# RENEWABLE ENERGY: SOLAR –WIND HYBRID SYSTEM FOR POWER SUPPLY DIFFERENT AREA-A REVIEW

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## Abstract

*Demand for energy is increasing day by day because of increasing the population and industrialization but we have very limited resources. In this critical stage of energy crisis, renewable energy is one of the most important alternative energy sources. Renewable energy sources are an "indigenous" environmental option, economically competitive with conventional power generation where good wind and solar resources are available. Hybrid plants can help in improving the economic and environmental sustainability of renewable energy systems to fulfill the energy demand. It consists of PV and solar thermal modules, wind turbine and biomass plant. In this paper we study of different hybrid power generation system suitable for various application areas.*

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## Introduction

Energy plays an important role in all types of development, including economic development. The world total energy annual consumption generally increases, with the vast majority of energy being produced by fossil fuels such as coal, oil and natural gas. In 2002 fossil fuels provided the three quarters of the total. With the current energy consumption rate, proven coal reserves should last for about 200 years, oil for approximately 40 years and natural gas for around 60 years. With constantly increasing development, diminishing fossil fuel resources and related environmental problems (e.g. emissions), sustainable development and the manner in which energy is produced and consumed is reconsidered.

In developing countries like India, it is very difficult as well as uneconomical to transmit power over long distances through transmission lines, to electrify remote and rural areas. The lack of an electrical network in remote areas and prohibitively high connection cost of grid extension and rough topography often leads to exploration of other options. Stand-alone hybrid systems consisting of renewable sources are found promising ways to satisfy the electrification requirements of these areas [2]. The need for energy efficient electric power sources in remote locations is a driving force for research in hybrid energy system [3]. In addition to that, use of renewable help in reducing fossil fuel consumption levels and the consequent effect of carbon dioxide and other green house gases[4]. The hybrid energy systems also provide an effective solution to meet the power demand in case of shortage from the grid supply.

Energy generated from solar, wind, biomass, geo-thermal, hydropower and ocean resources, could increase the diversity of energy supplies and offer "clean"-environmental friendly energy. Although wind and solar energy sources are significantly less productive compared to fossil fuels, the use of photovoltaic **(**PV) cells and wind turbines [2] has increased rapidly during the last years, especially in developed countries. Photovoltaic (PV) cells are electronic devices that are based on semiconductor technology and can produce an electric current directly from sunlight. The best silicon PV modules currently commercially available have an efficiency of over 18%, and it is expected that in about 10 years' time module efficiencies may raise to 25%. Wind power is basically electricity produced by a generator, which is driven by a turbine according to flowing air's aerodynamics, and is one of the fastest growing renewable energy technologies around the world.

PV modules and wind turbines [3] are now widely used in developed countries to produce electrical power in locations where it might be inconvenient or expensive to use conventional grid supplies, while other homeowners who choose the renewable energy sources prefer to connect their energy system to the grid as a huge 'battery' for some convenient grid-tied situation. However, when electricity grids are non-existent or rudimentary, all forms of energy can prove very expensive. In such cases, solar and wind energy can be highly competitive. The fact that natural energy resources are intermittent and storage batteries are expensive, has led to the utilization of so-called hybrid renewable energy systems. Any power system that incorporates two or more of the following is referred to as a hybrid power system: PV panels, wind turbines, or diesel, propane, gasoline generators. For small loads, the most common combinations [4] are PV-wind hybrid system. PV and wind is a good match, because inland wind speeds tend to be lower in summer, when solar energy can compensate, and higher in winter, when sunshine falls to very low levels.

