ANALYSIS OF SOLAR PV/BIO-GAS HYBRID WATER PUMPING SYSTEM FOR MINOR IRRIGATION AND COMMUNITY DRINKING WATER

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Abstract:- This research paper on "Analysis of Solar PV / Bio-Gas Hybrid Water Pumping System for Minor Irrigation and Community Drinking Water" presents systematic study of the renewable energy system like Photovoltaic, Biogas and Hybrid energy systems with their advantages and disadvantages. Hybrid systems are best suitable for the remote and isolated areas far from the grid, where it is impossible to meet the small power load either through long distance distribution network or by the conventional generation. Hybrid energy systems are the most cost-effective, design – flexible, and reliable energy system. The proper sizing of the system components not only increases the accuracy of the system requirement but it also increases the overall efficiency of the system. In the present work, the Photovoltaic energy system, Bio energy system and Hybrid energy system are sized individually. The sizing of the components is based on the actual load requirements of the site. The renewable energy – based hybrid generation systems, especially Solar/ Biogas hybrid systems are an effective option for solving the power – supply problem.

Introduction

Energy is an important product for development and prosperity of an economy of any nation. Globalization is making the world a smaller place. Energy is the driving force behind any development, ranges from powerful for everything. With continuous developments and growth, the exploitation of the natural resources has caused warning signals of its depletion. The use of energy has been rising continuously and is expected to keep on rising at a relatively higher rate in the near future. With increase demand of energy and decrease in availability of non renewable energy sources have caused an imbalance and price hike. Fuels have become expensive and they cannot be used again once exhausted. The limited reserves of non-renewable energy sources such as coal, gas and oil, threat of nuclear accidents and unpredictable international political situations that greatly influence fuel prices have significantly increased the interest in renewable energy sources such as tidal, wind, solar, biogas, biomass etc. These alternative sources of energy are the most promising and cost effective amongst all the sources of energy. The most remarkable future of renewable source of energy is that they are environment friendly. They don't leave any harmful waste that causes destruction to the living beings and pollution in environment.

RENEWABLE ENERGY SOURCES

India is well endowed with substantial renewable energy sources. There is significant potential in our country for generation of power from renewable energy sources such as wind, solar, small hydro, Biomass. The exploitable potential depends upon the status of technology, availability of land and the end use. It is recognized that renewable energy sources can provide.

SOLAR ENERGY

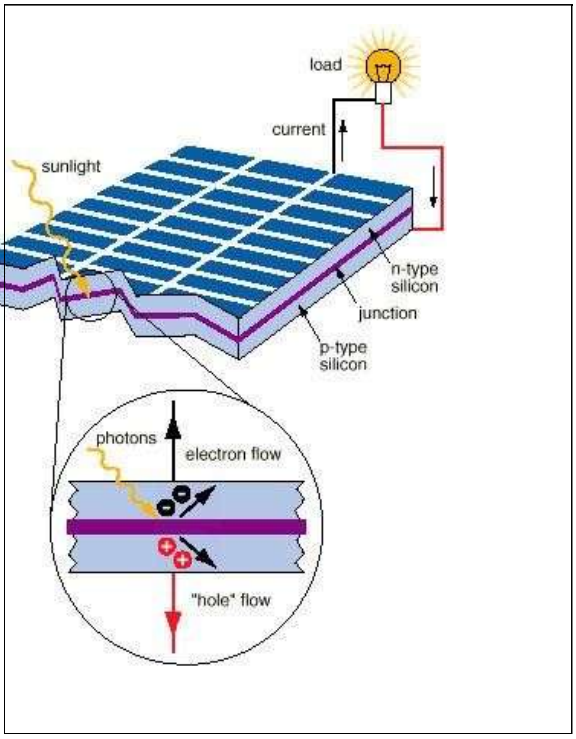
Solar energy is one of the cleanest forms of non-conventional energy resources. The sun is the planet's most abundant source of energy is shown in ***Fig. 1.1*** this energy can be captured either directly through collectors mounted roof top or through photovoltaic cell or indirectly through the storage of energy. Solar energy in organic material such as trees, grasses, agriculture waste or garbage can be burned to produce electricity or synthetic fuels

