Hybrid Renewal Energy Stand Alone System for Rural House Buildings in Kerala

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Received: 29.12.2019 **Revised:** 04.01.2020 **Accepted:** 09.01.2020

***Abstract*—**India has aimed to apply a certain number of strategies in order to promote and endorse renewable energies. Detailed energy simulations with many input variables, which makes them unsuitable for decision-making in the early design stage. Hence, it is necessary to develop a simplified HRES (Hybrid Renewable Energy Systems) design method to apply during the early design stage.

***Keywords*—**Hybrid System; Renewable Energy; Stand Alone System.

***Abbreviations*—**Environmental Protection Agency (EPA); Hybrid Optimization Model for Electric Renewable (HOMER); Hybrid Renewable Energy Systems (HRES); Ministry of New and Renewable Energy (MNRE).

I. INTRODUCTION

SIMPLIFIED design method assesses whether design alternatives meet the MRESR requirements. It also provides support to select suitable types of RES for the building by evaluating the performance and economic feasibility. First, previous RES design methods were reviewed and targets of the simplified RES design method were defined. A simplified design method consisting of four steps as follows was then proposed: establish the RES design objectives, generate design alternatives consisting of different RES, evaluate each design alternative, and determine the optimal HRES design [1, 2].

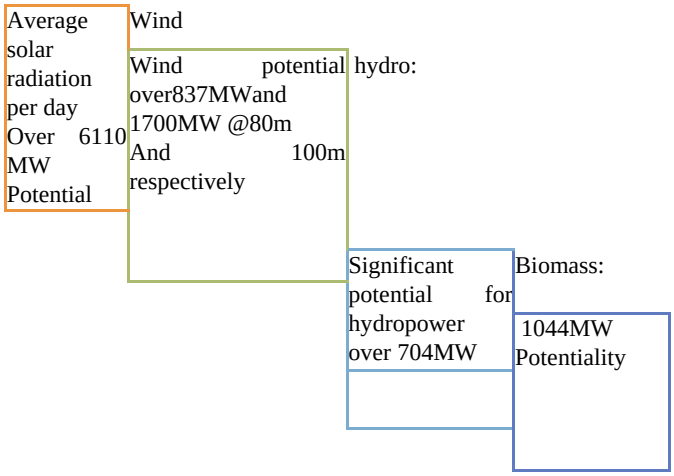
Aware of the promising future of green energy sources, has increased in priority the development of renewable energy across its territory to carry their share to 14.8% of the total capacity in 2016-17 [3, 4].

The year of 2022 marked target of 175GW, a turning point in this process of energy transition with a contribution of renewable energy sources are wind and water [5].

MNRE implementing a wide range of schemes with fiscal and financial support and conducive policies to this target i.e. exceeding 43% of wind energy capacity and 116% of solar power capacity compared with 2015-16.

India is also a nation with a rich geographical resource. From high, mid, and low Mountain ranges, to flat, arid and warm spaces and long coastal areas India is a hub for both solar and wind energy that has been implemented in multiple regions [6].

Kerala is southern state of India having geographic importance like long coastal areas and western gat mountain within a span of average 75 km. Most areas of Idukki district of Kerala under the western region with extremity in climatic conditions



Nearly zero-energy buildings have very high energy performance and the low amount of energy these buildings require come mostly from renewable energy sources. The U.S. Environmental Protection Agency (EPA) has also published the Energy and Environment Guide to Action to gather the latest best practices and opportunities, which the states are using to invest in energy efficiency, renewable energy, and combined heat and power.

Hence, the demand for HRES is increasing, but there are a few difficulties in designing HRES in buildings. First, the

DOI: 10.9756/SIJIFBM/V8I1/IFBM20004
ISSN: 2321-242X

high cost of installing HRES is still a barrier to applying HRES in buildings

Furthermore, HRES are generally designed within a given budget, so simplified design techniques are required to consider both technical reliability and economic feasibility.

