TECHNO-ECONOMIC SECURITY OF OFF-GRID HYBRID SYSTEM FOR REMOTE AREA

Rashmi Parthi[1], Samina Elyas Mubeen[2]

Abstract: Nowadays, utility has begun to take into account the green power technology for having a healthier environment. The green power technologies reduce combustion of fossil fuels and also the resultant co2 emission that is that the principle reason behind global warming. By maximizing the utilization of the renewable energy, the usage of diesel generator for powering the rural area may be reduced or removed. This paper aims to investigate the economic, technical and environmental performance of varied hybrid power systems for powering remote locations. Simulations using Hybrid optimization Model for electric Renewable (HOMER) software are performed to determine the Initial Capital, the overall net present cost (TNPC), the cost of Energy (COE) further because the system capacity shortage of the various supply options. The simulation results recommend an appropriate hybrid system PV/DG/Battery which might be the feasible solution for generation of electric power for remote area. PV/DG/Battery has lowest cost of energy and also environment friendly solution. A close analysis, description and modelling of the system also are presented paper.

I. INTRODUCTION

In the recent years, India's energy consumption has been increasing at a quick rate within the world due to population growth and economic development [1]. In India, Industrial consumers are the largest group of electricity consumers, followed by the domestic, agricultural and commercial consumers, therein order. In the near future, the actual desire for electric vitality is expected to climb speedily due to the worldwide human population increase and industrialization. This specific increase within the vitality desire calls for electric amenities to boost their own energy technology ability. The latest scientific tests predict that the world's net electricity technology is expected to rise from 17.3 trillion Kilowatt-hours in 2005 to 24.4 trillion kilowatt-hours (an increase of 41%) in 2015 and 33.3 trillion kilowatt-hours (an increase of 92.5%) in 2030 [2]. At this time, a large write about of electric power is generated through fossil heats up, particularly fossil fuel due to its lower costs. The actual raising usage of fossil heats up led to important ecological polluting of the environment and varieties of greenhouse gases emission that happen to be the primary reason powering the actual worldwide increased temperatures. On the list of major troubles for India is usually to alter their present vitality made and that is completely outclassed by simply fossil fuel to greater write about of cleanser and monetary types of vitality. Moreover, possible depletion of fossil fuel reserves and hike in oil prices are two main concerns for industrialized countries. To overcome the issues related to generation of electricity from fossil fuels and rural electrification, renewable energy sources may participate within the energy mix. one among the renewable energy sources that may be used for this purpose is that the solar energy. The solar energy may be converted into electricity through the photovoltaic process. The use of photovoltaic (PV) systems for electricity generation started in the seventies of the 20th century and is presently growing at fast pace worldwide. In fact, several organizations expect a bright future for this PV based mostly systems. as an example, the European photovoltaic industry Association (EPIA) expects that the worldwide accumulative PV capability can reach two hundred GW by the year 2020 and 800 GW by the year 2030 [3]. A different renewable energy source that may be used for this purpose is wind energy. Wind is one among the foremost abundant renewable sources of energy in nature. The environmental and economic advantages offered by wind energy are the foremost necessary reasons why wind energy conversion systems are receiving widespread international attention. The general block diagram of off-grid hybrid system is shown in fig. 1.

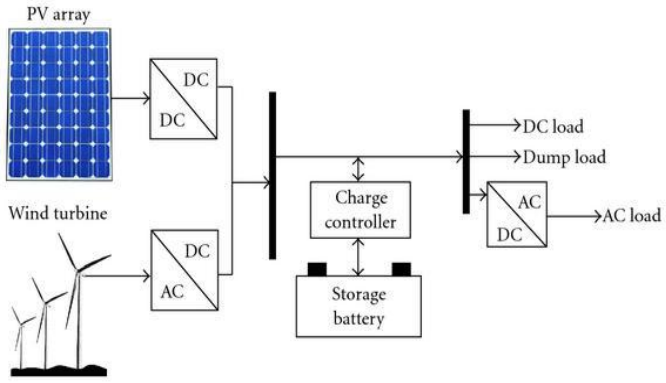

Fig. 1 general block diagram of off-grid hybrid

II. DESIGN OF HYBRID SYSTEM

In this proposes paper an off-grid hybrid system is designed for electrification of remote area at lower cost of energy and less emission. These hybrid system components are Load demand of the project location, PV, Wind Turbine, Battery, and diesel generator.