Harnessing Solar Energy

Solar energy can be connect to through a number of means Photovoltaic panels and material convert sunlight directly to electricity through a photovoltaic, chemical process. Solar thermal panels collect the sun's heat –to-heat water & thereby reduce the energy requirement of water heating. e.g. (in case of a Dhangour Kalan village, it can be used to maintain temperature in Biogas plant in winter season as it increases fermentation speed of gas). Double – pan windows also trap the sun's heat in the winter, reducing heating energy requirement in the home

Bio-Gas Energy System

Biogas appears to be the most important energy resource in the agriculturally dominated rural sector. It has been estimated that agricultural products produce as much as five times more energy in the form of biogas than they do in the form of dietary energy. Biogas can be utilized for Cooking, Crop drying, electric power generation and could prove to be a boon in the development of rural sector.



Biogas as Cooking Gas

Biogas is a clean, cheap and convenient eco-cooking fuel. It contains CH4 which in inflammable. The setting up of biogas plants improves the sanitation around a house hold as well. Eye and lung disease caused by kitchen smoke can be eliminated and environmental conditions would improve as forest cover is protected by saving of fuel wood. The large scale promotion of biogas plants also helps in generating employment in rural areas.

Biogas for Power Generation

Biogas along with diesel or by itself can be used to run diesel engines (generators). A sterling engine has been developed to run on biogas. These engines can be used to drive pump to lift water or to drive generators for electrical power generation. Biogas can be used for lighting purposes also.

Biogas has enough potential to be used for various purposes to meet the energy needs of rural areas. Biogas can be used to produce electricity by coupling a dual fuel engine to an asynchronous generator. Based on results of several studies carried out 1KW of electricity can be generated from 0.75 m^3 of biogas which can light 25 electric bulb of 40 watt rating where as 0.75 m^3 of gas if directly burn can light only 7 biogas lamps for one hour. Hence it is advantageous to first generate electricity & then light larger number of electric bulbs.

HYBRID POWER SYSTEM

The term hybrid power system is used to describe any power system with more than one type of generator- usually a conventional generation powered by a diesel or a gas engine and a renewable energy sources such as photovoltaic (PV), Biogas or hydroelectric power system. Renewable power system may include one or more biogas plant, solar photovoltaic (PV) cell banks, batteries thermoelectric converters, and one or more diesel generators of various size. There are thousands of these systems in use today. They range in size from few tens of watts to tens of kilowatts. The smaller systems are mostly on remote residence where homeowners add a few PV modules to their existing generation to reduce the noise and inconvenience of hearing the generator running all the time. Inconvenience may be of more importance than cost for this homeowner maintained systems that are installed near their homes.

RENEWABLE RESOURCE AVAILABILITY

A renewable resource is judged by its magnitude and consistency. If there is plenty of sun or biogas/ biomass year round at a location it may be a great site for renewable or hybrid system. Any site that received more then 1800 kilowatt – hours per year of solar insulation is considered a good site for a PV system. An average can dung per day is considered a good biogas resources.

PV – BIOGAS HYBRID SYSTEM

Bio-gas is generally produced in all seasons. Hence solar and biogas are ideally suited for hybrid systems that capitalize on the advantages offered, by each technology. A solar electric (PV) array could be coupled with biogas generator, which would create more output from the biogas generator during the winter, whereas during the summer the solar panels would produce their peak output. Hybrid systems can make more economical sense than solar or biogas alone.

Literature Review

The previous study by the researchers are as:

The Paper contributed by **Keith Presnell et al [1] has detailed out the significance of** renewable energy in today's world. Environmental concerns about the negative aspects of society's energy needs have led to advanced technologies that could facilitate the changes needed to sustain productivity. The progression from high carbon based energy industry to a sustainable industry is advancing to comfortably accommodate a range of renewable energy technologyoption.

