International Journal of Engineering Works
https://www.ijew.io/
ISSN-p: 2521-2419
ISSN-e: 2409-2770
Vol. 9, Issue 02, PP. 28-31, February 2022
https://doi.org/10.34259/ijew.22.9022831

Potential and Cost Benefit Analysis of Alternative Sustainable Energy

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Received: 07 January, Revised: 25 January, Accepted: 01 February

***Abstract*—** As Pakistan is confronting colossal energy emergencies since 2007 in view of the spontaneous strategies of government due to which monetary development of our nation is affected and numerous every day schedules are upset. To make itself an independent in electrical energy each association in Pakistan is utilizing numerous strategies like generators UPS and so forth Numerous associations use generators as another fuel source however the cost of raw petroleum continues to change and are for the most part high which can't be managed and power got by this strategy is expensive. Different strategies like UPS are not intended to run weighty loads and can be utilized for a setback of an hour or two or on the off chance that you need to expand its reinforcement superior grade and more batteries are required which turns out to be over the top expensive. This paper will introduce the plan and examination of a biogas plant. Biomass (human waste) can be utilized as a restoration fuel source to deliver reinforcement energy for power interference. Biogas plant cost investigation will likewise be incorporated to show its financial proficiency.

***Keywords*—** Biogas, Biomass, Energy self-sufficiency, Payback period, Energy Crisis

I. INTRODUCTION

The population of Pakistan as of 2021 is 225.2 million and is increasing with an enormous rate of 2.4% per year [9]. With such an increase in population the needs of energy are increasing day by day. In past Pakistan has been relying on the energy produced from the fossil fuel but as the rates of the fossil fuel keeps rising which keeps on increasing the rate of the energy produced and if it goes on like this it will become difficult for the people to access the energy for their basic needs. The solution for these crises is to find renewable energy sources and utilize those so that mankind can take advantage from these sources of energy. Nonconventional or Renewable energy sources are such type of energy sources which is reversible on human time scale like Biogas, wind, tides, waves, sunlight etc. All these sustainable power sources can be utilized for energy creation and can be gainful to humankind additionally these sorts of fuel sources have numerous different points of interest with one of contamination free energy or efficient power energy which can be gotten up to limitless time with appropriate activity and support of any inexhaustible force plant. Globally approximately 16 % of energy consumption is from renewable energy as shown in fig.1.

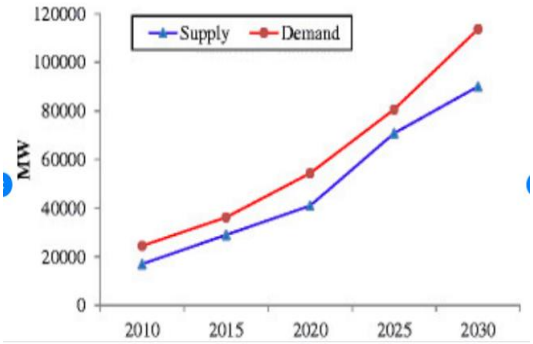

Figure. 1 Energy Supply & Demand

As we can see that the supply and demand gaps in the energy needs for the country has much gap and is increasing day by day. To fill this gap investor in Pakistan mainly rely on fossil fuel generation plants which is not a best approach to fill it because these energy sources prices keep on rising and hence producing a high price energy which is again above the reach of the local people but to fill this gap huge investment is needed in the energy sector and especially in the renewable energy sector of Pakistan.

In this paper we will be designing a biogas plant. The materials which are produced from the waste materials of living organism is known as Biomass. The Biogas is generated from the biomass in anerobic condition which means with no air. We can burn this biomass to produce heat when used directly or energy can also be liberated from it by converting it to other form of fuels. In this paper we will be discussing the production of biogas from the biomass human and kitchen waste and then producing an electrical energy from that biogas.

As like many other sectors the education sector is one of the main sectors in the development of Pakistan. The difference in the supply and demand of the energy effects this

sector very much. Like due to power outages in the educational institutions cause the wastage of very important and precious time of the students and hence keeps them deprived from learning new things. In Pakistan to get rid of this problem maximum institutions have an approach of installing diesel generator but its working and cost is very high as fuel prices keeps on rising. The main aim of this research paper is to provide cost effective and reliable power for Government College of Technology Peshawar Pakistan from the human waste and kitchen waste to a biogas which in turn runs a generator to produce electrical energy for the hostels.