A. Load profile

In remote villages the demand of electricity is not high compared to urban areas. Electricity is demanded for domestic use, agricultural use and commercial use [4]. We have considered Tilsua village for our study which is located in Malihabad tehsil of Lucknow district in state of Uttar Pradesh. It has total 244 families living there with population of around 1450 as per population census of 2011 [5]. The demand has been estimated considering two different

seasons prevailing in the area, namely summer season (April to September) and winter season (October to March). Village load assessment is done carefully considering village economic condition.

B. WIND profile

The monthly average wind speed data was obtained for selected site from NASA website. The 10 year average monthly wind speed profile at anemometer height of 50 m is 3.25m/sec [7]. Wind speed is highest for the month of June and lowest for month of November. The peak wind speed occurs at 15 hrs. Fig.2 show Monthly Average Wind Speed

Fig. 2 Monthly Average Wind Speed

The diurnal pattern strength i.e. wind speed variation over a day is taken as 0.25 and autocorrelation factor i.e. randomness in wind speed is taken as 0.85. Wind speed data of design location is given in table no 1.

Table no 1 solar and wind data

MONTH	CLEARNESS INDEX	DAILY RADIATION kWh/m^2/day)	WIND SPEED (m/sec)
January	0.370	3.720	2.76
February	0.450	4.670	3.12
march	0.547	5.750	3.21
April	0.619	6.320	3.75
May	0.680	6.570	4.34
June	0.635	5.910	4.58
July	0.509	4.800	3.95
August	0.452	4.480	3.28
September	0.437	4.510	3.04
October	0.470	4.870	2.34
November	0.422	4.260	2.23
December	0.363	3.600	2.49
Average	0.495	4.954	3.25

C. SOLAR

The monthly solar radiation data for village located at 26.8814417 (26°52’53’’N) latitude and 80.7020359 (80°42’7’’ E) longitude is obtained from NASA surface meteorology and solar energy website [7]. The 22 year average annual solar radiation received by the area was 4.95kWh/m2/day [30]. It can be observed from table 1 that range of solar radiation is from 3.60 to 6.57 kWh/m2/day. More solar radiation is expected for the month of March, April and June and less solar radiation for the month of December and January. Solar radiation data of design location is given in table no 1. Fig. 3 shows Monthly Average Solar Radiation and Clearness Index

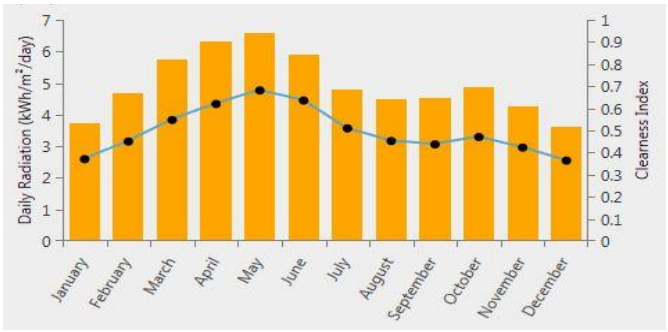

Fig. 3 Monthly Average Solar Radiation and Clearness Index

D. BATTERY

An electric battery is a device which consists of electrochemical cells that convert stored chemical energy into electrical energy. Battery bank is used in off grid hybrid system to maintain constant power supply during peak hours or in condition of lower electricity production from RES. The Surrette 6CS25P storage batteries are utilized in off grid hybrid system.

E. DIESEL GENERATOR

The size of generator is 1kW recognized as for a hybrid system. The capital cost, replacement cost and operating maintenance cost of the generator is usually $500, $400 along with $0.520 respectively. Fuel used for the generator is usually diesel-engine along with the money necessary for diesel-engine is usually varying according to overseas current market pace.

