POTENTIAL OF ELECTRICITY GENERATION FROM A COMMUNITY BIOGAS PLANT FOR RURAL DEVELOPMENT

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ABSTRACT:

Anaerobic wastewater treatment in rural area has great potential for applications considering the lack of proper system of sewage collection, treatment and disposal in such areas. The advantage of the technology is production of biogas during the treatment which has further potential of utilization as fuel. However the bio gas thus produced requires some treatment prior its use especially for removal of hydrogen sulfide (H_2S) and carbon dioxide (CO_2) gases. The biogas has limited applications when utilized as a fuel in its gaseous form but if it is converted into electricity its application field becomes more and more wide. Moreover in developing countries, projects of biogas conversion into electricity may apply for the Clean Development Mechanism (CDM) under the Kyoto Protocol. This would further increase the economic viability of the project through the marketing of certified emission reductions (CERs). In the present paper various aspects of design of biogas production and conversion into electricity for a rural community are discussed. The various environmental and economic benefits of such projects are also discussed.

KEYWORDS: Anaerobic digestion, biogas, Methane, CDM, Electricity, Scrubber.

INTRODUCTION:

As our fossil fuel resources are on the verge of depletion, the non-traditional energy sources i.e. solar radiation, marine tides and waves, wind, biomass, and biogas have recently become increasingly popular. The Chinese were the first to use biogas energy, as far back as a hundred years prior to our era. Any farm household collects a considerable amount of dung, plant tops, and other wastes in the course of the year. Usually, after decomposition the digested waste is used as organic fertilizer, while the biogas generated as a result of anaerobic digestion, i.e., fermentation of organic materials of differing origin occurring without air access is used for cooking and heating. If this biogas is converted into electrical energy we can use it for other applications like lighting of the homes and streets, running of pumps for domestic and agricultural purposes, and almost all the applications where electricity is required. For our country India, this can play a curtail role in the overall development of the rural area as after more than 60 years of the Independence thousands of villages still embraces darkness after the sunset.

The technology used for such projects are very simple to install and use. The amount of gas generated largely depends on the temperature because it directly affects the microbial activity: the warmer the air, the higher are the rate and degree of fermentation of the organic material. The stock material should meet certain requirements: it should be suitable for bacteria growth and contain biodegradable organic matter and a large amount of water, i.e., 95%. Varieties of materials like vegetation and domestic waste, dung, and gray sewage can be used for biogas generation. The biogas obtained from the reactor or fermenter is allowed to pass through the scrubber. This will remove H_2S and CO_2 from biogas. This will help in increasing the calorific value of biogas so higher energy is obtained. This gas is then diverted to the storage tank where it can be stored for a longer duration under pressure. This stored gas is then fed to the gas engine which will give output in form of rotation of axis. To start the gas engine first we have to use very little quantity of diesel. The alternator connected to gas engine which will generate the electricity. This electricity can be stored for later use or it will be directly utilized. This can be used for many applications as most of the equipment run on the electricity. This biogas plant is designed for a community.

TABLE 1.1 GENERAL CONSTITUENTS OF BIOGAS AND ITS QUANTITY (IN PERCENTAGE)

Substances	Symbol	Percentage
Methane	CH_4	50 - 70
Carbon Dioxide	CO_2	30 - 40
Hydrogen	H_2	5 - 10
Nitrogen	N_2	1 - 2
Water vapour	H_2O	0.3
Hydrogen Sulphide	H_2S	Traces