II. BIOGAS HISTORY IN PAKISTAN

Biogas innovation isn't new in Pakistan. Administration of Pakistan started biogas plot in 1974 and introduced 4,137 biogas units everywhere on the country, the plan was carried out in three stages. During first stage 100 units were introduced which was completely subsidized by the public authority, in second stage cost were divided between the public authority and the recipients and in the third stage, government just offered specialized help for nothing, yet the plan didn't advance any further [2]

Pakistan Chamber of Renewable Energy Technology (PCRET) was set up on May 8, 2001. PCRET is pioneer in the nation to disperse biogas innovation and has upheld establishment around 4600 plants all through Pakistan, which has the capability of around 15 million such plants [3].

A. COMPOSITION OF BIOGAS

Biogas is a combination of different gases which are produced from animal dung, sewage, food or agricultural waste, municipal waste under anaerobic (no air) condition and this organic material is passed through the process of fermentation. Biogas contains Methane (CH4) and Carbon dioxide (CO2) which can be combusted to produce heat energy and then the energy can then be used to produce electrical energy [4]. A table below shows the chemical composition of biogas from the waste produced at household level such as biomass and kitchen waste [4], [5].

Table: 1 Composition of biogas

Gas	Percentage
Methane(CH4)	50-60%
Carbon dioxide (CO2)	34-38%
Nitrogen	0-5%
Oxygen	0-1%
H2S(mg/m3)	100-900

B. PROCESS OF BIOGAS PRODUCTION

- The organic waste or biowaste crushed into smaller pieces and slurrified. The process of slurrifying means adding water to the waste to make it easy for the upcoming process.
- For anaerobic process warm conditions are required so a temperature of about 37^{o} is maintained.
- The bio gas is produced in the period of about 3 weeks in the digester through anaerobic assimilation.
- At the end the biogas produced is decontaminated or filtered by removing useless gases such as CO_2 etc.

C. DIFFERENT TEREMONOLIGIES IN BIOGAS

- Total solid (TS):

The only solid waste used in the production of the biogas without the liquid is known as Total Solid or TS [7]. TS indicates the amount of biogas production which is approximately 8% of TS.

- Fresh Discharge:

Moisturized miniature obtained from the humans and animals etc.

- Hydraulic Retention Time (HRT):

The time required for the waste to be in the Digester to produce the biogas is known as the HRT or Hydraulic retention time [8] it can be calculated by a formula
HRT=volume of digester/amount of slurry produced

- Solid Retention Time (SRT)

Calculated as
SRT = weight of volatile solid / weight per unit time of volatile solid leaving

- Liquid Part

To make the TS 8% of waste water is added to the waste which is called Liquid Part

D. DIFFERENT PARTS IN BIOGAS PLANT

There are different components of a biogas plant which produce electrical energy from the biomass which are as followed [1]

- Receiving tank

Before going to the digester, the solid waste is mixed with water to make TS in the receiving tank.

- Digester

Digester is the main part of biogas plant. In digester all the fermentation process takes place and the biogas generated is gathered in the upperpart of the digester also known as chamber. It is made in such a way that no gas enters the digester

- Outlet:

As the gas is produced in the upper part of the digester which in turn causes the pressure on the solid waste which moves out through outlet and enters the overflow tank.

- Gas Purification Unit:

As discussed earlier the biogas produced has a lot of impurities which effect the combustion process are removed by the Gas Purification Unit.

- Gas Generators:

The gas received from the chamber and after passing the gas purification chamber goes to gas generators to produce electrical energy. The following fig. 2 given below.

