Scope of Large Scale Biogas in Livestock Farming: A case study in Bhadrakali Cow Farm

Kabita Sharma[1,2], Ajay Kumar Jha[1], Jagan Nath Shrestha[1]

[1] *Central Campus, Pulchowk, Institute of Engineering, Tribhuvan University, Nepal*

[2] *Nepal Electricity Authority, Kathmandu, Nepal*

Corresponding Email: kavitasharma071@gmail.com

Abstract: Biogas plant uses bacteria to break down wet organic matter like animal dung, human sewage or food waste which produces biogas, which is a mixture of methane and carbon dioxide, and also a semi-solid residue. The biogas plant is used for biogas production and management of the cow dung safely. In the present energy situation of Nepal, where there is a large energy deficit, the use of biogas plants to produce energy can bring a new vision in the energy sector. The construction and operation of family sized biogas is successful in Nepal. It is seemed to give emphasis on large sized biogas plants as there are several cattle farms and consequently huge potential for big biogas plants. This study mainly focuses on calculation of size of biogas plant, the energy that will be produced and the possible usages of the biogas produced in Bhadrakali farm as an example.

A biogas plant of 38m^3 can be constructed in the farm ,which can produce energy of 125kWhr and it can replace the use of 11.36m^3 natural gas,12.07 liter kerosene,13.88 liter petrol or 12.75 liter diesel per day and it will also help us to reduce 28.49tCO_2 per year.

Keywords: Biogas; livestock farm; energy demand; electricity

1. Introduction

Biogas plant uses bacteria to break down wet organic matter like animal dung, human sewage or food waste. This produces biogas, which is a mixture of methane and carbon dioxide, and also a semi-solid residue. The main part of a biogas system is a large tank, or digester. Inside this tank, bacteria convert organic waste into methane gas through the process of anaerobic digestion. Each day, the operator of a biogas system feeds the digester with household by-products such as market waste, kitchen waste, and manure from livestock. The biogas is used as a fuel for cooking, lighting or generating electricity. Using biogas can save the labor of gathering and using wood for cooking, minimize harmful smoke in homes, and cut deforestation and greenhouse gas emissions. Biogas plants can also improve sanitation, and the residue is useful as a fertilizer.(How Does Biogas Work, 2009)

The advantages of biogas plant are that initial investment is low for the construction of biogas plant; the technology is very suitable for rural areas. Biogas is locally generated and can be easily distributed for domestic use, biogas reduces the rural poor from dependence on traditional fuel sources, which lead to deforestation, the use of biogas in village helps in improving the sanitary condition and checks environmental pollution, the by-products like nitrogen rich manure can be used with advantage, biogas reduces the drudgery of women and lowers incidence of eye and lung diseases.

Raw materials for biogas generation Biogas is produced mainly from Cow dung, Sewage, Crop residues .Vegetable wastes, Water hyacinth, Poultry droppings, Pig manure etc.

Anaerobic digester –fundamental steps

In the anaerobic digestion process four main steps are involved, namely hydrolysis, acidogenesis, acetogenesis and methanogenesis.

Hydrolysis

In general, hydrolysis is a chemical reaction in which the breakdown of water occurs to form H+ cations and OH- anions. Hydrolysis is often used to break down larger polymers, often in the presence of an acidic catalyst. Through hydrolysis, these large polymers, namely proteins, fats and carbohydrates, are broken down into smaller molecules such as amino acids, fatty acids, and simple sugars. While some of the products of hydrolysis, including hydrogen and acetate, may be used by methanogens later in the anaerobic digestion process, the majority of the molecules, which are still relatively large, must be further broken down in the process of acidogenesis so that they may be used to create methane.

Acidogenesis

Acidogenesis is the next step of anaerobic digestion in which acidogenic microorganisms further break down the Biomass products after hydrolysis. These fermentative bacteria produce an acidic environment in the digestive tank while creating ammonia, H_2, CO_2, H_2S, shorter volatile fatty acids, carbonic acids, alcohols, as well as trace amounts of other byproducts. While acidogenic bacteria further breaks down the organic matter, it is still too large and unusable for the ultimate goal of methane production, so the biomass must next undergo the process of acetogenesis.

Acetogenesis

In general, acetogenesis is the creation of acetate, a derivative of acetic acid, from carbon and energy sources by acetogens. These microorganisms catabolize many of the products created in acidogenesis into acetic acid, CO_2 and H_2. Acetogens break down the Biomass to a point to which Methanogens can utilize much of the remaining material to create Methane as a Biofuel.

Methanogenesis

Methanogenesis constitutes the final stage of anaerobic digestion in which methanogens create methane from the final products of acetogenesis as well as from some of the intermediate products from hydrolysis and acidogenesis. There are two general pathways involving the use of acetic acid and carbon dioxide, the two main products of the first three steps of anaerobic digestion, to create methane in methanogenesis:

$CO_2 + 4\,H_2 \rightarrow CH_4 + 2H_2O$

$CH_3COOH \rightarrow CH_4 + CO_2$

While CO_2 can be converted into methane and water through the reaction, the main mechanism to create methane in methanogenesis is the path involving acetic acid. This path creates methane and CO_2, the two main products of anaerobic digestion.(BioSphere Plastic Additives – How They Enhance Biodegradability, 2010)

2. Methodology

This research was performed by taking the relevant data of Bhardakali cow farm which is situated in Kathmandu valley. The farm was visited and the data was taken. Other necessary data was taken from the internet for the calculation. The data collected from the farm and the other assumed data were used for calculation. Several other organizations: BSP Nepal, AEPC and other organizations were also visited.

