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Design Assessment of Hybrid Solar – Biomass Renewable Energy System

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ABSTRACT— The demand of energy is increasing day by day with the growth of population but the limited conventional energy sources cannot fulfil the demands for a longer time. Thus, non-conventional energy resources are used in huge amount as well as these renewable energy sources are mostly cost free and easily available. Regional energy supply from renewable sources, such as solar energy and biomass, employing distributed energy systems plays a significant role in the overall structure of the world's energy supply. These renewable energy sources when combined become increasingly attractive as compared to utilizing them alone. This paper will be focusing on design and construction of hybrid system from renewable energy sources namely solar, biomass.

Keywords— **HRES, PV, Biomass, RHES, NPC, COE, HOMER, NREL, RET, Optimization**

I. INTRODUCTION

Energy is the basic need for any developing country. World's conventional energy sources includes fossil fuels like natural gas, coal, crude-oil etc. There are several issues like rapid depletion of fossil fuel, negative impact on environment, increasing cost, increase in global warming which are forcing to find out and use alternative energy source [1]. Environment friendly or more reliable energy generation sources play an important part in energy generation. Thus, renewable hybrid energy sources are most widely available alternative energy source like wind, solar, hydro, biogas, fuel cells, tidal, geothermal etc.

The most widely used renewable energy sources are solar and biomass in rural and remote areas. Renewable energy sources are dependent on environment conditions and intermittent in nature therefore two or more renewable energy generation resources can be integrated together along with storage can increase system performance [2]. Table I shown some features of RHES (Renewable hybrid energy system). The applications of renewable hybrid energy system in isolated and remote areas are more reliable than grid connected systems. The present paper represents the basic concepts and design analysis of Hybrid renewable energy system [HRES]. The thorough overview of hybrid systems has been given in Table II, which may be seen below.

TABLE I
CHARACTERISTICS OF RHES

S. No.	Advantages	Disadvantages
1	Renewable energy is eco-friendly in nature	Renewable energy generation is based on natural cycles
2	Less maintenance and operational requirements	Installation cost of these systems are high
3	Pollution free	Energy storage are required for handling peak-loads

1.1 CONTRIBUTIONS

The main contributions of the research are as follows: -

- In this research, eco-friendly hybrid systems including solar energy and biomass fuels are analysed.
- Employment possibilities are another benefit of hybrid renewable energy sources.

1.2 ORGANIZATION OF THE PAPER

The organization of the paper are as follows: - Section II and Section III explains about the solar and biomass energy. Section IV represents the hybrid energy system that is solar and biomass architecture. Section V describes about the software tools for analysis. Finally, section VI concluded the paper.

II. SOLAR ENERGY

The sun's rays may be captured to produce solar energy, which is a kind of energy that is both beneficial and environmentally friendly. Solar array converts solar radiation which are directly coming from sun into electrical energy. Solar energy is the boundless or eco-friendly renewable energy source. When sun ray's incident on PV cell they absorb the heat and emit electrons [8]. Due to the movement of electrons, current is generated. By this process solar panel convert solar energy into electrical energy directly [9]. Every system needs specific components beyond PV modules. Standalone PV system contains inverter, which is generating AC power, Battery requires for storage or backup supply and charge controller. The capacity of each component depends on

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estimated load. A typical stand-alone PV system is shown in the fig.1.

TABLE II COMPREHENSIVE REVIEW OF HYBRID SYSTEM

References	Location	System	Findings
[3]	Sierra Leone	Hybrid Grid-Connected Renewable power system	It investigates the technical and financial viability of a hybrid renewable energy system (HRES) for the electrification of rural areas in a sustainable manner
[4]	Pakistan	Solar-Wind	The generation of electrical energy via the use of renewable and clean sources of energy while minimizing the amount of pollution produced is the primary focus of this study.
[5]	Remote location	Solar–wind	It provides an extensive analysis of the many features of HRES
[6]	Rural parish placed on the Ecuadorian coast	Solar/Wind/Diesel	It designs of a Hybrid Electric System (HES), with the intention of satisfying the need for electricity in a rural area.
[7]	Middle East and Africa	Hybrid renewable energy system	It presents a detailed and up-to-date resource and economic overview of HRES that have been established in various regions.