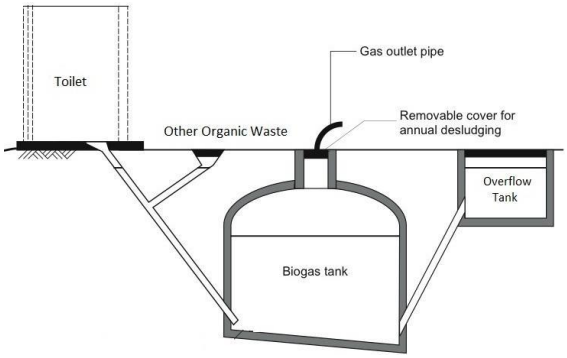

Figure.2 A proposed biogas plants

III. BIOGAS TO ENERGY SYSYTEM

As shown in fig. 3 pictorially the bio waste produced goes to the digester in which the fermentation process takes place to produce biogas or methane gas. The gas produced goes through the gas purification unit to purify the gas for combustion process. The gas then then goes to generator to produced electrical energy, from that energy some of the energy was used for auxiliary energy of the biogas plant. The waste going to the overflow tank is known as slurry which is a very good fertilizer which compose rich elements such as Nitrogen, Potassium, Phosphorous Iron etc [6].

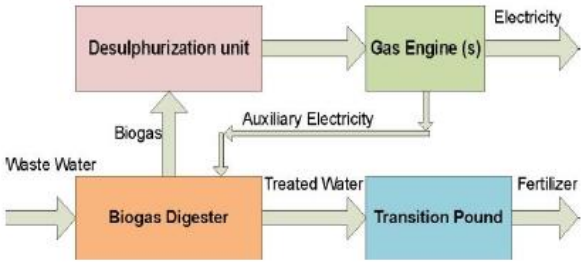

Figure. 3 Biogas Energy System

A. CASE STUDY

We consider student hostels of Government College of Technology Peshawar as shown in fig, 4 a waste and biogas generation plus the peak electrical load of these hostels to be covered by this Renewable energy plant.

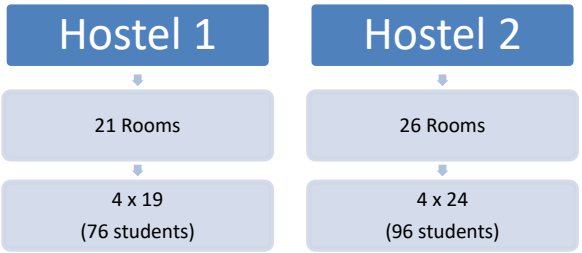

Figure. 4 Hostels

Two rooms are used by warden and security guard
So total number of persons in hostel 1 = 76+2 = 78
Total number of persons in hostel 2 = 96+2=98
Total persons= 78+98 = 176

B. WASTE AND BIOGAS GENERATION

Average waste by one person per day = 0.5kg [1]
At temperature of 30oC biogas obtained from solid human waste is 0.365m^3/kg which is 20% of total waste.
Total biogas obtained from n number of persons = (0.5 x n x 0.2 x 0.36)
Biogas obtained from 176 persons = (0.5 x 176 x 0.2 x 0.36) m^3= 6.336 m^3
Total amount of kitchen waste = 10kg per day
Biogas produced from kitchen waste is 0.3 m^3 per 1 kg
So amount of biogas produced from kitchen waste is 0.3 x 10 = 3 m^3
Total amount of biogas generated = 6.336 + 3 = 9.336 m^3

C. ELECTRICAL LOAD OF BUILDING LECTRICAL

As we know that total number of rooms of both hostels = 21 + 26 = 47
Electrical Load of one Room
2 Tube lights each 40W= 2 x 40= 80W
2 Fans each 80 W = 2 X 80 = 160W
2 cell phone chargers each 5 W = 2 X 5 = 10W
1 laptop charging point = 25 W
So electrical load of one room = 80 + 160 + 10 + 25 = 275W
As there are 47 rooms in total so total load = 47 X 275 = 12925W or 12.925KW

D. ELECTRICAL ENERGY GENERATED FROM BIOGAS

As the amount of biogas produced is 9.336 m^3 and each m^3 of biogas produces about 6KWH of calorific energy in which 2 KWH of energy is converted into electrical energy whereas the remaining 4 KWH of energy is wasted in heat sound and other forms of energy losses.
Electrical energy generated from the obtained biogas = 9.336 X 2 = 18.67 KWH

