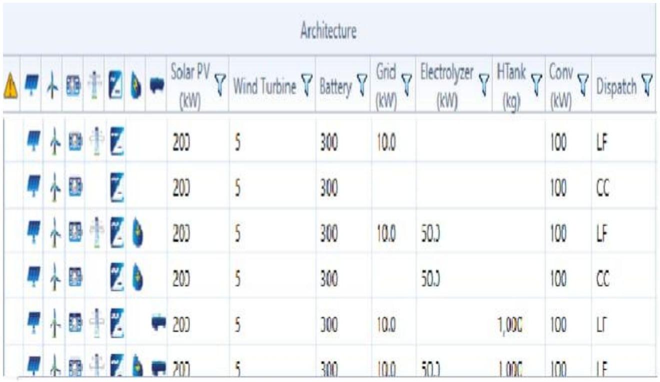
As mention in section 5.8, electrolysers produce hydrogen using excess electricity through a chemical reaction. Hydrogen is stored in tanks at high pressure using a gas compressor, and it is used by the fuel cell as required. Hydrogen tanks are modelled as a limited sink and/or source of hydrogen. Therefore, these tanks are implemented as simple constraints on the HRES operation. The table 9 shows sizes considered of electrolyzer.

Table 9: cost and size of hydrogen Tank

Size of PV(kW)	**Capital cost($)**	**O&M cost($/year)**	**Life span of PV (year)**	**considered Sizes(kW)**
1	450	250	25	0, 100,200

VI. SIMULATION RESULTS AND DISCUSIONS

This chapter gives the details of the optimization results for a selected hybrid power system are shown in figure 11.



Architecture

Solar PV (kW)	Wind Turbine	Battery	Grid (kW)	Electrolyzer (kW)	HTank (kg)	Conv (kW)	Dispatch
200	5	300	10.0			100	LF
200	5	300				100	CC
200	5	300	10.0	50.0		100	LF
200	5	300		50.0		100	CC
200	5	300	10.0		1,000	100	LF
200	5	300	10.0	50.0	1,000	100	LF

Fig.11. HOMER Results

Optimization results are presented in an overall and classified form showing the most workable power system structure which is suitable for a load and input constraints made by the modeler. The workable solutions are shown in an increasing order of the Net Present Cost in a descending order. A classification table gives the least cost-effective combinations from all the components setup. While, the general optimization results presented all the affordable systems combinations based on our NPC. Net present cost was the basics of selecting the power systems. The parameters were like low capacitive shortage, low excess electricity generation and high renewable fraction, are used for comparison of power generation schemes in order to test their technical feasibility. The configuration forthe proposed system is shown in table10

Table 10. Optimized system architectures for the proposed system.

System confg.	Size of PV (Kw)	Size of wt (10 KW)	Grid power consumption (Kw)	Size of batteries	Size of converter (Kw)	Size of electrolyzer	Size of hydrogen tank (Kg)
System1	200	5	10	300	100	-	-
System2	200	5	0	300	100	-	-
System3	200	5	10	300	100	50	-
System4	200	5	10	300	113	-	100

System 1: PV-Wind-battery-Grid

System 2: PV-Wind-battery-

System 3: PV-WT-Battery-Electrolyzer

System 4: PV-Wind-battery-Grid-Hydrogen tank

This study discusses the outcome of the homer simulations and optimizing regarding the results. In all the simulations the main concern is the result of the projects the availability of the grid. As a result, the configuration of the best system for the different types of system structures are presented as well as cost, electrical and environmental analysis are carried out.

Table 11. Analysis of Cost of the scenario

System configuration	COE	NPC (M)	Initial capital cost ($)	O & M cost ($)
System 1	0.355	1.73	56485	500
System 2	0.413	1.81	484750	500
System3	0.391	1.81	614851	500
System 4	0.586	2.86	1.56 M	500

The cost analysis points out that PV-wind system with battery storage as the least NPC and the lowest starting capital requirement. The negative operation and maintenance cost clearly show all the systems excluding the wind configuration make a subcutaneously profit from the operation. The profit is sufficient for maintenance and much exceeds the costs seen from the negative cost of O&M. it can be seen from table11. The most acceptable system for its economy would be the PV-wind system. As it has the lowest NPC and lowest initial capital investment. The electrical analyses conducted by HOMER are presented in table 11 and table12.

