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***Research paper***

# Electrification in Rural Areas Using Realistic Equipments

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**Abstract**

This paper presents a method of low cost setup for the generation of the electricity via Biogas in rural areas. The proposed setup requires easily available items in the villages. In this paper, authors have suggested a technique to minimize the running cost of the electricity generation system. The superiority of the proposed method is to reduce diesel quantity as much as possible, which may further reduce the capital cost and also making pollution free environment.

***Keywords*:**

## 1. Introduction

Biogas is a combustible mixture of dissimilar gases that is formed through decomposition of biodegradable organic materials via microorganisms in deficiency of air (or oxygen). The formation of Biogas is depends upon anaerobic digestion of biological wastes such as vegetable wastes, cattle dung, poultry droppings, sheep, landfill, industrial wastewater and municipal solid waste, etc. In this paper authors have used domestic waste and cattle dung, where Biogas formation includes complex photochemical and biological practices with different factors and stage of modifications. The Biogas and slurry are the main products of the anaerobic digestion. The Biogases are combination of different component gases, where major gases are Methane (CH4) and Carbon dioxide (CO2) with traces of Sulfur Dioxide (H2S) and Hydrogen (H2) gas. In addition with this the slurry is rich in NPK (Nitrogen Phosphorus Potassium), which is a macro nutrient of the soil and can be used as good organic manure. Percentage composition of Biogas are - CH4 (50 – 70) %, CO2 (30 – 40) %, H2 ( 5 – 10) %,N2 (1 – 2)%, Water Vapor H2O 0.3% [1]. Prior to the Biogas storage, Biogas purifier must be installed to remove the moisture and H2S content in Biogas. To maintain CH4 content of the Biogas over 60% by removing CO2, a water scrubber is necessary as a typical Biogas. The electricity generator requires Biogas input with more than 60% methane content for combustion. Prior to water scrubbing, removal of H2S is more sensitive because H2S is more soluble in water than CO2[8]. The Small scale gas engine has many advantages such as its availability in the small sizes, fast start-up, shutdown capability, good part load operation, high electrical efficiency, able to run with different working mediums (natural gas, LPG).Also the waste heat recovery will not affect the mechanical energy output [3]. The electricity needs by the most remote villages like Cameroon (Africa) uses Biogas technology to reduce the cost of energy. So it may be the best option for the villages of India because a few years ago, India was the world's No. 1 milk producing country. Therefore a number of the cattle will produce the largest amount of methane. In most of the places, farmers are not in the condition to purchase separate machine for different purpose. Hence, they want adjustment with easily available equipment's to minimize the installing cost. As an example a rotating machine is frequently used in the villages, which can rotate the alternator to the synchronous speed to produce the electricity.

## 2. Preliminaries

In South Asian region nearly 50 percent of people are faced with lack of access to electricity and about 90 percent of them live in rural areas [4]. The objective of this paper is to minimize the cost of per unit generation of the electricity. To minimize the running cost, the authors have proposed the idea of green energy, which is generated with frequently available equipment's in the villages like cattle dung, diesel engine , petrol drum and alternator etc.

The Large power unit is not easy to manage by the villagers if there is only one Biogas based power generation station. The following difficulties may occur due to the single generating unit.

Inconsistent of pet animal dung and also difficult to collect at generating point.

1. In case of failure of the single generating unit there will be a dark hour in the village.
2. Transmission loss from generating station to the load.
3. Requirement of skilled worker for running of new technology.
4. Solar panel technology is a much matured technology, but still in the expensive range for a rural village.

In this paper, the attention is drawn towards the frequently available energy source in rural areas, where energy is available in living forms. As it is the lowest cost method to generate electricity from the available resources which are already in use. It is the best option to use one thing for two purposes and that provides an economic path also. The main factor in the Indian rural area is the economy because a Richey can purchase electricity at high tariff, which may increase the demand for electricity and finally making costly for villagers. Biogas as a fuel is the best method to promote green energy in the villages where cattle waste is thrown on the road side which emit harmful gas in the air and pollute the environment. This project requires few additional machines (alternator) and equipment's which

are already in use of farmers, like diesel engine used in the villages for grass chopping, can run on low quality fuel like Biogas and diesel or kerosene in fixed ratio can give cost effective energy.

