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HYBRID GENERATION SYSTEM OPTIMIZATION FOR RURAL ELECTRIFICATION BY HOMER –A REVIEW

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Abstract: *The Hybrid Generating systems have become a very common avenue of generating sustainable energy in the modern world. The success of this particular method of power generation is widely attributed to the technological advancements in the field of renewable energy. The production of electricity via diesel generators is subject to operational challenges related to the fluctuating prices of diesel. On the other hand, wind energy is intermittent in nature, hence a limited reliability. In this regard, it will be a remedial move to adopt the use of various hybrids to internalize these shortcomings. The advantages of one particular element in a given hybrid will compensate for the shortcomings of a given element within the same hybrid. There exist a variety of hybrids that are used in the generation of electricity in the modern world. A typical hybrid will harness or store energy from two or more sources. This work present a deep review of Homer optimization tool used for the analysis of cost and optimum size of hybrid system.*

Keywords: Hybrid system, HOMER, Wind, Solar, Converter and Generator system.

1. Introduction

Solar–wind hybrid energy systems allow improving the system efficiency, power reliability and reduce the energy storage requirements for stand-alone applications. Good compensation characters are usually found between solar energy and wind energy. These hybrid systems are now becoming popular in urban area for power generation applications due to advancements in renewable energy technologies and substantial rise in prices of petroleum products. This study recommend an optimal design model for hybrid solar–wind systems employing battery bank for calculating the system optimum configurations and ensuring that the annualized cost of the systems is minimized while satisfying the custom requirements.

The main benefit of solar-wind hybrid system is that when solar and wind powers are used together, the reliability of the system is enhanced. These alternatives may include hybrid power systems like wind-PV, wind-diesel, PV-diesel and others with or without battery backup option. With continuous research and development efforts, it has been established that the hybrid systems, if optimized properly, are both cost effective and reliable compared to single power source systems. Additionally, the size of battery storage can be reduced as there is less dependence on only one source of power generation. Often, when there is no sun, there is plenty of wind in India (as in Monsoon season). Winds are usually relatively strong in winter and solar radiations have higher intensity in summer.

To get the continuous power from renewable energy sources hybrid system installation is increasing day by day, which can provide the reliable power. Lot of researchers has suggested different ways of optimization of hybrid system, interfacing of hybrid system with grid etc. Here the brief note of the work which has been already done in the subject area is presented.

Authors of [1], present the design and analysis of an energy/water system that combines a 20 MW hybrid concentrated solar/biomass power plant with an advanced wastewater treatment facility. Designed to be installed in one of the most demanding areas of the Iberian Peninsula, the Spanish region of Andalusia, this plant seeks to provide the area with potable water and electricity. The solar block works with a mixture of molten salts, while the biomass backup system of the power plant uses olive pomace.

Telecommunication towers located in remote locations are generally powered using diesel generators and batteries. However, diesel generators require higher maintenance cost and for remote sites this cost will be more due to the added oil transportation cost. Maximizing the use of renewable energy is beneficial in reducing the diesel generation cost [2].

The design idea of optimized PV-Solar and Wind Hybrid Energy System for GSM/CDMA type mobile base station over conventional diesel generator for a particular site in central India (Bhopal). For this hybrid system ,the meteorological data of Solar Insulation, hourly wind speed, are taken for Bhopal-Central India (Longitude 77o.23'and Latitude 23o.21') and the pattern of load consumption of mobile base station are studied and suitably modeled for optimization of the hybrid energy system using HOMER software[3].

Article [4] discussed that the economic feasibility of stand-alone hybrid power system consisting of Biomass/PV/Wind generators for electrical requirements of the remote locations. It emphasizes the use of renewable hybrid power system to obtain a reliable autonomous system with the optimization of the components size and the improvement of the capital cost.

A novel intelligent method is applied to the problem of sizing in a hybrid power system such that the demand of residential area is met. This study is performed for Kahnouj area in south-east Iran. It is to mention that there are many similar regions around the world with this typical situation that can be expanded. The system consist of fuel cells, some wind units, some electrolyses, a reformer, an anaerobic reactor, and some hydrogen tanks [5].

Authors of [6] described that Decentralized distributed generation technologies based on renewable energy recourses such as Solar Photovoltaic (SPV)/ Wind Turbine Generators (WTG) address the major issues concerned with conventional diesel generators to a large extent and are therefore considered as emerging alternate power solutions to stand alone applications.