Table 12. Detailed analysis electrical energy of the scenario

Configuration of the System	Production of Electricity from (PV) Kwh/year	Production of Electricity from wind (Kwh/year)	Electricity import from grid (Kwh/year)	Electricity sold to the grid (Kwh/year)
System 1	337825	171111	33558	31531
System 2	337825	171111	0	0
System 3	337825	171111	33558	12576
System 4	337825	171111	542495	31531

The electrical analysis table 13 shows that for the system configuration the total fuel are nil, are that no fuel is used. Are in other words no fuel electrification occurs. In table13 also the fuel consumption for the prediction of energy is zero for the whole year. Therefore, there is no cost for running the generator that's why the O&M cost for the from said systems in table11 are identified. From the electrical analysis this clear at fuel electrification is not the best option in the presented context.

The PV- wind system produces at considerable lowest amount of excess electricity than the systems having only the PV or the wind resource. Which clear shows that a system with only one resource is less flexible than hybrid PV and wind system? The PV-wind combination has a higher amount of unmet load.

The main focus of an environmental analysis is the carbon oxide (CO_2) related to the operation of power systems. Considering the respective together the financial aspects standout. Since the difference between systems is important while the impact or the effect of the environment is positive in all the system configurations. Though the PV-wind system is the most advantage, from the point of view of all that perspectives, like the economical, electrical and emission analysis.

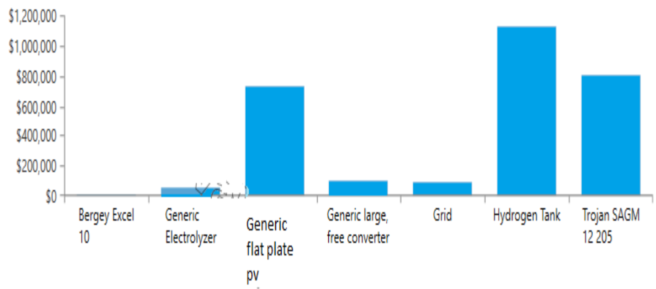


Fig12. The NPC of each component for the recommended PV-wind system.

According to the figure 12 the highest component NPC is for the PV panels and the batteries constitutes the main cost also. Figure 13 represents the monthly average electricity produces from each and electricity words are presented as recommendation for PV-wind configuration.

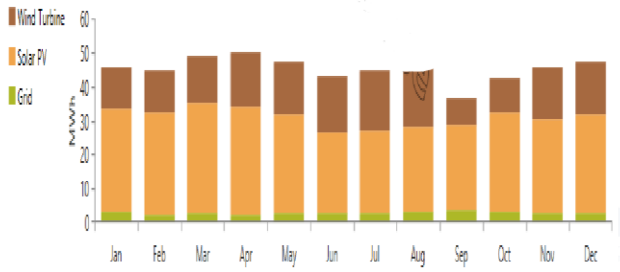


Fig 13. Monthly average electricity production.

Figure 13 indicates for most of electricity produced by the system comes from the PV panels, while only a small part comes from the wind turbine. This relates to the installed capacity as well as to the component NPC. Lastly in figure 19 we see how electricity utilization is distributed by the system loads.

VII. CONCLUSION

In This paper configuration of a viable system design of a hybrid renewable energy system using distributed energy resources for the application in the college have been done for different cases of availability of renewable sources. Considering mainly PV and wind. A case study as already being done for in different cases of renewable sources availability. Considering solar, PV-wind. Another case study was performed to recon the energy load and the resource availability for electricity production here. The scale annual average electrical load at the college was estimated as 964.2Kw/day with peak load of 35.34 kw. The electrical analysis shows that remaking scenarios are not economical fit for the current situation. During the conditions figured in this study the relatively low NPC of the system are much dependent under among the price at which power can be sold at grid. Therefore of selling electricity as an important role for the systems economical suitable such an agreement would make the energy system much more economically viable for the college, which would continue not power to the stage power grid, reduce the CO2 emissions and contribute to an increase renewable energy use and increased availability of power supply.

REFERENCES

[1] Vendoti Suresh, Muralidhar, M. and Kiranmayi, R. (2017). "Optimization of Hybrid Renewable Energy Systems for Sustainable and Economical Power Supply at SVCET Chittoor". i-manager's Journal on Power Systems Engineering, 1(1), 26-34.

[2] Wattala Fernando, Naren Gupta, Givaki Kamya, C Ozveren Suheyl (2019) "Feasibility Study of Small Scale Battery

Storage Systems Integrated with Renewable Generation Technologies for Sri Lankan Domestic Applications", IEEE Conference Proceedings, 2018.

[3] Suresh Vendoti, M. Muralidhar, R. Kiranmayi, "Techno-Economic Analysis of Off-grid Solar/Wind/ Biogas/Biomass/Fuelcell/Battery Based System for Electrification in a Cluster of Villages by HOMER Software", Environment, Development & Sustainability, January 2020.