In this Paper **J.C. Hernadez et al [2]** are discussed a methodology that allows to know the optimal size of PV generator in building. The adopted design criterion is to optimize the profitability and the amortization of photovoltaic installations. There is an optimal maximum size of PV installation for each building after which the profitability decreases strongly for sized higher than optimal one. This size minimizes the photovoltaic electricity fed in to the grid and covers a good degree of building electricity need and consumption.

Dave Turcotte et al [4] have laid emphasis on wide range of rules and tools that are needed for system sizing. Numerous Software tools exist, but it is sometimes difficult to assess the adequacy of tools for specific task. Accuracy requirements are different for pre- feasibility analysis, system design optimization and R& D. The analysis depicts the current status of PV system of software tools by surveying and categorizing some of the most common of programs available today.

In this Chapter, **V. Bakthavatsalm [5]** are focus discussed the important role of renewable sources of energy in today's world, when non renewable sources of energy are depleting day by day. Due to constant increase in the price of fossil fuel and its adverse effect on the environment and ecology there is a consciousness all over the world to promote generation from renewable energy sources. Out of all renewable energy sources, biogas energy is the most promising due to its cost effectiveness and for delivering grid quality power..

Farah sheriff et al [5] has rermarked the performance of data acquisition system on PV/Biogas hybrid system in remote sites where its use is more complicated than in accessible location for multiple reasons. Since accessibility is limited to the remote site, several issue need to be addressed to assure the success of data acquisition installation. These include system reliability, data storage and transmission, choice of installation & monitoring equipment and their impact on the existing system. To overcome all of these issues, a rigorous procedure is required. The paper presents the significant aspects to consider when preparing data acquisition system and their installation at remote sites. Every system and location is different; therefore every monitoring system installed is different as regard to collecting quality data.

Michael M.D. Ross [6] has laid emphasis on the Lead Acid battery typically used by the hybrid system for storing the energy generated. The battery included in the system is a complex, nonlinear device exhibiting memory. The battery stores energy in between the time when it is generated and when it is required by the load. A simple model appropriate for modeling of energy flows within a hybrid power system has been developed and the model accounts the heat evolved by the battery during the charge and discharge, the water loss by the battery and the ageing of battery.

Tomas Markvart [7] has described a procedure , which determine the size of the PV array and Biogas plant in a PV/Biogas energy hybrid system. Using the measured value of solar and Biogas energy at a given location, the method employs a simple graphical construction to determine the optimum configuration of the two generator that satisfies the energy demand of the user through the year. Hybrid system is chapter than the PV array or Biogas plant alone is the fact that energy generated by the hybrid cab be matched more closely to the load.

Attila Meggyes, Valeria Nagy et al [7] are described in their report that the utilization of the biowaste are beneficial to rural people by using the renewable energy sources and ruraldevelopment.

Rosenthal Andrew L et al [8] are discussed the application of demand size management to the small village electrification by biogas for life time extension of energy system.

Khandelwal et al [9] have completed analysis of solar / Biogas hybrid energy system. Solar energy Biogas energy technologies are generally used for area that is inaccessible to utility power systems. If energy from the solar PV cells alone is harnessed then during the non-sunny days the power supply will be interrupted. If biogas energy alone is exploited then during the full hours continuous power is not assured. The reliability and continuous supply of electricity is less if the solar and biogas energy system are used separately for electricity generation. Among the various energy alternative the Biogas energy system clubbed with solar PV panels for the generation for electricity (as a PV/Biogas Hybrid energy system), stand out distinctly especially in tropical regions. The system offers an increased reliability against the load variations. Hybrid energy system generates energy in eco-friendly manner free from any harmful emission.

