Hybrid Solar & Kitchen waste based Plant for Green Buildings: An Approach to meet the standards of Zero Energy Buildings

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Abstract - ***The use of renewable energy sources are becoming very essential due to the limited reserves of fossil fuels. The global environmental concerns like Kyoto protocol or also restricting the use of fossil fuels. Hence, there is an immediate need to concentrate on renewable energy sources with localized power generation. In most of the hostels, restaurants and community centers it is easy to use biomass based systems with integration of solar power. Even though the use of solar power is becoming popular, but due to some economical and technical limitations it may be not possible to depend on solar power completely.***

Kitchen food waste which is available in hostels and restaurants can be used for power generation by integrating with solar power can improve the reliability of the system. By optimizing these two resources can decrease the unit cost of the solar power and improves the reliability of the overall system performance.

In this paper a case study has been analyzed for a College campus "Gandhi Institute of Engineering and Technology, Gunupur" central mess with the possibility of using canteen food waste to generate power and integrating with solar power. This paper also highlights the economical considerations of Solar - Biomass hybrid systems by using Homer software simulation.

Key Words: *Biomass, Solar power, Kitchen food waste, Homer software.*

1. INTRODUCTION

Biomass energy, or "Bioenergy", is energy produced from living organisms, residues, municipal solid waste, crops and forests waste etc.. There are three forms of Bioenergy available with today's technology: heat, fuels, and electrical power. Farmers are potentially good to use the biomass energy in many ways which they can use for various purposes in the form of heat and sometimes they are not economical. But, using kitchen food waste based biomass energy requires some special skills to make it more economical.

Till now, biogas technology mainly concentrated on the "wet fermentation" of agricultural and communal organic waste, with many limitations.

There are residues and waste at all points in the food supply chain from initial production, through processing, handling and distributions to post-consumer waste from hotels, restaurants and individual houses. It has been calculated that about a third of all food grown for human consumption in India is thrown away. Many food materials are processed at some stage to remove components that are inedible or not required such as peel/skin, shells, husks, cores, pips/stones, fish heads, pulp from juice and oil extraction, etc.

Food preparation on both the commercial and domestic scale yield residues and waste, used cooking oils and food that has had to be disposed of because it has gone bad, for health and safety reasons or because it is surplus to requirements. Indian households alone produce about 5 million tons of kitchen waste annually.

1.1 Kitchen waste food and Processes

There are residues and waste at all points in the food supply chain from initial production, through processing, handling and distributions to post-consumer waste from hotels, restaurants and individual houses. It has been calculated that about one third of all food consumption in the India is thrown away.

Food preparation on both the commercial and domestic level generates residues and waste, used cooking oils and food that has had to be disposed of because it has gone bad, for health and safety reasons or because it is surplus to requirements. Indian households alone produce about 5 million tons of kitchen waste annually.

Food waste can be divided into dry waste and wet waste, however the majority is of relatively high moisture content.

A. Wet food waste
B. Waste oils
C. Agricultural residues

A. Wet food waste: It is not efficient to transport high moisture content material to industries or other processing units. It should be used economically and it should be locally based. Anaerobic digestion for the production of biogas is well suited to the processing of high moisture content and wet organic waste.

B. Waste oils: A proportion of food waste that does not have high water content is oily waste, particularly waste vegetable oils and animal fats.

C. Converting to biodiesel: Much waste oil can be collected, filtered and converted to biodiesel by advanced technologies. This chemical conversion process can be used to convert waste vegetable oils into biodiesel and further it can used to run IC engines.

1.2 Solar PV systems:

With the latest technical advancements and declining prices in Solar Energy can be easily integrated in to the Distributed generation. Particularly in India, the solar availability are an average of 300 to 330 days in most of the regions.

The energy in the photons from the sun can be converted to electrical energy. The term for this process is called as "Photovoltaic Effect". The amount of solar radiation at a site at any time, either it is expressed as solar intensity (W/m2) or solar insolation or radiation in MJ or Wh, is primarily required to generate the solar power. The amount of electrical energy produced by a PV-array depends primarily on the insolation at a given location and time.

1.2.1 Sizing a PV system:

Sizing a photovoltaic system is an important task in the system's design. There are three important processes has to be considered for sizing a PV system.

a) The solar insolation of the site and generally the METEO data
b) The daily power consumption (Wh) and types of the electric loads, and
c) The storage system to contribute to system's energy independence for a certain period of time

The PV generator is oversized it will have a big impact in the final cost and the price of the power produced.
If the PV-generator is undersized, problems might occur in meeting the power demand at any time.