E. COST ANALYSIS PER SECTION

- Digester
- Hydraulic chamber and Inlet recharge chamber
- Overflow tank
- Pipeline and others
- Generator
- Digester volume and cost:

Hydraulic Retention Time (HRT) is about 40 – 60 days (for temperature 30 C)
Total solid waste per day = 0.5 x 176 = 88kg
Kitchen waste = 10 kg
Total waste = 88kg +10kg = 98kg
Total solid fresh discharge = 98 x 0.2 = 19.6kg
We have 8% of total solid, for mixing extra water in with new release the measure of required water can be determined in the manner 8 kg equals 100kg of influent.
19.6 kg of solid equals = 100 x 19.6/8 = 245kg
Total influent Q = 245kg
Volume of digester required for working = Vgs + Vf = Q x HRT = 245 x 40 = 9.8m^3

Geometrical assumption Vgs + Vf = 80% of V or 9.8m^3 = 0.8 x V
Total volume of digester = V =12.25 m^3
12.25 m^3 = 432.6 Cubic Feet (CFT)
Cost of 500 CFT digester is about RS 108000/=
Total cost of digester = 108000 x 432.6/500 = RS 93442/=
Digester of 432 CFT approximately costs RS 93442/=

- Total Cost of hydraulic chamber and inlet recharge chamber:

Volume of hydraulic chamber and inlet recharge chamber is 2 x Recharge per day (Q) = 2 x 0.245 = 0.49 m^3 = 17.3 CFT
Cost = 108000 x 17.3/500 = RS 3737/=
Over flow tank:
Half volume of main digester which will approximately 6.125 m^3 of volume which will cost 108000 x 6.125/500 = RS 46721/=

- Purification unit:

Filtering and drying of biogas purification unit according to market survey will cost approximately RS 15000/=

- Pipeline and other charges:

PVC pipes are used for waste and GI pipes are used for biogas will cost approximately RS 30000/=

- Generator cost:

Through market survey 15 KVA generator costs about RS 470000/=

Table: 2 Total cost on the Biogas plant

Parts	Price
Digester	RS 93442/=
Hydraulic chamber and inlet recharge	RS 3737/=
Overflow tank	RS 46721/=
Purification Plant	RS 15000/=
Pipeline and other charges	RS 30000/=
Generator	RS 470000/=
Total	RS 658900/=

F. Pay Back Period

As we know there is difference in between the generation of electrical energy the amount of electrical energy produced is 18.67 KWH but the peak electrical need of the building is 12.925KWH the remaining amount of energy can be sold out to the grid by installing a smart meter to the facility which can be used as an electrical energy from grid in case of emergency so we can say that total energy produced can be sold out so we find the payback period.

Electrical energy produced per day = 12925 x24/1000 = 310200/1000 = 310.2KWH

Energy produced per month = 310.2 x 30 = 9306KWH
Today tariff of electrical energy is 12 per KWH without taxes
Payback per month = 9306 x 12 = RS 111672/=

Total payback period = total cost/payback per month = 658900/111672 = 5.9 months excluding maintenance and other operational charges.

G. Feasibility Analysis

Biogas production mainly depends on the waste. As we are using solid and other organic waste as well so it becomes feasible to produce produce biogas from it. The monthly electricity cost of the building is approximately RS 111672/= which is paid to meet the energy needs of the building. As we if the project is installed the energy can be produced from waste to meet the energy needs plus it can payback its cost in approximately six months and after that the energy for the building will be free plus it will be a small effort in helping the country to meet the energy need of the country.

Conclusion

This paper has discussed the current energy crises in Pakistan. The conventional energy produced is from fossil fuels which is very costly we have explored an option of green energy generation from the waste material like biomass and other organic material.

As we have analyzed that the energy generated from bio mass is cheaper then using the conventional energy sources as the installation cost of this energy is very less as compared to other energy sources and the plant can be built up easily with little or less labor.

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How to cite this article:

Ibad ur Rahman, Syed Waqar Shah, Sanaullah Ahmad, Muhammad Amir Aman "Potential and Cost Benefit Analysis of Alternative Sustainable Energy", International Journal of Engineering Works, Vol. 9, Issue 02, PP. 28-31, February 2022, https://doi.org/10.34259/ijew.22.9022831.