Bucciarell, Klein and Backman, Egido and Lorenzo [10] Hybrid power systems are combination of electricity generating sources and storage devices. Generating sources include diesel, photovoltaic, wind, biogas and micro-hydro generators. These technologies on their own or in a hybrid configuration are the dominant non grid electrification options available for remote areas. The choice on optimal technology will be unique to its application and the properties of the particular location where they are to be applied, such as distance from the grid, access to reliable supply of diesel and climatic resources. A combination of system in a hybrid configuration often be the best option. Situations where this is true include cases where peak demand profiles are present, and where the resources required by each generator complement each other, such as might be the case between Biogas & solar resources.

R.C. Bohra et al [11] have described a sizing procedure for the two generators in a PV/ Biogas energy system. In contrast with the previous studies emphasis is placed here on the seasonal; variation rather than the hourly change during one day. The potential benefit of this approach becomes apparent, from the examination of a typical seasonal pattern of the available biomass & solar energy in temperature climates. To supply reasonable flat load profile, either generator operating along would need to size for the minimum of the corresponding energy supply.

Tomas Markvart [12] has described a procedure, which determine the size of the PV array and Biogas plant in a PV/Biogas energy hybrid system. Using the measured value of solar and Biogas energy at a given location, the method employs a simple graphical construction to determine the optimum configuration of the two generator that satisfies the energy demand of the user through the year. Hybrid system is chapter than the PV array or Biogas plant alone is the fact that energy generated by the hybrid cab be matched more closely to the load. An important aspect of design of standalone PV and Biogas energy system has been to recognize the determination of sizes of PV array and battery for a desired reliability of power supply

Blier F. Fan et al [13] Have completed analysis of the systems should encourage the read to thick of alternative means of achieving desired result, since normally their is no signal best solution to a design problem. An effort will be made to point out the area where the PV system is open to the discretion of the designer: Perhaps reliability, performance and cost are among the items of common concern. One of the most common PV applications is water pumping especially when the water to be pumped is a long distance from a utility grid. Water pumping application does not produce an adequate supply of water to meet the pumping needs during the period of peak sun. When designing a water pumping system, it is necessary to determine number of parameters in order to property size the system components. First fall the daily water needs must be determined. Secondly the source must be characterized in terms of available water and vertical distance over which the water must be pumped. Once these factors are known along with the number of hours per days available for pumping, the pumping rate can be determined. The pumping rate along with the pumping height equates to the pumping power, once again the product of a pressure quantity with a flow quantity. The pumping power can then be converted. To horse power so that size of the pump motor can be determined. Once the size of the pump motor is known, the ampere-hour requirements of the motor can be determined, and finally the size of PV array needed to provide. The ampere – hours can be determined.

