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Designing and Strategic Cost Estimation of Stand-Alone Hybrid Renewable Energy System

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Abstract

Use of renewable energy resources to coup with current energy crisis is the only way forward for Pakistan to meet millennium development goals and develop as a sustainable economy. Energy shortage not only effects country economy but also other sectors like education and health. Pakistan's energy shortage has badly affected education sector as well , students studies in laboratories and classrooms not only suffer but their most precious time is wasted due to outage of electricity. As load shedding backup different University campuses have installed Gensets which are very expensive in terms of installation, operational and maintenance cost. This paper presents a new idea of "Green Campus", renewable energy base education campus, a test case of IQRA National University, Peshawar is taken converting the campus load completely on Biogas and Solar energy further more to minimize conversion losses DC load is energized with DC source while AC loads are energized from AC source, Design and cost analysis is done also payback period is calculated.

Keywords: *Renewable Energy systems, Energy deficit , Biogas, Solar Photo Voltaic System, Green house Gases, Pay Back Period.*

1. Introduction

Pakistan's population is about 180.9 million. 37.4% are living in urban areas while 62.6% in rural areas. Population growth is at a rate of 2.03%.Pakistan is situated on equator, such that it lies between longitude 60E & 76E and latitude 23N & 27N[1].The Population is increasing rapidly that it put pressure on the government to fulfill the energy need because energy is the key element for development and prosperity. Pakistan is blessed with immense Renewable energy resources but they haven't been explored yet.

Pakistan economy is in huge stress because of current energy crises. Electricity Supply is the need of every household. The 45% of Pakistan's population doesn't have even access to electricity [14].

There is a huge gap between supply and demand, Supply is about 12,755MW while the demand is too much i.e. 18,860MW during July-March 2011-2012[15]. So the difference in supply & Demand is also high i.e. 6000MW.The increasing demand and less supply is shown in Table-I [2][18].

A viable solution of these crises is to explore on renewable sources of energy and utilize it so that common men can be beneficiary from this type of energy. Renewable or non-conventional energy is that type of energy which is reversible on human time scale such as wind, tides, waves, sunlight & Biogas etc. [3].The consumption of renewable

resources throughout the globe is about 16% with 10% of energy used for heating purposes by biomass traditionally [5]. Sun is the largest source of energy. The radiation of heat and light from the sun is called solar energy. There are two technologies either Active solar or passive solar. These technologies depend on the way to how they are used, convert and utilize energy of sun. Active technology use solar thermal collector or photovoltaic panels for harnessing of energy. While passive technology use light dispersing properties, orienting a building to the sun.

Table-I Demand & Supply Situation of Electricity in Pakistan.

S.No	Year	Demand (Mw)	Supply (MW)	Difference (MW)
1	2004-2005	14642	15082	440
2	2005-2006	15483	15072	-411
3	2006-2007	16542	15091	-1457
4	2007-2008	17689	15055	-2634
5	2008-2009	19080	15055	-4025
6	2009-2010	20584	15055	-5529
7	2010-2011	20684	15055	-5629
8	2011-2012	20884	15055	-5829
9	2012-2013	22080	16111	-5969
10	2013-2014	22289	16050	-6239
11	2014-2015	22270	16050	-6220

Biological materials which are produce from the wastes of living organism is called Biomass. Biogas originates from biomass under anaerobic (without air) condition. Biomass produce heat through combustion when use directly or also use indirectly by converting it into different forms of biofuels [16].

Due to gap in supply and demand, different type of load shed techniques are used, the most common of them is to shed off the load from generation. Load shedding produces severe problem in places where a short cut off supply creates too much loss like hospitals, research laboratories, secondary schools, higher secondary schools & universities.

In such way also in education sector the load shedding have negative impacts, precious time of students and academia is lost. Some Universities solve this problem by installing diesel generators but its running cost and expenses are very high [17]. The aim of this research paper is to provide cost effective and reliable power for IQRA National University, Pakistan from the human wastes, kitchen wastes converted to biogas and from solar energy through photovoltaic panels and also comparing the cost benefits from these types of renewable energy after interconnection with university power supply or grid.

2. Biogas Energy

The process in which the biogas originates from bacteria under anaerobic (without air) by the process of biogradation of organic material [4].Biogas is generated by the carbon cycle of biogeochemical process. Different terminologies used in this type of energy are :

2.1 Total Solid (TS)

Without considering liquid part the total amount of solid material is called total solid (TS) [6].TS Indicates the biogas amount and for smooth fermentation 8% is favorable value of TS.

2.2 Fresh Discharge

Moisturized manure obtained directly from human, animals etc [6].

2.3 Hydraulic Retention Time (HRT)

Up to how much time the wastes particles or liquid put in digester & lays in digester are known as HRT [6].It is calculated by the formula:

HRT= Volume Of digester/volume of slurry per day

It is expressed in days.

2.4 Solid Retention Time (SRT)

It is calculated as:

SRT=weight of volatile solid/weight per unit time of volatile solid leaving the system

2.5 Liquid Part

To Make TS value to 8% water is added with the fresh discharge called liquid part [6].