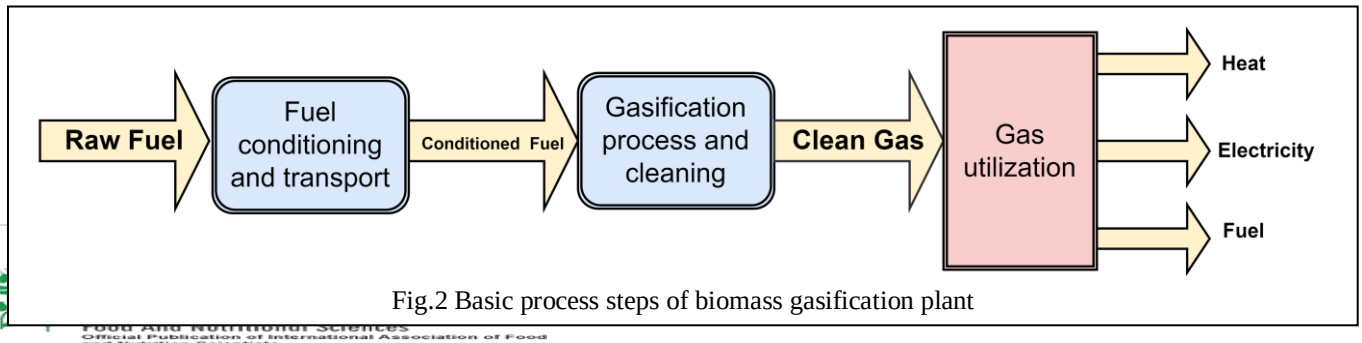

Fig.2 Basic process steps of biomass gasification plant

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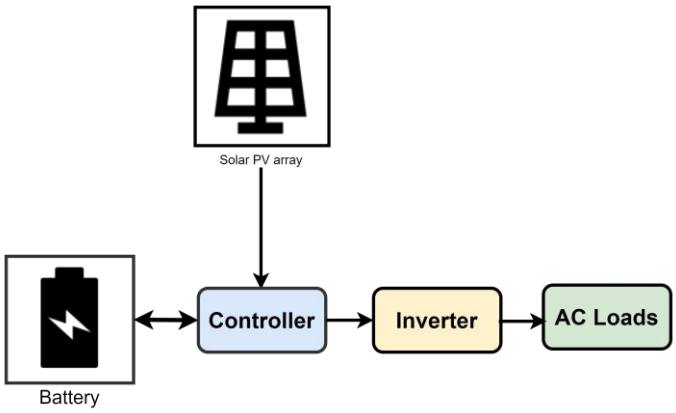

Fig 1 Standalone PV system

The amount of electricity available from a PV device is calculated by:
I. The sunlight intensity
II. The type and area of the PV material
III. The wave length of the sunlight

During the energy conversion relies the quantum nature of light, we receive light as a flux of particles called photons - which contain the energy, Eph given by equation

$$Eph = hc/\lambda \quad (1)$$

Where,

Eph= as a energy

h = the Planck constant,

c = the speed of light (m/s), and

λ = the wavelength of light (m).

A rough estimate of the current (I) that can be generated by a solar cell is given by equation (2)

$$I = qNA \quad (2)$$

Where,

N = the number of photons,

A= the area exposed to light, and

Q= the charge in coulomb

The maximum voltage is given by equation (3) below

$$V = Eg/q \quad (3)$$

Where,

Eg = gap energy

V = the maximum voltage

III. BIOMASS ENERGY

Biomass is a renewable resource of energy taken from various ways such as agricultural residue, wood waste, animal waste, energy crops etc to generate electricity. Biogas contains CO_2 (carbon dioxide), CH_4 (methane), and have some amount of H_2S (Hydrogen), siloxanes and moistures. Table III shown biogas compositions [10]. Biomass gasification has been one of the most effective process steps for using biomass as a renewable energy resource. Gasification is a process of converting solid fuel (biomass) into producer gas (combustible gas) through a series of thermo-chemical reactions. During thermo-chemical reactions in biomass gasification process, raw fuel (solid biomass) breaks by thermal energy and gets converted into product gas. The product gas needs to be cleaned and used for the electricity or heat generation [11]. Gasification plant consists of various operational steps which are shown in fig.2.