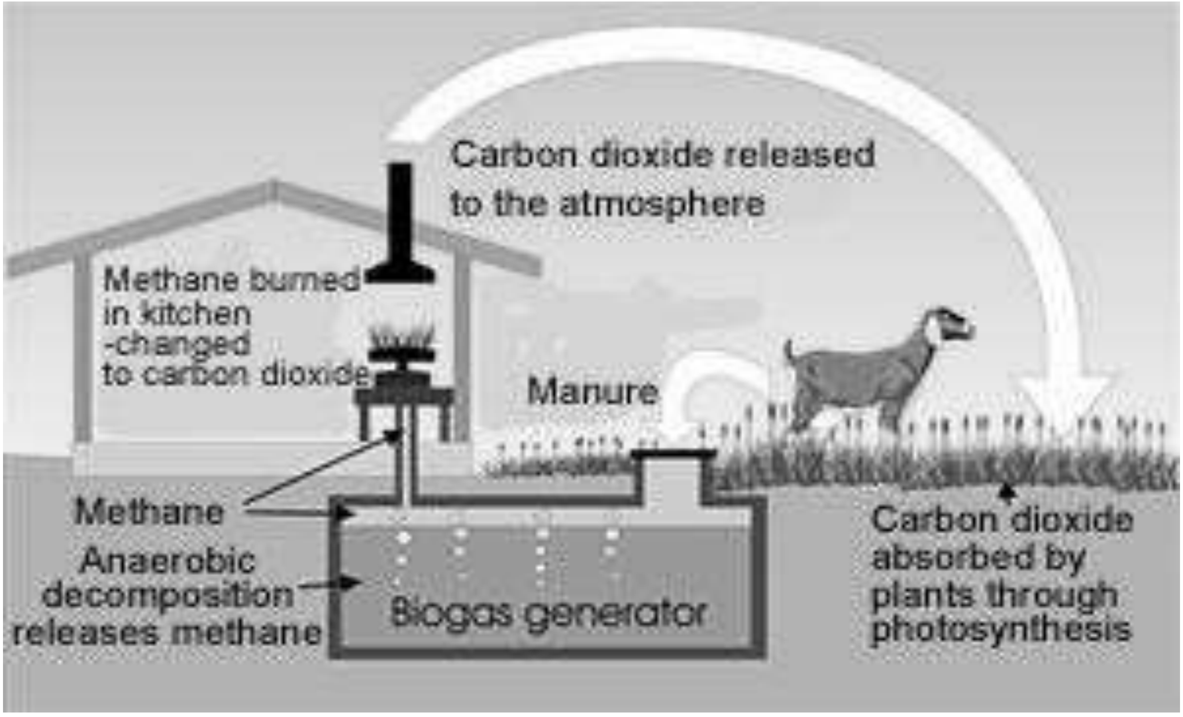
M.A. Sathianathan et at [14] have described in their report biogas system of specific interest to rural areas. The products of this system being the result of anaerobic digestion of a number of agricultural, animal and municipal waster residues seen as solution of two problems faced in rural areas i.e. shortage of energy and scarce availability as well as high cost of fertilizers. To this effect, biogas us a renewable source of energy that provides much needed cooking and lighting fuel and the digested slurry is seen as fertilizer, more valuable than the original manure, that will improve the agricultural productivity. Biogas plants can be easily installed in remotes tribal areas where electricity is not available, Biogas a product of biomethanation of various organic matters. The liquid and solid residues of a biogas plant are valuable. Fertilizer & soil conditioning agent have retained all the minerals and most of the nitrogen of the original manure.

Fowler and Joshi et.at [15] are studied the anaerobic fermentation of material such as newspaper, filter papers, banana skins etc by inculating with sludge obtain from a septic tank. It was reported that materials rich in hemicelluloses. Produced a gas composed mainly of methane, the calorific value of which was 1.4 times that of ordinary cool gas.

Estimated that out of the total bovine wet dung available 69 percent is used as manure, 29 percent as cakes for fuel and remaining 2 percent is used for other purpose. In terms of soil nutrients the loss due to burning of these dung cakes amount to 0.8 million ton of nitrogen, 0961 million ton of P_2O_5 and 0.961 million ton of K_2O.

Research Methodology

Energy is a vital input for economic & social development, with the increasing industrial and agricultural activities in the country the demand for energy is also raising. The use of conventional energy sources is expected to continue increasingly to meet the rising energy requirement in our country whose economy is global today and operate in an open environment. Now the scenario demands relevant power services in rural agricultural villages recognizing the challenges. The proposed Hybrid system is designed for using water pumping system can be used for minor irrigation and community drinking water. The basic input towards designing renewable energy system (whether stand alone or Hybrid) is the assessment of the load. The village has around 110 families and total population about 550 people in the village is completed and presented stand alone & hybrid system is sized and their economic feasibility is worked out. The system is redesigned due to limited resources and proposed for using (Minor irrigation & Community drinking water.