F. Converter

The particular SPV array output DC at a voltage, which depends on the specific settings along with the sunshine-oriented radiation. The DC control then races to an inverter, which changes over it into standard AC voltage. Inverters regularly utilized as a part of extensive scale applications are main inverters that offer simple establishment and high effectiveness. The sizing of the particular inverter are demand in entering direct current (DC) energy in the SPV and also productivity energy of alternating electric current (AC) connected to the particular grid. The proper sizing of inverter possesses skilful to take the most energy from the SPV as well as lower the price of the particular inverter without worrisome the particular operations in the system. The lifespan of the converter is 15 year and efficiency is 90%. Capital cost, replacement cost and operating-maintenance cost of the converter is .700, 500 and 0.0 respectively.

G. HOMER Software

The Hybrid optimisation Model of electric Renewables (HOMER) is a general purpose designing software package developed by the U.S. National Renewable Energy Laboratory (NREL) in 1993 [8]. range of software are developed by completely different establishments for analysing the hybrid energy system, for e.g. HOMER, PV systs, Hybrid2 etc. among all these software HOMER is that the wide used tool for hybrid system sizing [9]. This

optimization software package simulates varied renewable energy sources (RES) system configuration and scales them on basis of net present cost (NPC) that is total value of installing and operating system over its lifespan [8]. HOMER will model grid-connected and off-grid hybrid systems serving the need electric loads, and comprising any combination of photovoltaic (PV) modules, wind turbines, small hydro, generators, micro turbines, fuel cells, batteries, and hydrogen storage. HOMER permits modeller to check variety of various designs options, taking into consideration the technical and economic features of system configuration. The analysis and design of hybrid systems is difficult, owing to the massive range of design options and also the uncertainty in necessary parameters, like load demand and future fuel price. Renewable power sources add any quality as a result of their power output could also be intermittent, seasonal and also the accessibility of renewable resources could also be uncertain. HOMER keeps the accounts of such challenges.

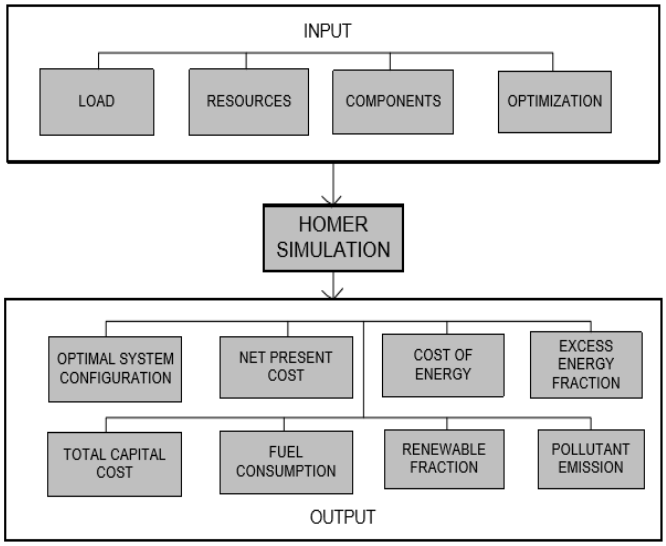

Fig. 4 Architecture of homer simulation and optimization

HOMER performs three principal tasks: simulation, optimization, and sensitivity analysis [10]. Within the simulation process, HOMER models the performance of a selected micro power system configuration every hour of the year to work out its technical feasibility and net present cost. Within the optimization process, HOMER simulates several different system configurations in search of the one that satisfies the technical constraints at the lowest net gift cost. Within the sensitivity analysis method, HOMER performs multiple optimizations under a wide range of input to visualize the effects of uncertainty or changes within the model inputs. Sensitivity analysis helps to visualize the uncertainty or changes in the variables over which the designer has no control, like the average wind speed, solar radiation or the longer term fuel price. Fig.4. shows the design of HOMER simulation and optimisation. To make use of HOMER, you ought to give you the HOMER software package along with inputs, which often explain technological know-how choices, aspect fees, sizes and also source supply. HOMER uses these inputs in order to replicate diverse system configurations, and also yields outcomes which can be known as a summary of probable configurations taken care of by means of NPC. HOMER also demonstrates simulation ends up with many tables as well as a graph which often aids inside comparing diverse configurations and also evaluates these people on the monetary and also techie time frame [8].