The proposed biogas plant is shown in figure-I.

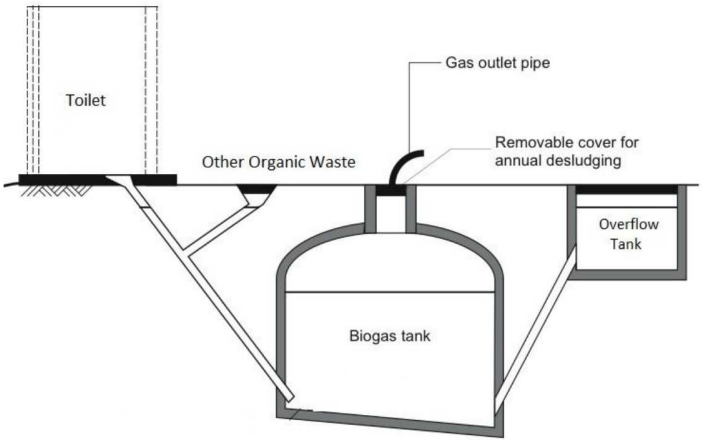

Figure 1: Proposed Biogas Plant.

3 Solar Photo Voltaic System

Sun is the biggest source of energy. It gives light and heat to the whole universe. Sun is about 109 times bigger than the earth [7].The distance between earth and sun is about 149.63×10^6 Km and the light takes 8 minute and 31 seconds to touch the surface of earth. With the speed of 186.262 miles per second to touch the earth surface. [8][9]. So in short using solar power plant the solar electricity is obtained with free of cost from the heat and light of sun.

Different components used in solar power plants are shown in figure 2.

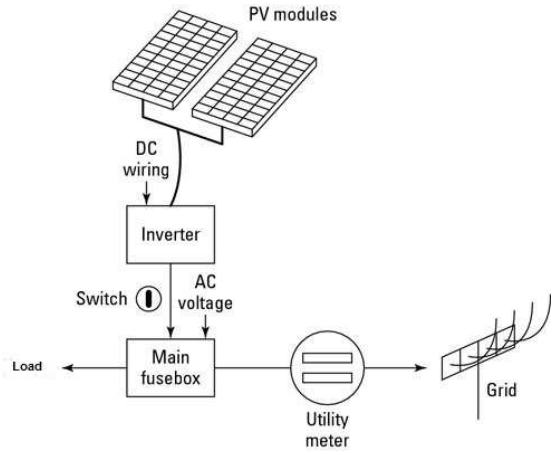

Figure 2: Solar PV system connected to grid.

3.1 Solar Cell

It consists of silicon wafer/sheet also called photo voltaic cell. When sun light touches the photo voltaic, it converted it into electricity directly without any further cycle of thermodynamics [10]. It works on photovoltaic principle. The solar energy converts into electromotive force directly by absorbing of radiations by the silicon wafer.

3.2 Inverter

The conversion of Dc electricity to Ac Produced by the solar panel is called Inverter [11].

3.3 Electrical Storage

When there is no sunlight mean in night or when cloudy weather than at that time there will be no electricity generated at PV so we use storage device so the electricity will be stored for later use.

3.4 Charge Controller

It controls or regulates the electricity that is coming from PV to battery, Load to battery or both. It also prevents battery from overloading and overcharging.

4 Problem Formulation

This Paper is about the use of renewable source of energy. We use two types of renewable energy i-e Biogas and solar energy to reduce the shortage of electricity during load shedding. We will design a model for biogas plant which was the waste human and kitchen to generate electricity and measure the roofs of university building and faculty building for establishing solar panels and also its economic analysis that either it is cost benefit or not when it is connected to the university power grid.

4.1 Biogas Power Plant

The Biogas Average composition is shown in table-II in percentage. It shows that highest Composition is of Methane CH4 gas i-e about 55-75% in Biogas [12]

Table 2: Average Composition of Biogas

Matter	%age
Methane,CH_4	55-75
Carbondioxide,Co_2	25-45
Nitrogen,N_2	1-5
Hydrogen, H_2	0-3
Hydrogen Sulphide, H_2S	0.1-0.5
Oxygen, O_2	0.1-0.8
Carbon monoxide, CO	o-o.3

4.2 Mathematical Calculation for Biogas plant

4.2.1 From kitchen waste

The number of students and staff are shown in table 3.

Table-3: Population strength of students & faculty

Building Name	Population/Strength
Campus/university Building	3000
Faculty Building	300
Total	3300

Total Numbers of Kitchen = 10 (one in each department and one in cafeteria)

Kitchen's waste of 1kg when digest produce 0.3m^3 of biogas.

The gas produce when the kitchen waste on average = 80kg/day

80 x 0.3 = 24m^3/day.