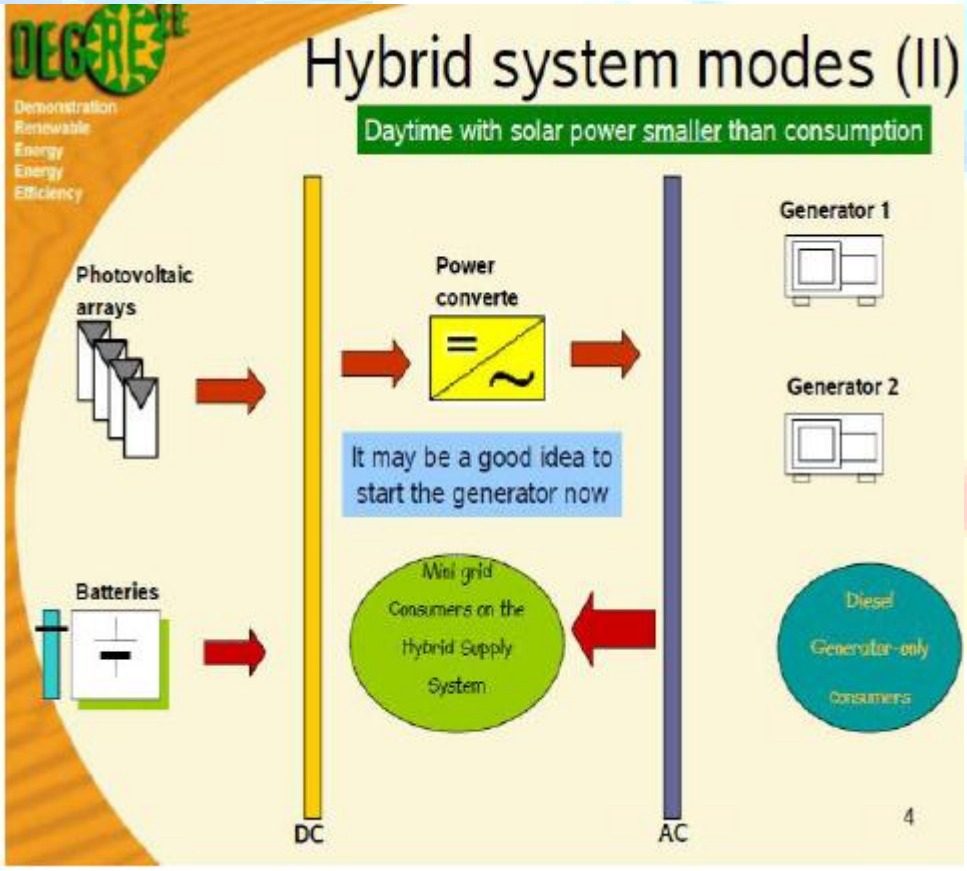


**Fig.1: Hybrid system model**

## I. Special issues of wind turbines and PV Cells

As both wind and solar energy sources are inconsistent and non-stable. Hybridizing solar and wind power sources together with storage batteries to cover the periods of time without sun or wind provides a stable form of power generation. However, the variable features, especially in the case of wind power, constitute a significant difference to the conventional fossil fuel, nuclear or hydro-based power generation. Even so, wind energy is currently the least expensive renewable energy technology.

Photovoltaic or PV cells, known commonly as solar cells, convert the energy from sunlight into DC electricity. PVs offer added advantages over other renewable energy sources in that they give off no noise and require insignificant maintenance.

Although solar energy is well known to students (e.g. found on most calculators), their operating principles and governing relationships are unfortunately not as pedagogically simple as that of wind-turbines. However, they operate using the same semiconductor principles that govern diodes and transistors.

The explanation of their functioning is straightforward and may even help many of the principles covered in semiconductor electronic classes to become more intuitive. Wind-turbines and PV cells provide DC but most industrial uses of electricity require AC power. A semiconductor-based device known as a power inverter is used to convert the DC to AC. This device has a relatively simple operation and is a vivid illustration of many topics traditionally covered in power electronics classes.

## II. System analysis

### a) Specific Site Conditions for PV-Wind Hybrid System

Intermittent and seasonally unbalanced natural energy resources are the most important reason to install a hybrid energy system. The PV-wind hybrid system suits to conditions where sun light and wind has seasonal shifts i.e., in summer the daytime is long and sun light is strong enough, while in winter the days are shorter and there are more clouds, but there is usually an increased wind resource that can complement the solar resource.

The PV-wind hybrid systems especially suit remote locations, where it is inconvenient or expensive to use conventional grid supplies. For the PV array, a direction without any obstacles facing the sun is needed. For the wind turbine, appropriate wind speed and wind direction are the

key elements. The turbine should be subjected to non-turbulent wind and mounted higher than trees and other obstacles.