The solid biomass fuel used in it requires fuel conditioning and handling. The conditioned fuel goes through gasification process, which produces raw product gas. Then raw product gas passages through cleaning process in order to achieve clean gas and produce gas utilize to generate electrical power, fuel and heat.

TABLE IIII
TYPICAL COMPOSITION OF BIOGAS

Compound	Chemical	%
Methane	CH_4	50-75
Carbon dioxide	CO_2	25-50
Nitrogen	N_2	0-10
Hydrogen	H_2	0-1
Hydrogen Sulphide	H_2S	0-3
Oxygen	O_2	0-0

IV. HYBRID ENERGY SYSTEM ARCHITECTURE

In recent years, hybrid power system has gained popularity. The hybrid systems could be combined as shown in fig. This type of system is called hybrid energy system because it

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contains two or more energy generating resources in order to achieve estimated load generally an AC load; sometimes DC load also supplied or in some cases both is supplied. In hybrid energy system, alternative energy sources are used which are may be renewable (solar, biomass etc.) as well as non – renewable (diesel generator or electric grid etc.) or energy storage components like battery, fuel cells are used to increase efficiency of the system. Control unit plays an important role in whole system architecture shown in fig.3 which takes a decision which energy source supply energy to the load [12]. Fig 4. Depicts the installed capacity of all renewable energy in India as on 31-01-2022.

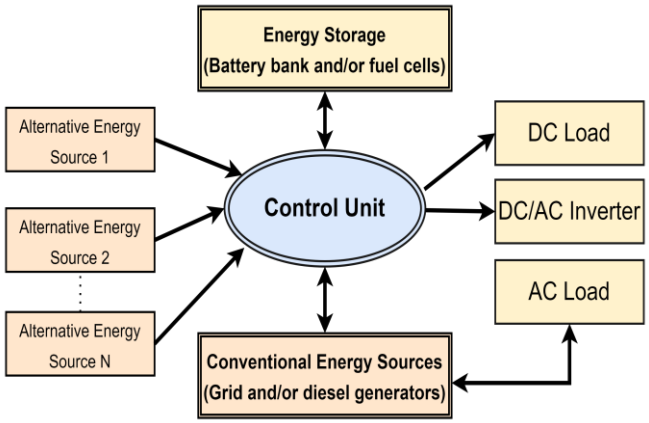

Fig.3 General Hybrid Energy System Architecture

V. SOFTWARE TOOLS FOR ANALYSIS

A hybrid renewable energy system is made by two or more energy sources based on alternative energy sources. For economic analysis of HES, we need to efficiently utilize RE resources. Hybrid energy system uses many energy generation systems, so system analysis is slightly complex. Due to this reason, different types of softwares are used for system design configuration, simulation, optimization etc. The software evaluated were HOMER, RETScreen, Hybrid2, RAPSIM iHOGA, iGRHYSO, TRNSYS, SOLSIM, HYBRIDS, SOMES, HySim, HybSim, ARES, IPSYS, HySys, SOLSTOR, INSEL and HYBRID DESIGNER [13].

The HOMER (Hybrid optimization model of renewable energy) is mostly used because it is user friendly and freely available. The HOMER Software is a computer-based modeling system and developed by USA National Renewable Energy Laboratory (NREL) for both grid-connected and off-grid power system [14].

A power system design in HOMER software compares different configurations throughout its life time.