## 3. Proposed Methodology

Each family in village has their own cattle; waste generated from these cattle is used for the Biogas production as follows.

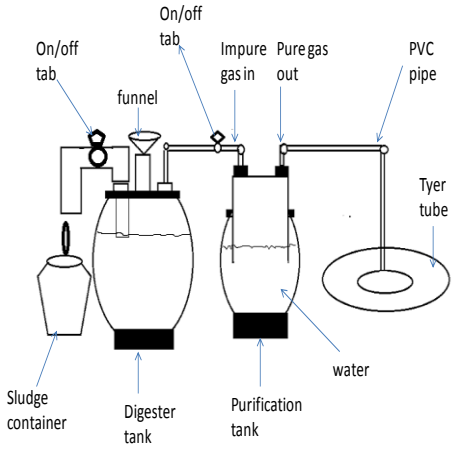


**Fig.1:** Biogas Digester

Figure 1 shows the construction of the Biogas digester. In this approach, the construction of Biogas digester is done with the help of petrol drum or plastic that is easily available in the villages. The construction of Biogas is mentioned below with few sub-sections.

### 3.1 Construction Procedure of Biogas System from Unused Material

#### 3.1.1. Required Material:

The following items are required for the construction of Bio-gas generation setup. One petrol barrel of 200litre, two plastic barrel of 120litre,one funnel,1/2inch pipe and bands, 6inch pipe and bands, PVC elbow, PVC glue, tier tube.

#### 3.1.2. Construction Procedure:

There are a few simple steps to construct a setup of Biogas digester and purification tank.

1. Drill three holes on the top of 200 liters barrel, where two holes of 6 inches and one is about 2inches as shown in the Figure 2.
2. All the holes must be on the same axis, where center hole is used as inlet for the waste product, the other 6inches hole is used as an outlet of slurry and 2inches hole is used as the Biogas outlet.
3. In the center hole of 6inches, join a pipe of the same diameter with help of PVC glue and conical funnel so that waste of inlet can be mixed properly before it discharges into the tank.
4. In the other hole of 6 inches, fix an outlet pipe and elbow as shown in the fig.1.
5. Now attach ½ inches hole with ½ inch pipe and elbow and on /off tab to control gas outlet.

For the construction of purification tank, take two barrels of 120litre and remove upside portions of both barrels. Now put one barrel inside another and in the upper one drill two holes of two inches on the same axis as shown in the Figure 3.

6. Fix the inlet hole of purification tanks with pipe of ½ inches and elbow to the outlet of the Biogas digester, and another hole will used as an outlet for the pure bio-gas which will be directly connected to the tube of any vehicle for the storage purpose.

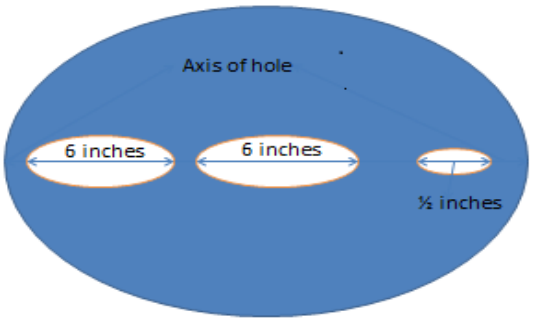


**Fig. 2:** Digester upside view

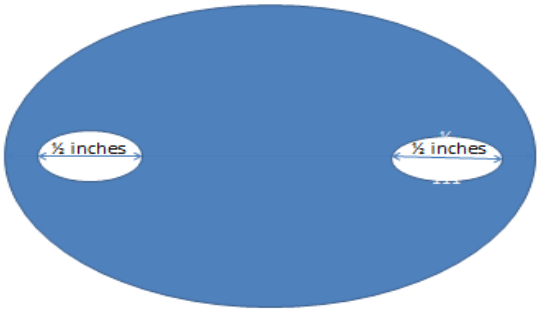


**Fig. 3:** Purification tank upside view

NOTE: - Pipe inlet of the purification water tank should be dipped inside the water properly and outlet of the digester tank should be in the waste. An Inlet of the digester tank must be closed after transferring the waste from waste storage to digester tank.