**b) System Components**

**i. PV Cells**

Photovoltaic's offer consumers the ability to generate electricity in a clean, quiet and reliable way. Photovoltaic systems are comprised of photovoltaic cells, devices that convert light energy directly into electricity. Because the source of light is usually the sun, they are often called solar cells. The word photovoltaic comes from "photo," meaning light, and "voltaic," which refers to producing electricity. Therefore, the photovoltaic process is "producing electricity directly from sunlight." Photovoltaics are often referred to as PV. PV systems are being installed by Texans who already have grid-supplied electricity but want to begin to live more independently or who are concerned about the environment.

For some applications where small amounts of electricity are required, like emergency call boxes, PV systems are often cost justified even when grid electricity is not very far away. When applications require larger amounts of ele

ctricity and are located away from existing power lines, photovoltaic systems can in many cases offer the least expensive, most viable option. In use today on street lights, gate openers and other low power tasks, photovoltaic's are gaining popularity in Texas and around the world as their price declines and efficiency increases.

**HOW IT WORKS**

PV cells are made of at least two layers of semiconductor material. One layer has a positive charge, the other negative. When light enters the cell, some of the photons from the light are absorbed by the semiconductor atoms, freeing electrons from the cell's negative layer to flow through an external circuit and back into the positive layer. This flow of electrons produces electric current.

To increase their utility, dozens of individual PV cells are interconnected together in a sealed, weatherproof package called a module. When two modules are wired together in series, their voltage is doubled while the current stays constant. When two modules are wired in parallel, their current is doubled while the voltage stays constant. To achieve the desired voltage and

current, modules are wired in series and parallel into what is called a PV array. The flexibility of the modular PV system allows designers to create solar power systems that can meet a wide variety of electrical needs, no matter how large or small.

For an off-grid PV system, consumers should consider whether they want to use the direct current (DC) from the PV's or convert the power into alternating current (AC). Appliances and lights for AC are much more common and are generally cheaper, but the conversion of DC power into AC can consume up to 20 percent of all the power produced by the PV system.

**ii. Wind Turbine**

A wind turbine is a device that converts kinetic energy from the wind, also called wind energy, into mechanical energy; a process known as wind power. If the mechanical energy is used to produce electricity, the device may be called a wind turbine or wind power plant.

**Wind turbine works** the opposite of a fan. Instead of using electricity to create wind, wind turbines use wind to create electricity. Most turbines have either two or three blades. These three-bladed wind turbines are operated "upwind," with the blades facing the wind. The other common wind turbine type is the two-bladed, downwind turbine. The wind turns the blades, which spin a shaft, which is connected to a generator and produces electricity. Utility-scale turbines range in size from 50 to 750 kilowatts. Single small turbines, below 50 kilowatts, are used for homes, telecommunications dishes, or water pumping.

**iii. Biomass**

Biomass Sources are forest or agricultural products. The resource is ultimately a function of such factors as solar radiation, rainfall, soil conditions, temperatures, and the plant species that can be grown. In India, fuel wood, crop residues and animal manure are the dominant biomass fuels. These are mostly used at very low efficiencies. Municipal solid wastes (MSW) and crop residues such as rice husk and bagasse can also be used for energy generation. The total potential of energy from these sources in 1997 is estimated to be equivalent to 5.14 EJ, which amounts to a little more than a-third of the total fossil fuel use in India. The energy potential in 2010 is estimated to be about 8.26 EJ. The cost of biomass varies according to the carbon content and the location of the biomass availability.

**iv. Generators**

A generator consumes fuel to produce electricity, and possibly heats a by-product. HOMER's generator module is flexible enough to model a wide variety of generators, including internal

combustion engine generators, micro turbines, fuel cells, Starling engines, thermo photovoltaic generators, and thermoelectric generators. HOMER can model a power system comprising as many as three generators, each of which can be ac or dc, and each of which can consume a different fuel. The principal physical properties of the generator are its maximum and minimum electrical power output, its expected lifetime in operating hours, the type of fuel it consumes, and its fuel curve, which relates the quantity of fuel consumed to the electrical power produced. In HOMER, a generator can consume any of the fuels listed in the fuel library (to which users can add their own fuels) or one of two special fuels: electrolyzed hydrogen from the hydrogen storage tank, or biomass derived from the biomass resource. It is also possible to co-fire a generator with a mixture of biomass and another fuel.