[4] Hussam J. Khasawneh, Motasem Bani Mustafa, Ahmed Al-Salaymeh, Motasem Saidan (2019) "Techno-Economic Evaluation of On-Grid Battery Energy Storage System in Jordan using Homer Pro" AEIT, 2019.

[5] S. Marais; K. Kusakana; S.P. Koko (2019) "Techno-economic feasibility analysis of a grid-interactive solar PV system for South African residential", 2019 Proceedings of the 27th Domestic use of Energy Conference,2019,pp.163-168.

[6] Suresh Vendoti, M. Muralidhar, R. Kiranmayi, "HOMER Based Optimization of Solar-Wind-Diesel Hybrid System for Electrification in a Rural Village", IEEE Digital Library Explorer, 2018, pp. 1-6.

[7] Bruno P. Pougoue Tchintchui, Atanda K. Raji (2019) "Techno-economic analysis of a renewable energy solution for a off-grid residence", Proceedings of the 27th Domestic use of Energy Conference, 2019, pp.43-50.

[8] Koshy M Kuriakose, Pinkymol K P, Deepu E Koshy (2019)" Design & Development of PV-Wind Hybrid Grid Connected System" , IEEE Conference Proceedings, ,2019, pp.1012-1017.

[9] Ouassima Boqtob, Hassan El Moussaoui, (2019) "Optimal sizing of grid connected micro grid in Morocco using Homer Pro" , IEEE Conference Proceedings, 2019.

[10] Vendoti Suresh, Muralidhar, M., & Kiranmayi, R. (2018). "Design and Analysis of Solar PV-Fuel Cell-Battery Based Hybrid Renewable Energy System (HRES) for Off-Grid Electrification in Rural Areas". i-manager's Journal on Instrumentation and Control Engineering, 6(3), 1-11.

[11] M. Haseeb Nawaz, Muhammad Umer Khan, Anam Zahra, Mazhar Ali, Rashid Wazir, Kafait Ullah, (2018) "Optimal Economic Analysis of Hybrid Off Grid (Standalone) Energy System for Provincial Capitals of Pakistan", The 4th IEEE Conference on Power Engineering and Renewable Energy ICPERE 2018.

[12] Vivek Kumar Soni, Prof. Ranjeeta Khare (2014) " Optimal Sizing of HRES for Small Sized Institute Using HOMER", 2014 IEEE 2nd International Conference on Electrical Energy Systems (ICEES), 2014. pp.77-81.

[13] Punyashree Pattanayak, Nigamananda Panigrahy, Sthitaprajan Mishra (2015) "Overcome of Energy Crisis Using Hybrid Renewable Energy Sources in India: HOMER application", IEEE Sponsored 9th International Conference on Intelligent Systems and Control, 2015.

[14] Hoarca Cristian, Nicu Bizon, Badita Alexandru, "Design of hybrid power systems using HOMER simulator for different renewable energy sources", ECAI 2017 - International Conference – 9th Edition Electronics, Computers and Artificial Intelligence 29 June -01 July, 2017, Targoviste, ROMÂNIA.

[15] Bin Shi, Wei Wu, Liexiang Yan, "Size optimization of stand-alone PV/wind/diesel hybrid power generation systems", B. Shi et al. / Journal of the Taiwan Institute of Chemical Engineers, (2016) , pp.1–9.

[16] Akbar Maleki, Alireza Askarzadeh "Optimal sizing of a PV/wind/diesel system with battery storage for electrification to an off-grid remote region": A case study of Rafsanjan, Iran, A. Maleki, A. Askarzadeh / Sustainable Energy Technologies and Assessments 7 (2014) pp.147–153

[17] Makbul A.M. Ramli, AyongHiendro, Khaled Sedraoui, SsennogaTwaha, " Optimal sizing of grid-connected photovoltaic energy system in Saudi Arabia", M.A.M. Ramli et al. / Renewable Energy 75 (2015)pp. 489-495

[18] Hassan Z. Al Garni, Anjali Awasthia, Makbul A.M. Ramli " Optimal design and analysis of grid-connected photovoltaic under different tracking systems using HOMER" EnergyConversionANDMANAgement155(2018),pp.42–57

[19] Y. V. Pavan Kumar, Ravikumar Bhimasingu, "Optimal Sizing of Microgrid for an Urban Community Building in South India using HOMER" 2014 IEEE International Conference on Power Electronics, Drives and Energy Systems.

[20] Tom Lambert, Paul Gilman And Peter Lilienthal "Micropower System Modeling With Homer" Integration of Alternative Sources of Energy, by Felix A. Farret and M. Godoy Sim~oes Copyright, 2006 John Wiley & Sons, Inc.pp.379-419.