Article [7] focused that Stand-alone hybrid renewable energy systems usually incur lower costs and demonstrate higher reliability than photovoltaic (PV) or wind systems. The most usual systems are PV–Wind–Battery and PV–Diesel–Battery. Energy storage is usually in batteries (normally of the lead-acid type).

A hybrid power generation system suitable for remote area application suggested by [8]. The concept of hybridizing renewable energy sources is that the base load is to be covered by largest and firmly available renewable source(s) and other intermittent source(s) should augment the base load to cover the peak load of an isolated mini electric grid system.

Article [9] suggested current power systems create environmental impacts due to utilization of fossil fuels, especially coal, as carbon dioxide is emitted into the atmosphere. In contrast to fossil fuels, renewable energy offers alternative sources of energy which are in general pollution free, technologically effective and environmentally sustainable.

A wind-pv-diesel hybrid power system has been designed from a village in Saudi Arabia which is presently powered by a diesel power plant consisting of eight diesel generating sets of 1,120kW each [10].

Authors of [11], proposes the planning of hybrid micro-hydro and solar photovoltaic system for rural areas of Central Java, Indonesia. The Indonesian government has paid great attention to the development of renewable energy sources, especially solar and hydropower.

Article [12], presents the results of an energetic and economical analysis of a hybrid power generation system (HPGS) which utilizes photovoltaic modules, wind turbines, fuel cells and an electrolyzer with hydrogen tank working as the energy storage. The analysis was carried out for three different residential loads, local solar radiation and local wind speed, based on the real measurement values.

Different hybrid configurations of wind, photovoltaic (PV), and diesel systems for a village in the north-eastern region of Saudi

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Arabia are presented. The configurations (i) diesel only, (ii) wind-diesel, (iii) PV-diesel, and (iv) wind-PV diesel power generation systems are designed and compared to select the optimal alternative system by considering the minimum cost of energy and least environmental impact[13].

2. Hybrid System

The hybrid energy system proposed consists of wind, solar power as depicted in Fig. 1. The energy system consists of a wind turbine generator, diesel generator, solar PV array, battery bank, grid power and an AC/DC converter [14].

Distributed electricity generation from Renewable Energy Sources (RES) such as solar and wind are increasingly seen as cost effective alternatives to centralized carbon-based generation. A disadvantage, common to wind and solar options, however, is their unpredictable nature and dependence on weather and climatic changes. The hybrid systems that combine solar and wind generating units with battery backup can attenuate their individual fluctuations and reduce energy storage requirements significantly.

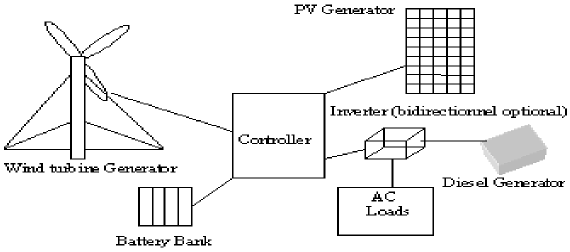

Figure 1: Schematic diagram of hybrid energy system.

2.1 Appropriate Hybrid System

Homer simulates the operation of a system by making energy balance calculations for each of the 8,760 hours in a year. For each hour, Homer compares the electric demand in the hour to the energy that the system can supply in that hour, and calculates the flows of energy to and from each component of the system. All the resources and inputs simulated and we got the 360 sustainable configurations [15]. This simulation results eliminate all infeasible combinations and rank the feasible systems according to increasing net present cost. There are 360 feasible designs for our site under desirable conditions.

After simulating all the possible system configurations, we should select at least one optimum hybrid system, sorted by net present cost, battery life and payback period. A 1.6 kW Solar wind hybrid system is the optimum system for this site because this system has lower net present cost, higher battery life with less payback period. The hybrid system has been designed based on the following steps:

(i) Power requirement,
(ii) Availability of Solar and Wind Resources,
(iii) Configure the inputs for generating sustainable conditions
(iv) Simulations of the sustainable Hybrid Systems,
(v) Chosen of the optimum system for fulfilling the consumer requirement.