**iv. Other Component**

DC-AC inverter changes low voltage direct current (DC) power, which is produced by the PV or wind turbine or is

stored in the battery, to standard AC which is most commonly 120 or 240 VAC, 50 or 60 hertz. The “modern sine wave” inverters supply uninterruptible power, i.e. there are no blackouts or brownouts. Such inverters come in sizes from 250 watts to over 8,000 watts. There are also the "modified sine wave" inverters which are cheaper and can handle most household tasks. However, this type of inverters may create a buzz in some electronic equipment and telephones, which can be an annoyance. It should be noted that inverters have made great strides in performance and price in recent years. Inverters can also provide a utility inter-tie between the renewable energy system and the utility grid, allowing the selling of excess energy to the utility. Many inverters also have built-in battery chargers to keep the batteries topped off from either the grid or your generator.

Safety equipment includes over-current and lightning protection components. Over-current protection components

such as fuses and fused disconnectors protect the system's wiring and components in the event of short circuits. Fusing protects from over-current situations, and disconnectors allow safe shutdown of system components for maintenance and repair. Fuses and fused disconnectors are rated by the amount of current they can handle. They may be as small as a few amperes, in case of measuring instruments, to as large as 400 amperes, in case of the inverter. Many renewable energy systems are in areas where thunderstorms and lightning are common. It should be

considered that the wind turbine is always the highest building in the remote area. Commercial lightning arrestors can be employed to boost protection of the system's electronics against lightning.

Measuring instruments can keep track of the battery voltage, the amount of consumed power, the state of battery

charge and the electricity traffic between the grid and the renewable energy system, if connected. Some instruments have more than one channel to monitor two battery banks or a battery bank and a generating source for the hybrid systems.

Batteries store electrical energy produced by the renewable energy source in a reversible chemical reaction. Most

renewable energy systems use lead-acid batteries, typically encased in plastic, wired together in series and parallel strings. Battery capacity is rated in amp-hours; with 1 amp-hour is the equivalent of drawing 1 amp steadily for one hour. A typical 12-volt system may have 800 amp-hours of battery capacity. This is the equivalent of 1,200 watts for eight hours if fully discharged and starting from a fully charged state. There are many brands and types of batteries available for renewable energy systems and the two most common batteries are the L- 16 and golf cart sizes.

Charge controller/regulator prevents the PV array and wind turbine from over-charging the battery. Most modern

controllers maintain system voltage regulation electronically by varying the width of DC pulses they send to the batteries (this is called pulse width modulation or PWM). This means the wider the pulse, the more power goes to the batteries. Another category is the "shunt type" controllers which divert excess energy into a "shunt load." Such controllers are more commonly used in wind or hydro systems, since these systems generally should not be run open circuit. Unlike a PV module, most wind and hydro turbines cannot be switched on and off by the controller. A new generation of PV controllers employs "maximum power point tracking." They take advantage of the maximum power available in the module by adjusting both current and voltage.