### 3.2. Working of the Biogas System

Biogas is produced from the cattle dung as a result of anaerobic fermentation of organic substances; hence an anaerobic digester is needed to produce Biogas from the cattle dung. In this paper, the self-made digester is suggested due to lesser cost as compare to the digesters available in the market. Digester available in the market may be costly due to big price decided by the manufacturer with installation charges which is not affordable for the farmers or villagers. An Output of the digester is the biogas, which contain (50-65)% $CH_4$and 40% $CO_2$, it also contains small amounts of $N_2$ and is saturated with Water $H_2O$.The biggest polluting element is $H_2S$ [2] .When this Biogas is passed through the purification tank, results sulphuric acid. The output gas from the water tank is pure or free from $H_2S$ and $CO_2$.

#### 3.2.1. Input to Biogas Digester

Cattle dung is the major source for the generation of bio-gas. Average Biogas produced, per 1kg of organic dry solid in cattle dung is around 0.21 m3 and organic dry solid content in cattle dung is 20% of its weight [5]. Hence 1 kg of the cattle dung will produce 0.042m3 of the Biogas.

#### 3.2.2. Output of the Biogas System and their Utilization

Filtered Methane from the water tank outlet can be directly used in generator as a fuel or may be stored in the tube for the further application, already shown in the Figure 1. Water in the purification tank changed into acid form, it can be used as an acid after converting

in the concentrated form. Sludge from the Biogas digester is rich in the NPK (Nitrogen, Phosphorous, Potassium), which are the macro nutrient of the soil and can replace the chemical fertilizer, that's cost around 200rupee per 10kg.

**Table 1:** Amount of Biogas liberated

| S. No. | Cattle dung feed | Amount of bio-gas liberated in m3 |
|---|---|---|
| 1. | 50 | 2.1 |
| 2. | 100 | 4.2 |
| 3. | 200 | 8.2 |

### 3.3. Mechanism to Extract Electricity

To rotate the alternator, a multi-tasking engine is used, which are easily available in the villages for grass cutting, pumping water and flourmill, etc. Such kinds of machines are adjustable, modifiable. We can use the same machine for two works simultaneously like grass cutting and rotation of alternator as well. Therefore, with a small investment, villagers can meet their demand of electricity production, where the input of the machine is the fuel which produces torque to rotate the rotor of the coupled machines. The system used in the Sabhamajara, Saharanpur (U.P.) India is the combination with an engine and an alternator as shown in Figure 4. In the system shown in Figure 4, inlet fuel can be both liquid (Diesel, Kerosene) and gas fuel like LPG, Biogas, depend upon the availability of the type fuel, which they have in the excess. Only gas fuel cannot be used without modification, it required an additional gasket to take gaseous fuel.

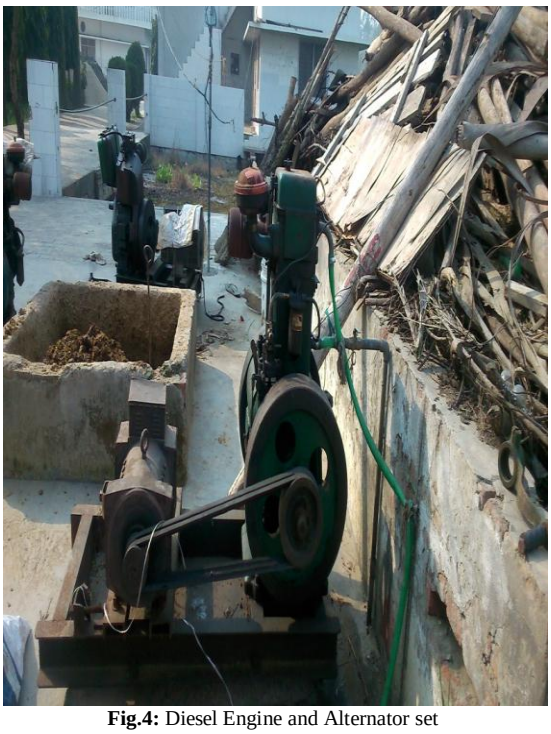

**Fig.4:** Diesel Engine and Alternator set

- The above system requires 2litre diesel for the production of 5kwh.
- Now for the production of 5kwh, the described system is changed with 400ml Diesel and 500gram LPG.
- LPG can be replaced by bio gas as 1m3 of the Biogas equivalent to 0.45kg of LPG.
- 1kg of cattle dung is equivalent to 0.042m3 of the Biogas, so 50kg of the dung yield 2.1m3 of the Biogas [4].
- One cattle produces dung in day is equivalent 20-25kg per day.