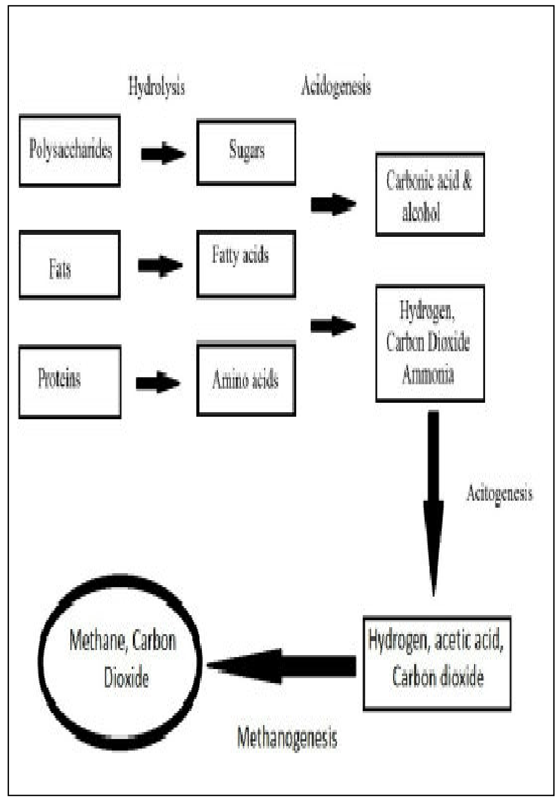

FIG.1.1 EVALUATION OF ANAEROBIC REACTION FOR THE PRODUCTION OF BIOGAS

TYPES OF BIOGAS PLANT

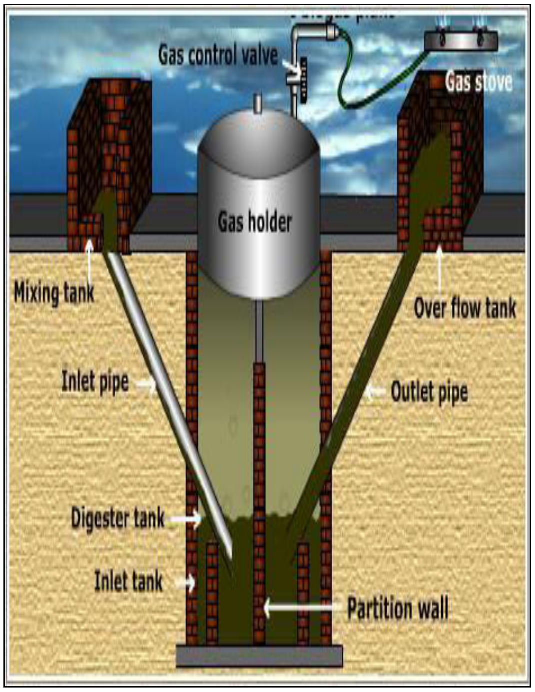

FIG.1.2 FIXED DOME TYPE BIOGAS PLANT

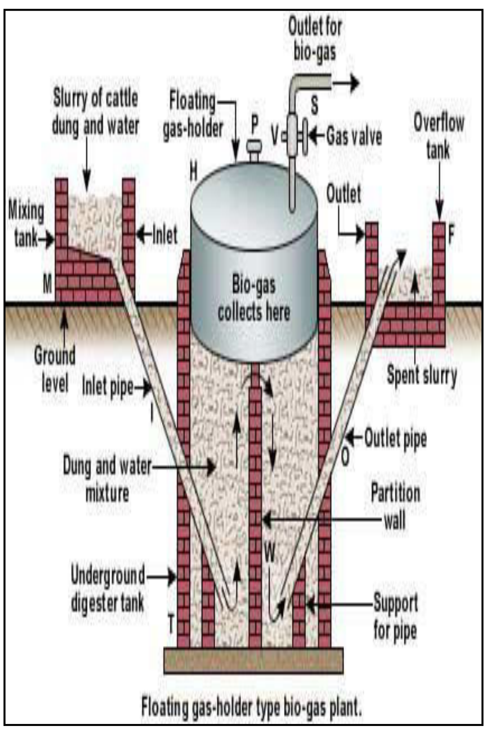

FIG.1.3 FLOATING DOME TYPE BIOGAS PLANT

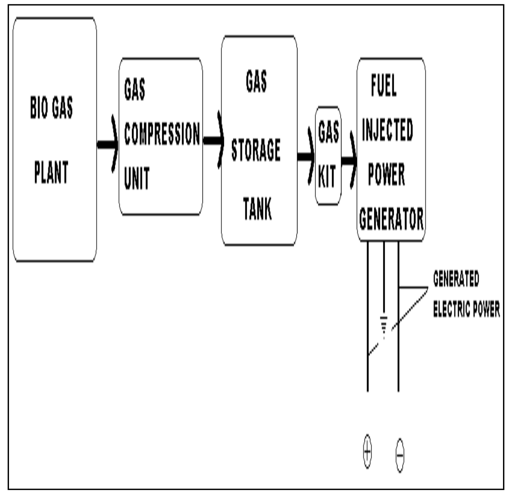

FIG.1.4 FLOW DIAGRAM OF CONVERSION OF BIOGAS TO ELECTRICAL ENERGY.

COMPONENTS OF THE SYSTEM:

1. REACTOR (FERMENTER)

A cylindrical digester built in stainless steel collector and masonry structure, provided with outlet port on top. Its function is to hold the slurry. The gas produced is collected in to the stainless steel dome at top.

2. SCRUBBER (FILTER)

Its function is to separate CH_4 from H_2S and CO_2 so that higher calorific value of gas is obtained.

VARIOUS METHODS OF SCRUBBING

- Absorption in Water
- Absorption By Chemicals
- Pressure swing Absorption
- Membrane Separation
- Cryogenic Separation
- Chemical Conversion

3. GAS COMPRESSION UNIT

It is used to increase pressure of the gas so that it will be stored in to less volume.