Second, increased collaboration between architects and engineers is needed from the beginning of the design process. The design process for HRES in buildings generally begins after the architectural plans have been confirmed. During the design process, architectural plans including the building shape and floor plan are frequently modified by architects. These modifications change the required MRESR of the building. If the expected amounts of energy supplied by the HRES do not meet the building's energy requirements, the HRES design should also be modified. This process requires considerable time, effort, and cost [14].

Lastly, it is difficult to estimate the HRES performance in a building in the early design stage. Different factors such as outdoor conditions, thermal properties of the ground, and building load patterns impact the performance of the HRES. Several types of renewable resources, such as sunlight, solar heat, and geothermal energy, may be used in a building. As they include multiple types of resources and demands, as well as a number of related facilities from energy resources to demand sides, HRES are very common. MNRE implementing a wide range of schemes with fiscal and financial support and conductive policies to this target i.e. exceeding 43% of wind energy capacity and 116% of solar power capacity compared with 2015-16

II. DESIGN OF A PV/WIND/BIO GAS/ STORAGE BATTERY SYSTEM

There is a clear challenge to provide hybrid house buildings at remote locations where a reliable power supply is not available. All the necessary modeling, simulation, and techno-economic evaluation are carried out using Hybrid Optimization Model for Electric Renewable (HOMER) software. The best optimal system configurations namely PV/Battery and PV/Wind/ biogas/Battery hybrid systems are compared with the conventional stand-alone system. Simulation results show that the hybrid energy systems can minimize the power generation cost significantly and can decrease CO2 emissions as compared to the traditional diesel generator only. The sensitivity analysis is also carried out to analysis the effects of probable variation in solar radiation, wind speed, biogas availability and average annual energy usage of the system load in the optimal system configuration Stand-Alone Systems are designed and optimized to meet the power demand of remote places are off-grid power systems. An off-grid system does not have a connection to the main grid electricity and vary widely in size and application [15].

Hybrid power systems are designed for the generation of electrical power using number of power generation devices such as wind turbine, PV, micro hydro and/or other conventional generators. In addition, it includes power electronics and electricity storage bank. Some of the advantages of using HRESs are gain an immediate access to reliable electricity at any time; reduce the dependency from oil price fluctuations and the transportation costs of fuels; increase economic productivity and fight climate change India is a land of renewable energy source's opportunity. However, currently only less than 2% of the renewable resources (excluding hydro) are exploited for electricity generation across India. This presents a huge untapped potential for large scale renewable power projects as well as small scale mini-grids and off-grid power systems.

Despite the fact that around 80% of the population India lives in rural areas, electricity supply from the grid is almost entirely concentrated in urban areas. And limited grid infrastructure and inadequate power generation capacities has greatly affected the availability and quality of electricity supply. Among other things, dispersed demand and very low consumption level of electricity among rural consumers, limited grid electricity penetration to rural population. Therefore, in order to meet the continuous typical load demand of a rural house building during varying atmospheric conditions, different energy sources need to be integrated for extended usage of alternative energy. This will create a large demand for off-grid power supply in rural areas which renewable energy is best suited to realize power needs with renewable energy technologies. Solar and wind and biogas are available freely and thus appears to be a promising technology to provide reliable power supply in the rural areas of Kerala. The research project aim to design an off-grid hybrid renewable energy system for a house building 200 square meter area, so that can generate and provide cost effective electric power to meet electric load requirement.

Different research is carried in the field of renewable energy; applications of stand-alone power system and hybrid renewable energy systems have been conducted for the maximum usage of the resource potential are here taken as case studies.

The techno economic analysis of this option has been done using HOMER software and hybrid PV/wind/biogas power generator system became economically feasible for the proposed site at Idukki of Kerala based on some important parameters such as high renewable penetration, less annual recurring cost, less carbon dioxide emission and less cost of energy.