Biogas produce from each cubic meter contains 6kwh of calorific energy. When this gas is converted into electricity only 2kwh of electricity we get and the rest of energy is converted into heat, which is further used for heating purposes/applications so total electricity generated from

Kitchen Wastes = 24 x 2 kWh = 48 kWh

4.2.2 From Human Wastes

Per Person waste on average per day is about 0.5kg.The Probability to use washroom is half of the total population so it is 1650.And total waste produce is

1650 x 0.5 = 825kg

Total solid (TS) value of human waste = 20%

And the hydraulic retention Time (HRT) = 40 days

The biogas obtained in ordinary temperature of 30°c from human waste = 0.365m^3/kg TS (estimated) [19]

So the total biogas produce from this strength is = 1650 x 0.5 x 0.2 x 0.365 = 60.225m^3

Or Total electricity generated from human wastes = 60.225 x 2kwh = 120.45kWh

4.2.3 Total Generation Capacity

From Kitchen Wastes = 48kwh

From Human Wastes = 120.45kwh

So Total Capacity = 120.45+48

Total Biogas Energy = 168.48Kwh

5 Solar Energy System

For solar energy system we use PV (solar photo voltaic). Solar PV is used to convert sunlight directly into electricity. As PV gets its name for conversion of light (Photon) to electricity (voltage) called PV effect [13].

5.1 Required Solar Panels

As 100 watts solar panel required area such as

Length = 3.36 ft, width = 2.20ft

So, Area = 3.36 x 2.20

Area = 7.392 sq.ft

As The roof space of university/campus &faculty Buildings = 20 Kanal

As 1 Kanal = 107991.36 sq.fts

Or 20 Kanal = 108000 sq.fts

So, 7.392 sq. ft equals to 100 watt

1 Square feet = 100 / 7.392

1 square feet = 13.52 watt

So, 108000 sq.ft = 100 x 108000 / 7.392 watts

= 1461038.961 watts
= 1461.038 Kw
Total Power = 1461 Kw (Approximately)
So Total Panels required = 14610 pieces
As Each Panel = 100watt.

6 Total energy generated from biogas and solar PV system

Total energy produced from human and kitchen waste is = 168.48kwh.

Power Generated from Solar PV = 1461kW.

7 Total energy consumption

Table 4 shows the total consumption of IQRA national university.

Table 4: Identifying Continuous Supply important Loads

Load Areas	Total No of Fans	Rating of Fans	Total no of CFL	Rating of CFL	Other loads	Rating (watts)	Load(KW)
Total	436	700	1220	440	238	1110	112.96

Figure 3 shows total energy consumed in 24 hours.

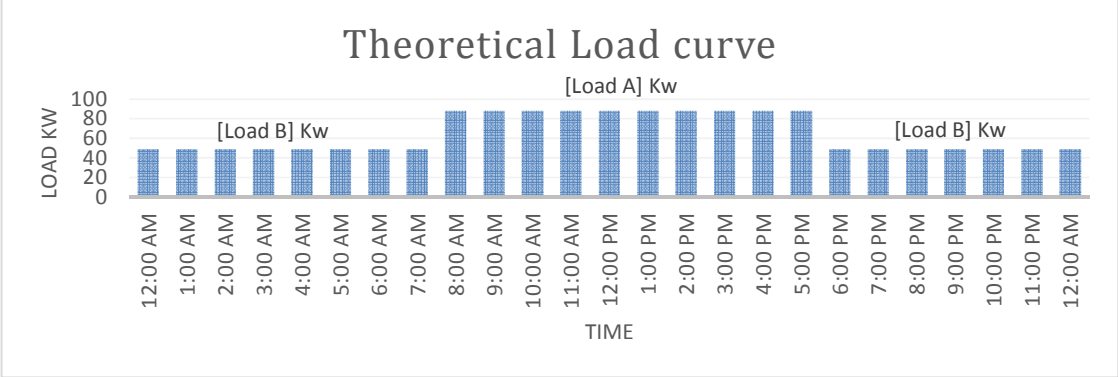

Figure 3: Total Load per hour.

8 Pay Back Period:

Total energy from biogas and solar PV system = 4480kwh

Government Tariff per unit:

16.5000-04.4100= 12.0900 x 300
18.5000-02.5000= 16.000 x 340

So energy cost is 16 Rs per kwh

So 16 x 4480 = Rs 71680 per day x 30 days = 2150400 per month.
Rs 2150400 per month can be saved using biogas and solar PV system.

9 Conclusion

This research described the current energy crisis in and its solution using renewable energy technologies. Since generating energy from fossil fuel is an expensive option, we have explored the green energy generated by biomass and solar energy using photo voltaic system. Our analysis shows that generating energy from biomass and solar PV is much cheaper as compared to the conventional energy sources as the initial installing cost is reasonably lesser than others, biogas plant can be build easily on the group floor of a building or in backyard, while building roof can be utilized for solar PV cell to generated electrical energy. The initial cost of building biogas plant and installing solar PV system is high but these energy sources are renewable energy resources so total expenditure is pay backed in minimum time. Using renewable energy source decreases green house gases which has environmental benefits as well.

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