The sizing should be carefully planned, examining various possible PV system configurations and various models of components in order to get a cost effective and reliable system.

1.3 Sizing a Kitchen waste based biogas plant:

To understand technical and economical features of Kitchen waste based biogas plant the below example will give an approach for 1 cum family size bio waste treatment plant:
Case study of Kitchen waste based biogas:
Waste Treatment Capacity - 2 Kg Solid waste
20 – 30 Liters Waste Water
Volume of Digester - 1000 Liters
Suitable for - 3-5 member family
Space required for the installation - 1.25 Sq Mtrs.
Gas generation per day - 1 Cum Biogas
Liquid fertilizer - 20 Liters per day
1 Cu.m Biogas - 0.5 Kg. LPG
Annual income in the form of gas &manure - Rs. 12,000/-
Annual Biogas generation - 365 Cu.m
Generation of 365 Cum Biogas - Emission reduction of 3.5 ton of CO_2
Various characteristics of bigger size biogas plant of 1m^3 and smaller size biogas plant of 0.5 m^3 has shown in Table 1.1

Table 1.1: 1m^3 and 0.5 m^3 of various biogas plants with kitchen waste

Characteristics	Bigger size biogas plant	Smaller size biogas plant
Size	1 m^3 digester	0.5 m^3 digester
Capacity	up to 2 kg kitchen waste	up to 1 kg kitchen waste
Quantity of gas produced	up to 1 kg biogas, capable of replacing 250 gm of LPG	up to 0.5 kg biogas, capable of replacing 100 gm of LPG.
Uses under cooking purposes	Either breakfast or one meal can be cooked entirely on biogas.	About 15-20 min of cooking (tea, hot water etc.) can be done.

The calorific value of biogas is about 6 kWh/ m^3; which is equal to about half a liter of diesel oil. The net calorific value of fuel also depends on the efficiency of the burners or appliances. Methane is the main important component under the aspect of using biogas as a fuel. The use of biogas can replace various conventional fuel like kerosene or firewood and protect the environment. Biogas is the best substitute of firewood in rural households. The biogas generated from small and medium sized units (up to 6 m^3) is generally used for cooking and lighting purposes. If we use 8 kg (1:2 ratio) kitchen waste for biogas production, we can save various fuel sources which can be used as alternatives. Total biogas production from 8 kg (1:2 ratio) kitchen waste of volume capacity 0.018 m3 biogas plant was 0.258157 m^3 during whole retention period. The amount of other fuel sources which we can save by the use of 8 kg (1:2 ratio) kitchen waste in respect of ICAR data. Women spend 2-4 hours per day in searching and carrying the firewood. Once a biogas is installed, they will have much extra time for herself and her children. This will help in improving their quality. They will get more time for education and interesting activities outside the home. Biogas plants also improve health conditions in the homes. The annual time saving for firewood collection and cooking average to almost 1000 hours in each household provided with a biogas plant.

2. Hybrid Solar and Kitchen waste based plant:

After careful study of the possibility of generation of biomass power from canteen kitchen waste there are some technical difficulties are the main drawback to such type of systems. Sometimes, adequate kitchen waste may not be available; hence the system has to depend on conventional grid power. But, depending on conventional grid power will not permit to go for green building criteria.

Hence, this problem can be overcome to hybrid the solar PV plant with kitchen waste based system can improve the reliability of the system. To test the economic viability this hybrid system can be modeled by using Homer software. With this approach a suitable Hybrid system can be planned in a systematic way.

2.1 Hybrid system Simulation approach:

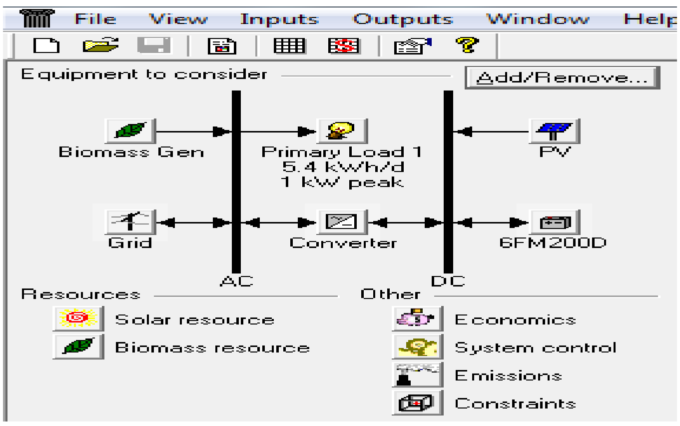

Fig. 2.1: Hybrid system procedure

Fig. 2.1 will give the clear idea about how to connect the loads with Hybrid system. Fig. 2.2 and 2.3 are indicating Solar and Biomass energy sources individually.