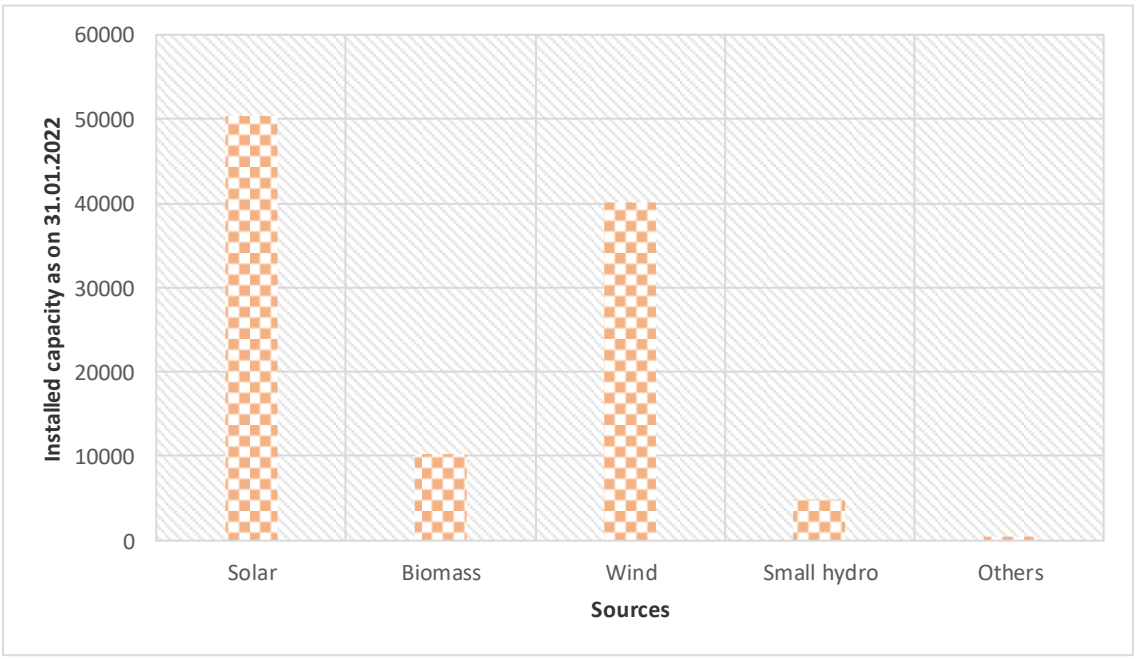

Fig 4 Summary of All India Renewable Energy Generation

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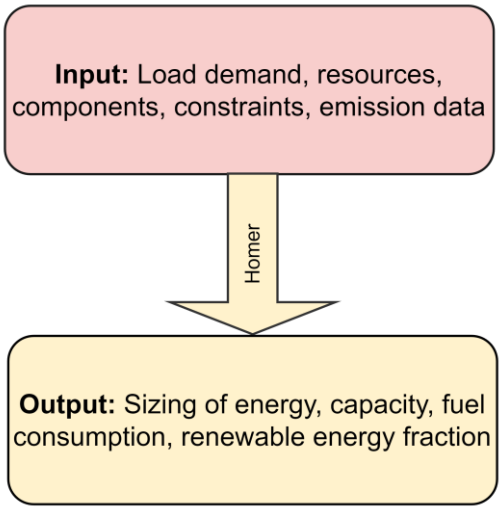

Fig 5 Schematic representation of HOMER

It takes various inputs such as component costs, manufacturing data, resource availability etc. Three basic operations performed by HOMER are: Simulation, Optimization and Sensitivity. The schematic representation of HOMER is shown in fig. 5. HOMER finds the lowest cost configuration of components those fulfill electrical 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. HOMER simulates different designs and obtains lists of results in the form of NPC (Net Present Cost), COE (Cost of Energy), O&M (Operations and Maintenance Cost) and Initial Capital Cost.

VI. CONCLUSIONS

HRES (Hybrid Renewable Energy System) is the design technique that integrated several sources of renewable energy to obtain optimized power output. This paper summarizes the current developments of HRES (Hybrid Renewable Energy System) with popular reference to solar energy and biomass energy. Different type of software tools are utilized for optimization of HRES but HOMER provides best configuration output. Homer takes various inputs and performs simulation to generate best result. So, solar-biomass HRES are one of the best options for the electrification of large scale or small-scale areas.

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