4. GAS STORAGE TANK

During fewer requirements the gas is stored into these tanks. Theses tanks can be made airtight so no other gas can enter the tank and vice versa.

5. INTERNAL COMBUSTION (IC) ENGINE

It is used for combustion of biogas and converts it into mechanical energy of rotating axis. The IC engine is run in dual fuel mode in which the engine starts on diesel and subsequently run on biogas provided. The quantity of diesel used is only 35-40 ml per run of engine.

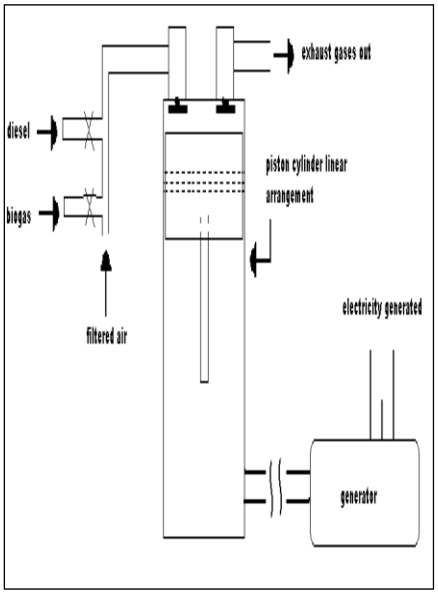

FIG.1.5 DUAL FUEL

6. GENERATOR (ALTERNATOR)

The generator each couple to IC engine which will receive a mechanical energy & gives electric energy as output.

TABLE 1.2.MINIMUM CALORIFIC VALUES OF BIOGAS AND OTHER FUELS AND EQUIVALENCE TO METHANE

Sr. No	Name of fuel	Calorific value Kilo-calories	Mode of burning	Thermal efficiency %	Effective heat Kilo-calories	Replacement value equivalent with 1 cu M. biogas
1.	Biogas (M^3)	4713	In Standard burner	60	2828	1.0
2.	Kerosene (litre)	9122	Pressure Stove	50	4561	0.620

3.	Fire wood (kg)	4708	In open chulha	17.3	814	3.474.
4.	Cow-dung cakes (kg)	2092	In open chulha	11	230	12.296.
5.	Charcoal kg	6930	In open chulha	28	1940	1.458
6.	Soft Coke (kg)	6292	In open chulha	28	1762	1.605
7.	Butane (kg)	10882	In standard burners	60	6529	0.433
8.	Furnace Oil (Litre)	9041	In water tube boiler	75	6781	0.417
9.	Coal gas (M^3)	4004	In standard burners	60	2402	1.177
10.	Electricity (KWh)	860	Hot plate	70	602	4.698

TABLE 1.3 BIOGAS PRODUCTIONS POTENTIAL FROM DIFFERENT WASTES

SR. NO.	RAW MATERIAL	BIOGAS PRODUCTION Litres / kg	METHANE CONTENT (%)
1	Cattle Dung	40	60.0
2	Green Leaves & Twigs	100	65.0
3	Food Waste	160	62.0
4	Bamboo Dust	53	71.5
5	Fruit Waste	91	49.2
6	Bagasse	330	56.9
7	Dry Leaves	118	59.2
8	Non-edible oil Seed Cake	242	67.5

TABLE 1.4 PROPERTIES OF BIOGAS AS A FUEL

Ignition point	700^0 C
Density (Dry basis)	1.2 kg/m^3
Ignition Concentration Gas Content	6-12%
Heat Value	5.0-7.5kWh/m^3
Calorific Value	21.5 MJ/m^3 or 4713kcal/ m^3
pH	6.9-7.2
Temperature For Production	36^0C +/-1

CONCLUSION:

SOCIO-ECONOMIC BENEFITS:

1. This project can bring about socioeconomic development of the village due to availability of the electricity.
2. Apart from domestic sector, the electricity can be used for agricultural as well as development of small and medium scale industries.
3. As raw material is available throughout the year, so it will generate benefits throughout the year.
4. Burdon on already over stressed electricity supply boards will be automatically reduced.
5. Excess electricity generated can be sold out to nearby village or industry for economic return.
6. This project can be effectively used under CDM for economic benefits.

ENVIRONMENTAL BENEFITS:

1. Reduction in green house gases emission from decomposition of organic matter
2. Reduction in CO2 gas emission due to practice of burning of agricultural residues
3. Problems related to disposal of sewage treatment and disposal in rural area are solved.
4. Solid waste from rural area is directly get converted into energy.
5. As electricity is produced burden on demand of coal in thermal power plant is reduced.

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