III. OPTIMIZATION AND SIMULATION

This section deals with the result of our analysis. The optimization results are presented for off-grid system, which is followed by outcomes of the sensitivity analysis. The proposed system is considered at 4.95 kWh/m^2/day global solar radiation and 3.25m/sec wind speed. The environmental aspect of system configuration is also considered by performing emission analysis. Fig. 5 show off-grid model.

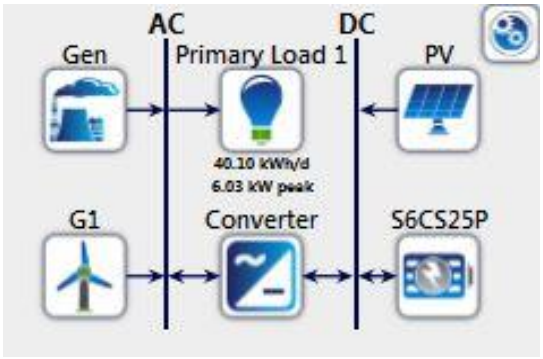

Fig. 5 off-grid hybrid system

The optimal sizing is through the homer softer output result. The optimal configuration found as 5Kw PV-4Kw generator-5Kw convertor- 5units of battery. This optimal sizing has lowest cost of energy, higher renewable factor, high electrical production and has lowest emission amongst various configuration simulated by homer software. Fig.6 shows the electrical production of the each month of year of the off-grid system. Fig. 7 show cash flow of each component which used in the design of off-grid system

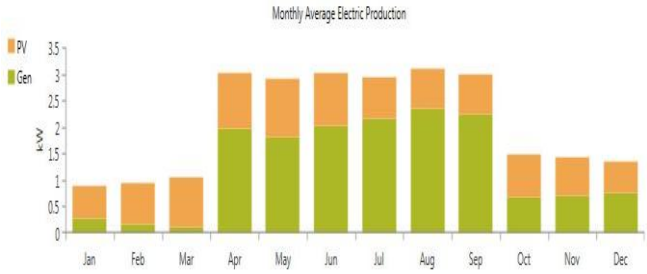

Fig.6 Monthly Average Electricity Production for Off-Grid hybrid system

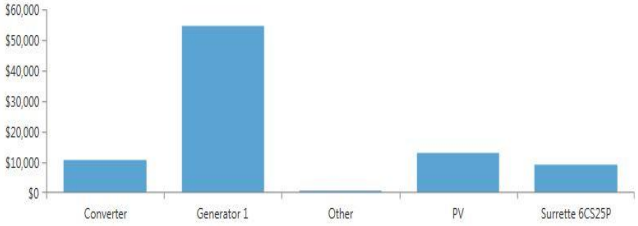

Fig.7 Cash Flow Summary for Various Equipment's in Off-Grid hybrid System

IV. RESULTS AND DISCUSSIONS

The simulation is performed using HOMER for each hour on a yearly basis. The inputs are the hybrid selected system resources data (wind speeds, solar irradiance, and load demand, the technical and economical specification) described in the previous sections. Emission Before simulating the power system, the emissions issue is set (kg of waste matter emitted per unit of fuel consumed) for every waste matter. Once the simulation, the annual emissions are calculated of that waste matter by multiplying the emissions issue by the full annual fuel consumption. The assembly of carbon dioxide, carbon mono oxide, unburned hydro carbon, particulate matter, sulphur dioxide, nitrogen oxides and uses the values when calculating different O & M cost are done. the hybrid combination PV/Battery/DG produce lowest emission. Production the electricity production of varied systems depends on totally different combinations of hybrid system. Homer calculates the electricity that may be produced by all sources, power needed to produce the load, unmet load, and excess electricity. From the simulation results, the capability shortage among all combination of simulation cases is lower in PV/Battery/DG PV/Wind/Battery system. Cost ($) The total net present cost (TNPC) is Hybrid optimization Model for electric Renewable (HOMER) software's main economic output. HOMER ranks all systems in line with the whole net present cost (TNPC). The total net present cost (TNPC) of a system is that the present worth of all the costs that it incurs over its lifetime, minus the present value of all the revenue that it earns over its lifetime. Prices include capital costs, replacement costs, O&M costs, fuel costs, emissions penalties, and, therefore, the costs of buying power from the grid. Revenues include salvage value and grid sales revenue. Fuel Homer finds the energy released per kg of fuel consumed. The fuel price taken is$0.8/L. This is used to calculate the generator fuel cost. HOMER calculates this value by multiplying the fuel price by the amount of fuel used by the generator in one year. The system configurations connected with DG consumes fuel which again will increase the price of system. Sensitivity analysis eliminates all unfeasible combinations and ranks the feasible combinations taking under consideration uncertainty of parameters. HOMER allows taking under consideration future developments, like increasing or decreasing load demand in addition as changes relating to the resources, as an example wind speed variations or the diesel costs. Here, varied sensitive variables are thought of to select the most effective suited combination for the hybrid system to serve the load demand. Optimisation results for each sensitivity case that it solves, HOMER simulates every system in the search space and ranks all the feasible systems according to increasing net present cost (TNPC).