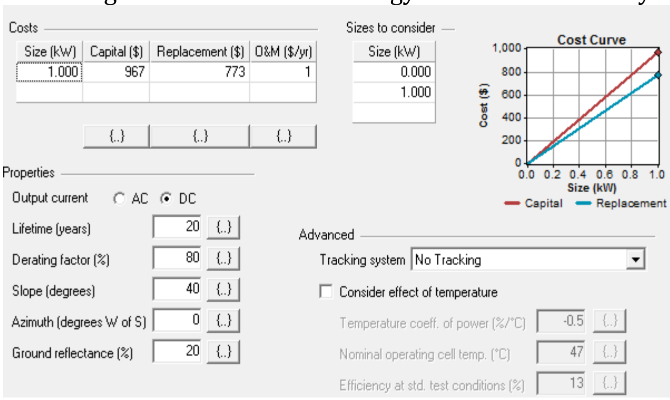

Fig. 2.2: Sizing of PV system

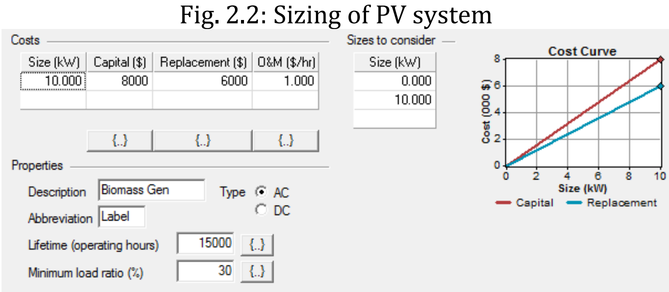

Fig. 2.3: Sizing of Biomass System

After entering all the technical parameters in Homer software; it will simulate with the weather conditions of local area, load scheduling, and availability of resources. At the end it will gives the result in percentage of load pattern with hybrid system sharing power generation as shown in fig. 2.4

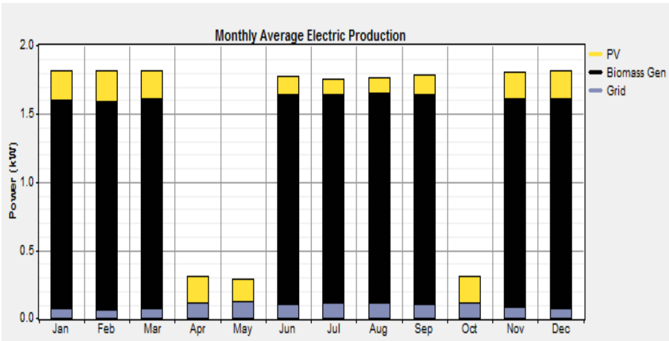

Fig. 2.4 Percentage of power generation

3. Conclusion

Using hybrid systems with solar and biomass at home is becoming increasingly popular. Due to government incentives and subsidies on solar systems, the prices of solar panels are becoming more affordable to the everyday consumer. Home solar power can be used independently from a grid system. Excess electricity made during the day is stored for night use. More commonly are solar energy systems that are tied to a grid and trade electricity. During night hours and cloudy days, electricity from the grid is used.

Independent solar power generation systems need to optimize the design. Finding sufficient supplies of clean energy for the future are one of society's most daunting challenges. Renewable energy sources will play a significant role in a sustainable development of the energy supply in the future, due to the minor impact they are expected to have on the environment and their large technological potential.

3.1 Payback analysis:

Table 3.1: payback analysis

Particulars	Cost
Total system cost	1,48, 000 Rs/-
After subsidy	1,03,600 Rs/-
No. of units generated from solar panel	1527 kwh
No. of units generated from biomass	84.5 kwh
Each unit rate by considering maximum demand rate and diesel generator option.	9 Rs/-
Total revenue from solar power	1612 × 9 = 14508 Rs/- year
Payback period	10 years (without considering net metering option)

This paper highlighted the economical consideration of standalone Biomass systems in college campuses. In College campuses by utilizing the hostels food waste and other biomass residues can be utilized for better purposes. Biogas production requires anaerobic digestion. Creation of an Organic Processing Facility to create biogas which will be more cost effective, eco-friendly, cut down on landfill waste, generates a high-quality renewable fuel, and reduces carbon dioxide & methane emissions. Overall by implementing biogas reactors in the backyard of hostels will be beneficial.

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