So from the above data, it state that LPG can be replaced by Biogas as a fuel in the engine. This system can work continuously for 6hr in which inverter can charge the battery bank that can be used as the auxiliary power during the time generator is off.

**Table2:** Running Cost Parameter

| S. No. | Load | Fuel used and quantity of fuel | Cost per hour (rupees) |
|---|---|---|---|
| 1. | 5kw | Diesel (1.25 liter) | 62.50 |
| 2. | 5kw | Diesel (0.25 liter) + LPG(0.450kg) | 26.50 |
| 3. | 5kw | Diesel (0.25 liter) + bio-gas (1m3) | 12.50 |

**Better Energy Method**

Solar panels may be expensive for villagers to use as an energy source [4]. Diesel generator or gas generator is costly, which meet only one demand i.e. electricity generation. But in the proposed setup, where engine and alternator meet and fulfill the two demands simultaneously, i.e. grass cutting, electricity generation. The combined system can produce electricity for peak load and the rest of time inverter with battery can meet the demand [6]. The villagers will prefer and utilize such kind of machines as they do not have experience about working of the machine, where there is no need of the technician to operate normally.

**Table 3:** Installation of Proposed Setup

| S. No. | Equipment used for 5kwh load | Number of items used | Cost of installation |
|---|---|---|---|
| 1. | Alternator | 1 | 12,000 |
| 2. | Engine | 1 | 400-500 (Few hundred rupees for the modification already available) |
| 3. | Bi-gas setup | 1 | 1,000-1,200 |

## 4. Demand of Power

Demand of power varies for the whole day, week, month, even on a quarterly basis in the village, town and city, etc. For the villagers, power consumption completely dependent on the environment. Therefore, for the proposed setup the production of the Biogas varies with changing environment say ambient temperature, etc. In summer, the temperature is up to 30 degree Celsius. Hence there is the requirement of cooler and ceiling fan, etc., which has loads of 100W each but now days fan with 50W are used by the villagers due to availability of present inverters. Also, one tube has loads of 20W, if 10 tubes are used for a particular time, the lighting load will be 200W, the consumption of the LED TV is about 50W, and one refrigerator may be of 1KW and tube well pump of 2KW. Therefore, total load in summer will be 3.7KW. Biogas liberations are also high enduing to increase of organic decomposition with an increase in the temperature. In the winter season, the load of the village decline due to the decrease in the use of the fan and other cooling system like refrigerator, cooler, etc., so the load will be up to 2KW. As the production of the Biogas increases with the increase of the temperature, therefore for the summer season, fuel requirement will be reduced by increasing the environmental temperature. But in the winter season, it will be reduced due to the slowdown of the fermentation process. Production of the Biogas decreases as the temperature decreases, therefore in winter; it slows down the organic reaction. As the load like pump and fan not necessary to operate for a full day because in day time of summer season load is only for the fan and is reduced in the winter season about few watt say 0.5KW. In the night, load increase slightly up to 0.8KW, this can be handled by the inverter or generator set.

## 5. Conclusions

In this paper, the authors have proposed low cost bio gas setup. With the increasing load, production of Biogas increases in the summer and liberation of Biogas decreases with decreasing in the load. Therefore production of the Biogas is approximately proportional to the load. Also, we use easily available equipments, so installation cost

decreases because of using the single machine for two purposes which further save the money. Therefore, cost estimation of the proposed setup is reduced. Total setup cost is around 15,000 rupees excluding the cost of bottling of Biogas but in this setup authors use raw Biogas. The waste of the proposed setup produces rich manure in the form of NPK that can be used as NPK fertilizer, whose market price is about Rs. 200/10Kg. Therefore, it further reduces the running cost of Biogas setup.

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