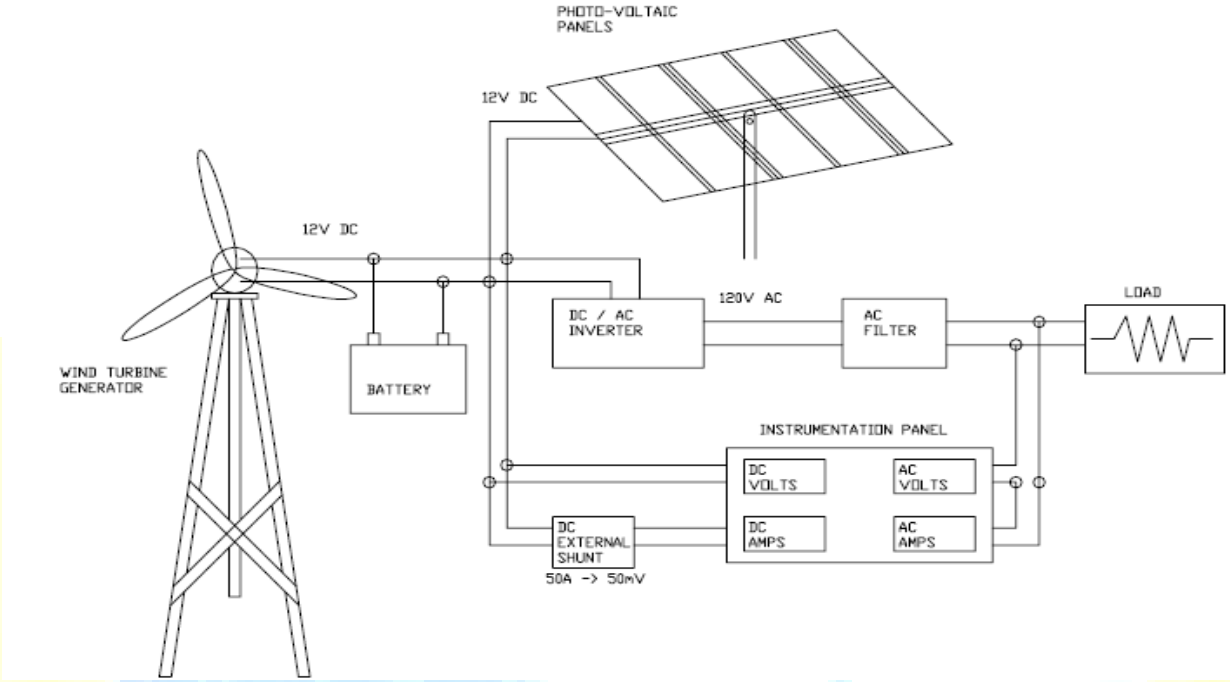


**Fig.2: Block diagram for hybrid system**

## II. Literature Summary

**M. A. Motin (2012**): In this paper energy efficient renewable energy based Base System for an isolated location, such as Saint Martin's Island, has been proposed. Saint Martin's island is one of the most beautiful tourist islands in

Bangladesh where grid connected electric system for the residents and for the telecommunication system will not be

Possible to launch even in future. The residential consumers use diesel, kerosene and wood for fulfilling their energy demand. Solar and Wind resources are the hybrid options for the Island[13].

**Mohamed El Badawe(2012):** 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. This paper describes the optimization of a hybrid power supply system for a telecommunication tower located in Mulling, Labrador. The hybrid system consists wind, solar,

diesel generation and batteries. Hybrid Optimization Model for Electric Renewable (HOMER) software was used for the sizing, and sensitivity analysis is performed in order to obtain the optimal configuration of hybrid renewable energy system [7].

**J. K. Maherchandani(2012):** The present paper discuss 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. The main source of power to the energy system is biomass generator, whereas, photovoltaic panels and wind generators are the supported additional sources. The batteries are used to store extra energy generated that can further be used for the backup. This investigation assessed the potential of using solar, wind and biomass renewable energy in hybrid off-grid system. The optimization is realized through the NREL HOMER package[5].

**S. M. Hakimi et al. (2011)**: In this paper, 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 electrolysers, a reformer, an anaerobic reactor, and some hydrogen tanks. The system is assumed to be stand-alone and uses the biomass as an available energy resource. System costs involve investments, replacement, and operation and maintenance as well as loss of load costs. Prices are all empirical and components are commercially available. In this study, we consider load growth and different types of load profile for their system. In this village, four types of loads exist such as residential, agricultural, industrial, and official loads [3].

**Deepak Kumar Lal et al (2011):** A large proportion of the world's population lives in remote rural areas that are geographically isolated and sparsely populated. This paper proposed a hybrid power generation system suitable for remote area application. 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. The study is based on modelling, simulation

and optimization of renewable energy system in rural area in Sundargarh district of Orissa state, India. The model has designed to provide an optimal system configure ration based on hour-by-hour data for energy availability and demands. Various renewable/alternative energy sources, energy storage and their applicability in terms of cost and performance are discussed. The homer software is used to study and design the proposed hybrid alternative energy power system model. The Sensitivity analysis was carried out using Homer program. Based on simulation results, it has been found that renewable/alternative energy sources will replace the conventional energy sources and would be a feasible solution for distribution of electric power for standalone applications at remote and distant locations [4].