V. CONCLUSION

Due to the steady growth of associated industries in India, there's a necessity to develop a new generation DC Power supplies. it's true that the share of electricity growth in rural areas is far beyond metros. An autonomous energy system combining renewable energy sources, traditional sources and batteries or hydrogen as a storage medium was studied. This paper shows wherever solar, wind resources are available; preparation of solar, wind can satisfactorily meet energy need of remote area electrification. The simulation results indicate that hybrid systems comprising of PV/DG/Battery is often feasible as this kind of has no co^2 and CO emissions and also cost of enegy. Its environment-friendly nature makes it an attractive choice to supplement the energy provide from different sources. The surplus electricity are often keep within the battery and used for future use. The price is additionally moderately less. Solar and wind are obtainable freely and therefore seems to be a promising technology to provide reliable power supply within the remote areas of India.

REFERENCE

[1] Dmowski Antoni, Piotor Biczel, Kras Bartlomiej. Hybrid solar panel fuel cell power plant, 11; 2001; 22–3.

[2] "International Energy Outlook, 2008", Energy Information Administration, available: http://www.eia.doe.gov/oiaf/ieo/index.html. Retrieved February 2009.

[3] Report prepared for Industry Canada by the Delphi Group, “Unleashing the Potential of On-Grid Photovoltaic in Canada. An Action Plan to make PV an Integral Component of Canada’s Energy Future," available online: http://www.ic.gc.ca/epic/site/reiier.nsf/en/h_nz00017e.html. Retrieved February 2009

[4] Nurul Arina bte Abdull Razak, Muhammad Murtadha bin Othman, Ismail Musirin, “Optimal Sizing and Operational Strategy of Hybrid Renewable Energy System Using HOMER”, The 4th International Power Engineering and Optimization Conf. (PEOCO2010) Shah Alam, Selangor, Malaysia, pp. 23-24 June 2010.

[5] Amutha, W. Margaret, and V. Rajini. "Techno-economic evaluation of various hybrid power systems for rural telecom." Renewable and Sustainable Energy Reviews 43 (2015): 553-561.

[6] Shafiqur Rehman, Md. Mahbub Alam, J.P. Meyer, Luai M. Al-Hadhrami, “Feasibility study of a Wind-PV-diesel hybrid power system for a village”, Renewable Energy, 38, pp. 258-268, 2012.

[7] Chong Li , Xinfeng Ge , Yuan Zheng , Chang Xu , Yan Ren , Chenguang Song ,Chunxia Yang, “Techno-economic feasibility study of autonomous hybrid wind/PV/battery power system for a household in Urumqi, China”, Energy,vol.55,pp. 263-272, 2013.

[8] S. Mathew, Wind Energy Fundamentals, Resource Analysis, and Economics, Springer, 2006.

[9] Mohan Kolhe, K. M. Iromi Udumbara Ranaweera, A. G. B. Sisara Gunawardana, “Techno-Economic Optimum Sizing of Hybrid Renewable Energy System”, Industrial Electronics Society, IECON - 39th Annual Conference of the IEEE, pp.1898-1903, 10-13 Nov. 2013.

[10] User manual, HOMER Micro Grid optimization

software, NREL, USA.Luque Antonio, Hegedus Steven,(Editor) Hand Book of Photovoltaic Cience and Engineering, Wiley Publication, 2004, pp. 947-958.