This study presents the result of techno-economic analysis of hybrid system comprising of solar, wind energy, biogas energy for powering a specific rural isolated house at Idukki dist in Kerala state, South India. But the optimal system configurations obtained through simulation in HOMER. Two best optimal system configurations namely PV-Wind-Battery and PV-wind-biogas-battery system are compared with the conventional stand-alone diesel generator (DG) system. Finding indicated that PV array (2 KW)-Wind energy (1.5KW)-biogas energy (1KW) -Battery (24 units) is the most economically viable option with the total net present cost of Rs and per unit cost of electricity of Rs 4.09. The

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simulations indicate that a hybrid system option, compared to a diesel only system, is feasible for each of the four villages.

In this paper it is proposed a hybrid system cost analysis which has wind generation, solar system, biogas and storage battery system using efficient optimization tool HOMER for obtain the optimal cost of the hybrid system. Determine the optimal combination of solar, wind and biogas based hybrid system to fulfill the load requirement and minimize the cost. In this research presents a solution utilizing a hybrid of solar and wind power and bio gas systems with storage batteries to provide reliable power for a rural house building located. The meteorological data including solar sunshine hours and hourly wind speed are taken for a site in Idukki district at 1000 m altitude. The power consumption pattern of a rural house building depends up on the economic condition of the residents users. The cost of the hybrid system is also estimated. The proposed Research ensures the ultimate feasibility and financial benefit for the owners of the house building and more over the development of sustainable growth of the country.

Thus, based on the literature reviews, HOMER modeling software is taken for the purposes of this study to carry the feasibility analysis, when compared with other software's HOMER creates a list of feasible system configurations sorted according to cost effectiveness and presents the optimal configuration based on the lowest net percent cost (NPC) the supply in order to design system. This research also used the same software to design and optimize the off-grid hybrid power system to be provided electricity requirement of the remote areas of different countries. To improve the infrastructure of the rural community there must use Hybrid RES to provide electrical power depending on the geographical area and the resource availability of the area. Here in this research site of Idukki, it uses Hybrid Battery and Generator, but power supply is not continuous. However this study differs from the related studies in terms of application, load demand, climatic data, and location of the study area [16].

III. METHODOLOGY

In this research study, a hybrid stand alone grid is developed for single phase system. The voltage of the solar PV module is connected to a sine wave inverter. The output of the inverter is 230 volts. The wind uses a dc generator because the variation in velocity of wind is within the manageable limit in this region. Therefore low speed permanent magnet dc generator is coupled to the wind turbine. This is chosen as it is more technically and economically viable in rural/ remote areas. The voltage from the generator terminals is applied across the sine wave inverter which is designed to give output of 230 volts. The biogas and biodiesel generation makes use of ac generators. The excitation and input are so adjusted to get the generated voltage of 230 volts. Then all the four sources are synchronized at an AC bus. The power generated from all the sources supply the load. This provides sustainable power though all sources generate fluctuating power when operated independently. This small scale generation technology holds the potential to help basic electricity services to the people who are living in remote/rural areas, who don't have an access to grid connectivity. Thus the locally available resources can help becoming energy independent. The resource assessment from primary information collected in the field and secondary data available from different sources is encouraging to choose installation of standalone hybrid grid.

IV. MATHEMATICAL MODELLING AND SIMULATION

There are quite a few number of models have been proposed and are available, e.g. model formulation based on linear programming, mixed linear programming, hybrid optimization model for electric renewable, etc. including cost optimized models. In this work mixed linear programming model is used. Many software tools viz HOMER [7], PVSYST [8], SOMES [9], RAPSIM [10], SOLSIM [11], INSEL [12], PV- Design Pro [13] etc. are available and are capable of simulating, optimizing and determining sizes of equipment in hybrid energy systems. A mathematical model for each source is source is derived and simulated. Finally all the sources are integrated. The energy available from all the generators can be managed to serve the load by operating the generators as per the predefined schedule to fit the load curve under consideration. However, there is a flexibility to change the operating schedule to make it compatible with the load curve at hand.