**Pragya Nema et al. (2010):** This paper gives 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 Insolation, 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 modelled for optimization of the hybrid energy system using HOMER software. The simulation and optimization result gives the best optimized sizing of wind turbine and solar array with diesel generator for particular GSM/CDMA type mobile telephony base station. This system is more cost effective and environmental friendly over the conventional diesel generator. It should reduced approximate 70%-80% fuel cost over conventional diesel generator and also reduced the emission of CO2 and other harmful gasses in environments [5].

**GM Shafiullah et al. (2010):** 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. There is an increased interest in renewable energy, particularly solar and wind energy, which provides electricity without giving rise to carbon dioxide emissions. This paper presents economic analysis of a renewable hybrid system for a subtropical climate and also investigated the impact of renewable energy sources to the existing and future smart power system. Initially total net

present cost (NPC), cost of energy (COE) and the renewable fraction (RF) have been measured as performances metrics to compare the performances of different systems. For better optimization, the model has been refined with sensitivity analysis which explores performance variations due to wind speed, solar irradiation and diesel fuel prices [2].

**PrabodhBajpai et al.(2010)**: Inthis paper 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. Three stand alone WTG power systems using different energy storage technologies, i.e. WTG-Battery system, WTG-Fuel Cell (FC) system and WTG-FC-Battery system are optimized and compared in this paper. The analysis of such hybrid systems feeding a standalone load of 45.6 kWh/day energy consumption with a 2.3 kW peak power demand is carried out using Hybrid Optimization Model for Electrical Renewable (HOMER) software[7].

**Jose´ L. Bernal-Agustı´n et al.(2009):** 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). Another possible storage alternative, such as hydrogen, is not currently economically viable, given the high cost of the electrolyzers and fuel cells and the low efficiency in the electricity–hydrogen–electricity conversion. When the design of these systems is carried out, it is usually done resolve an optimization problem in which the Net Present Cost (NPC) is minimized or, in some cases, in relation to the Levelized Cost of Energy (LCE) [6].

## III. Software Resources for Renewable Hybrid Energy Systems

HOMER is a micro power optimization software used in evaluating designs of both off-grid and grid-connected power systems for a variety of applications. The cost benefit analysis of a wind turbine-solar hybrid system was done using HOMER software and comparison was also made with the cost per kilowatt of central grid or utility supply. The hybrid system have a pay-back period of about thirty-three years and at current costs, central grid power is the least expensive

option but may not be available to most rural households far from the grid. Hence it is necessary to supply these areas from isolated power sources. The HOMER energy modeling software was originally developed by NREL beginning in 1992. In 2009 HOMER Energy, LLC was awarded the exclusive license to commercialize the software. The micro power optimization modeling software assists engineers and non-technical users to compare power system configurations across a wide range of applications. HOMER models the physical behavior of the power system and quantifies the total cost of installing and operating the system over its lifespan. Its graphical user interface allows users to interactively compare design options on their technical and economic merits. HOMER performs three principle tasks: simulation, optimization, and sensitivity analysis.

HOMER is primarily an optimization software package which simulates varied renewable energy sources (RES) system configurations and scales them on the basis of net present cost (NPC) which is the total cost of installing and operating the system over its lifetime. It firstly assesses the technical feasibility of the RES system (i.e. whether the system can adequately serve the electrical and thermal loads and any other constraints imposed by the user). Secondly, it estimates the NPC of the system. HOMER models each individual system configuration by performing an hourly time-step simulation of its operation for project. lifetime, including initial set-up costs (IC), component replacements within the project lifetime, maintenance and fuel.

## IV. Conclusion

This paper has included the most relevant papers on the design, simulation, control, and optimization of the hybrid systems. As a result of this review, we determined that the most frequent systems are those consisting of a PV Generator and/or Wind Turbines and/or Diesel Generator, with energy storage in lead-acid batteries. The main criterion for sustainable development is that all key factors interacting within a global system should be in equilibrium. For a sustainable material development it needs optimum combination between three factors economy, ecology and energy. Homer software was used to determine the optimum hybrid configuration. The diversity of loading cases, geometry and material characteristics together with the new solution methods motivates to continue research. The review of these and earlier publication allow to conclude that, the crane hook, need a more extensive investigation since a very few articles in this field have been published yet.

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