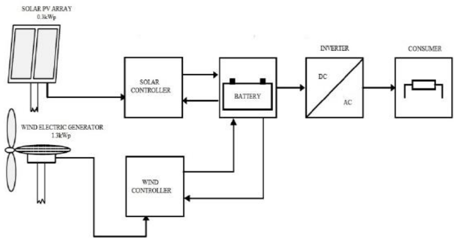

Figure 2: Optimum Solar Wind Hybrid

3. ABOUT THE HOMER

HOMER, the micro power optimization software developed by Mistaya Engineering, Canada for the National Renewable Energy Laboratory (NREL) USA, used in this analysis simplifies the task of evaluating designs of both off-grid and grid-connected power systems for a variety of applications. In designing a power system, many decisions about the configuration of the system are to be made: components to include in the system design, size of each component to use etc. The large number of technology options and the variation in technology costs and availability of energy resources make these decisions difficult. HOMER's optimization and sensitivity analysis algorithms make it easier to evaluate the many possible system configurations [16].

HOMER (hybrid optimization Model for Electric Renewable) software is a userfriendly micro power design tool that simulates and optimizes stand-alone and grid-connected power systems. HOMER allows the designer to compare many different design options based on their technical and economic merits. Recently, it has been used widely in the field of renewable energy. It can be used with any combination of wind turbines, PV arrays, run-of-river hydro power, biomass power, internal combustion engine generators, micro turbines, batteries, and hydrogen storage, serving both electric and thermal loads. The advantage of HOMER is that it can involve also all costs such as the initial capital and the maintenance costs including pollution penalties.

We can use HOMER to perform analyses to explore a wide range of design questions:

• Which technologies are most cost-effective?

• What size should components be?

• What happens to the project's economics if costs or loads change?

• Is the renewable resource adequate?

HOMER's optimization and sensitivity analysis capabilities help you answer these difficult questions. It performs a sensitivity analysis which can help the analyst to do 'what-if' analyses and to investigate the effects of uncertainty or changes in input variables. The objective of the optimization simulation is to evaluate the economic and technical feasibility for a large number of technology options, while considering variations in technology costs and energy resource availability. HOMER produces the amount of emissions of PV and wind-generator system along with the amount of emissions.

3.1.What does HOMER do

HOMER finds the least cost combination of components that meet electrical and thermal loads. HOMER simulates thousands of system configurations, optimizes for lifecycle cost, and generates results of sensitivity analyses on most inputs.

HOMER simulates the operation of a system by making energy balance calculations for each of the 8,760 hours in a year. For each hour, HOMER compares the electric and thermal load in the hour to the energy that the system can supply in that hour. For systems that include batteries or fuel-powered generators, HOMER also decides for each hour how to operate the generators and whether to charge or discharge the batteries. If the system meets the loads for the entire year, HOMER estimates the lifecycle cost of the system, accounting for the capital, replacement, operation and maintenance, fuel and interest costs. You can view hourly energy flows for each component as well as annual cost and performance summaries.

3.2 Optimal Size of the Proposed System Using HOMER

The system consists of; PV modules, wind energy system, batteries, charge controller, inverter, and the necessary wiring and safety devices. The system feasibility analysis was performed using the HOMER software [17, 18]. As before we have discussed HOMER is a computer model that simplifies the task of evaluating design options for both off-grid and grid-connected power systems for remote, stand-alone, and distributed-generation (DG) applications. HOMER's optimization and sensitivity analysis algorithms allow one to evaluate the economic and technical feasibility of a large number of technology options and to account for variation in technology costs and energy resource availability.

HOMER models both conventional and renewable-energy technologies. HOMER models a power system's physical behavior and its life-cycle cost, which is the total cost of installing and operating the system over its life span. HOMER allows the modeler to compare many different design options based on their technical and economic merits. It also assists in understanding and quantifying the effects of uncertainty or changes in the inputs.

4. Conclusion

In conclusion, this report encompasses background about the hybrid system that became a common technique for producing electrical energy globally. Also, it includes displaying some modes of power generation that can be combined with wind energy system including hydrogen, hydro, air compressed, diesel, solar systems and this in turn plays a significant role in addressing intermittent nature of the wind as a source of energy. Proposed hybrid system will be designed and optimized using HOMER software computer model to supply lighting load. All the optimization systems are ranked according to net present cost, and all other economic outputs will be calculated for the purpose of powering and finding the best net present cost. The result obtained from the optimization gives the initial capital cost as well as operating cost.

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