Load Assessment per Day for Electrification and Water Pumping

Sr. No.	ELECTRICAL LOAD	RATTING	QUANTITY	HOURS	TOTAL LOAD(WATT HOURS)
1.	**Single bulb connection for each family**	**60 Watt**	**110**	**05**	**33000**
2.	**Street lighting**	**100 Watt**	**15**	**06**	**9000**
3.	**Gaushala tube light**	**40 Watt**	**1**	**12**	**480**
4.	**Pump house** **(a)Tube light (b)Motor pump(3 HP)**	**40 Watt** **2238 Watt**	**1** **1**	**12** **10**	**480** **22380**
5.	**Community Drinking water places tube light**	**40 Watt**	**1**	**12**	**480**
	Total Watt Hours				**65580**

Electricity consumption per day = 65580/ 1000 = 65.580 SAY= (66 units)

(i)	Gas required for 3.0 KVA generator with 3HP engine HP x 0.43 m^3/HP/hr for 10 hours gas needed (Gas requirement using 80% biogas is 0.42 – 0.50 m^3/hr) 10 x 1.29	**1.29 m^3** **12.90 m^3/hr**
(ii)	Gas required for village electrification 11 HP x 0.43 m^3/HP/hr 8 x 4.73	**4.73 m^3** **37.84 m^3/hr**
(iii)	Gas consumed 3 kVA generator per day 12.90 m^3 + 37.84 m^3	**50.74 m^3**

Therefore total gas will be consumed as per the pattern given above and 45 m^3 biogas plants are not suitable to the load requirement of village under study.

SIZING OF STAND ALONE PV SYSTEM

In the last section the sizing of stand alone biogas plant is done. Keeping in view the per day energy requirement of the village, and that biogas plant alone cannot supply the demand of the village. It is therefore the design of standalone PV system to meet out entire village load is carried and its economic feasibility as worked out is presented in this section.

Step – I	AC loads are are calculated in watt-hour per week. Total watt – hour per week (refer Table) (65580 x 7 = 459060 Wh/Week)	**459060 Wh/Week**
Step – II	Total Wh/week is multiplied by 0.2 for inverter loss (20 %)	**91812Wh/Week**
Step – III	DC system voltage usually 12,24, or 48 volts	**24 Volts**
Step– IV	Total amp. hours per week used by AC loads 459060 ⍰ 91812 ――――――― 24	**22953Amph/ Week**
Step – V	DC loads are calculated in watt-hour per week Total watt-hour per week (No DC load is connected)	**0 Wh/Week**
Step– VI	DC system voltage usually 12 or 24 volts	**24 Volts**
Step–VII	Total amp hours per week used by DC load	**0 Amph/ Week**
Step-VIII	Total amp.-hours per week used by all loads (AC+DC)	**22953Amph/ Week**
Step– IX	Average amp-hours per day	**3279 Amph/Day**

Battery Sizing

The foremost thing that should be kept in mind before sizing a battery is the amount of storage or number of days backup that would be provided by the battery. Often this is expressed as “days of autonomy” because it is based on the number of days that are expected by the system to provide power without receiving an input charge from the solar array. In addition to the days of autonomy, usage pattern and the critical nature of application should also be considered.

Load Calculation

In a very simplistic form, the three basic steps involved in the system sizing are first, to determine the amount of AC and or DC load requirements- in watts – and secondly, to determine the size of the alternative electrical power sources to operate these loads, and – third, to determine the amount of battery storage required to provide the needed power during days when energy production is minimal. Batteries can also supply DC to AC inverter. Loads in watts require either inspecting each piece of equipment or appliance for the power consumption label using a meter. If the rating is slated in Amps, then multiply those amps by the voltage to get the watts by simple expression as Watts = Amps x Volt

Conclusion

In the present work study and sizing of photovoltaic, Biogas and photovoltaic/Biogas hybrid Energy system is carried out. It is observed that if an energy system is sized accurately then it not only decreases the overall cost of the system but also decreases per unit cost of the energy. Hybrid power systems combine two or more energy conversion devices that, when integrated provide additional advantages over those devices operated individually Advantages can be realized in terms of system efficiency, emission, fuel flexibility, availability, economics and sustainability. They range in size from a few tens of watts to tens of kilowatts. Hybrid becomes viable alternatives for power generation/production because they allow the designer to capitalize on the strengths of both conventional and renewable energy sources.

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