Mathematical modeling and simulation were done separately for Solar PV systems, Wind Turbine generator systems and Bio gas power generator systems.

DOI: 10.9756/SIJIFBM/V8I1/IFBM20004
ISSN: 2321-242X

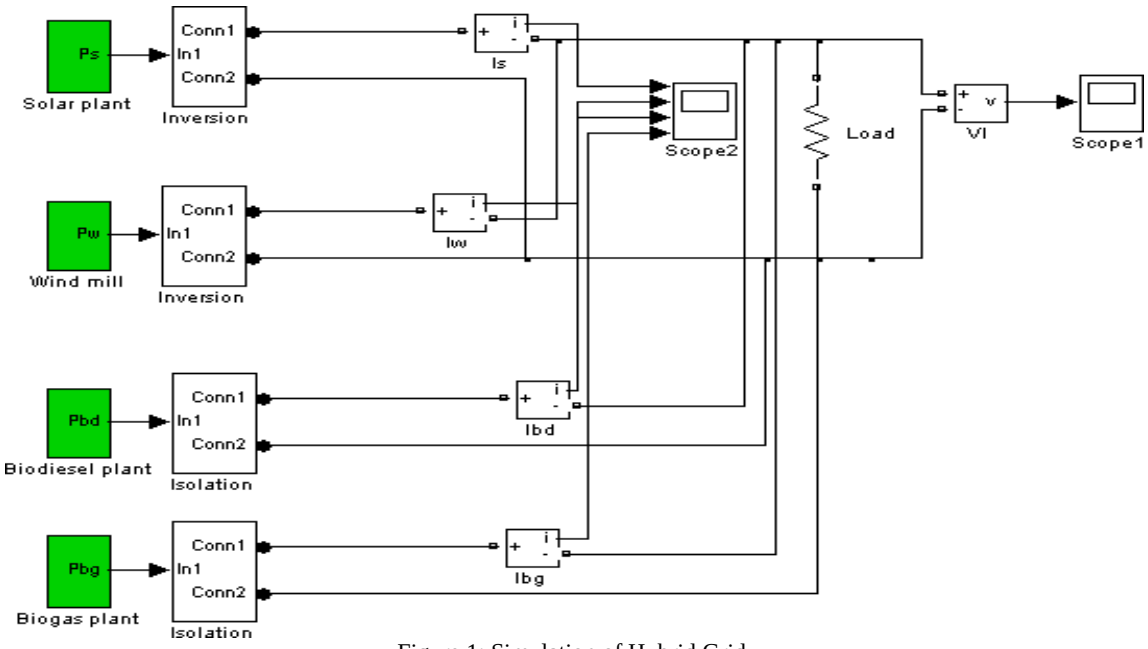

Figure 1: Simulation of Hybrid Grid

V. Simulation Results

The simulation is tested for the generated voltage at common points where all the sources are connected. It is observed that there is perfect synchronization of the sources and no local current paths are found. The voltage wave form obtained at the grid terminals is as shown in Figure

The rated unity power factor load of 2996 watts is connected and the currents supplied by all the sources are measured and waveforms are recorded. The observation of the current waveforms reveals that all sources are sharing the load proportional to their rated capacities. The current waveforms for the rated condition are depicted in Figure 8.

The practical load is not always constant. Therefore the performance and load sharing is evaluated for one more load condition at half the rated power. It is observed that the sources are sharing the load. The magnitudes of the currents supplied by the sources at half the full load are analyzed.

There is no appreciable change in the terminal voltage for both full load and half the full load. Thus the system voltage regulation is well within the permissible limits. The same is observed by looking at the load voltage at half the full load condition shown

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DOI: 10.9756/SIJIFBM/V8I1/IFBM20004
ISSN: 2321-242X