3. Result and discussions

Status of biogas in Nepal

Biogas is one of the alternative energy promoted by AEPC through biogas companies and microfinance institutions including cooperatives. Biogas Support Program (BSP), Biogas Credit Unit (BCU) and National Rural and Renewable Energy Program (NRREP) were designed to increase biogas use for cooking. With the subsidy help from these programs, there are a total of 2, 90,509 plants ranging from 4-20 cubic meter capacity installed in Nepal during fiscal year 2049/50 to 2069/70. AEPC is working with 100 different Biogas Companies in the constructional and promotional activities of the biogas plant. Biogas Technology has been playing a key role in generating lots of green job in the rural areas, AEPC statistics says that approximately 13000 green jobs are created by this sector in different districts of Nepal.

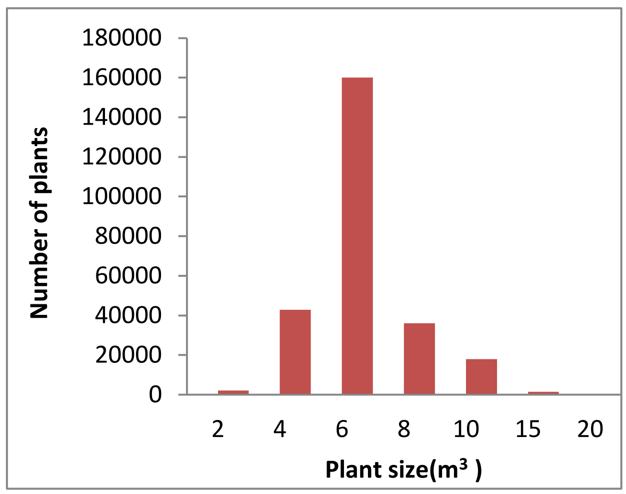

Figure: Size wise installation of biogas (AEPC, 2012/13)

The Bhadrakali cow farm is situated in Kathmandu, Nepal. The latitude and longitude for the place is 27° 45' 25" N 85° 20' 09" E respectively. The elevation for the place is 4429 ft. the farm was established in the year 2067 B.S. An area of 20 ropani is covered by the place, which also includes the grass land area for the animals in there. The total number of cows in the farm is around sixty two (at the time of visit).

The use of biogas plant in Nepal is successful in small scale and for domestic use. However the use of large scale biogas plants in community level and commercially is in very less amount. There are many livestock farms in Nepal but there is no broad vision of how the large biogas plants can be used for production of energy in the farm. So, the large scale biogas is not so successful.

This study emphasizes on the large scale use of the biogas plant, especially in the livestock farms. Livestock farming is done to produce milk, meat, eggs, wool, labor, etc. in such farms, the dung from the animals are available in large amount. Hence the construction of large biogas will be help to obtain huge amount of energy. In this study the size of the biogas plant in the Bhadrakali cow farm, total energy that can be produced from the biogas plant is calculated. The areas where biogas can be used is enlightened. The equivalent substitution fuel that can be saved and the reduction in GHG emission reduction is also calculated.

Calculation of size of biogas plant

The manure production per cow is 6kg /cow/day (Lowrance, 2010). So the total production from 62 cows is 372 kg/day. Among this 48 kg is being used in the farm. So the available cow dung is 324 kg /day. The biogas plant that can be constructed by using this amount of cow dung can be calculated as following:

=Fresh manure/day x amount of animal x 2 (for cow/buffalo) x Retention time (suppose 60 days)(chowdhary)

=324*2*60

=38m^3

The total cowdung available in the farm is 324 kg. from the calculation it is found that a biogas plant of size 38 m^3 can be constructed from the available feed. The plant can be constructed as a single large unit , or many small units. The biogas from the plant can be utilised by the farm for heating water, processing milk or some other purpose. It can also be distributed to the nearby housed by distribution pipes. The comparison of the energy from different energy sources can be seen in the table below:

Table: Energy content of different fuels

Fuel	Energy content [kWh]
1 m^3 upgraded biogas	9.67
1 m^3 natural gas	11.0
1 liter petrol	9.0
1 liter diesel	9.8
28 Second viscosity Heating oil (Kerosene)	10.35

Source: (AB, 2012)

The average production of biogas per kg of dung is 0.04m^3 (Tasneem Abbasi S.M Tauseef, 2012).So 324 kg of cow dung can produce 12.96 m^3 of biogas per day. This is equivalent to 125kWh of energy. This energy can be directly used as thermal energy of can be converted to electrical energy. If this biogas is used in place of natural gas, kerosene, petrol and diesel then it can replace 11.36m^3 natural gas, 12.07 liter kerosene, 13.88 liter petrol or 12.75 liter diesel respectively per day.

A generator can be connected and the electricity can be produced from it. However for electricity generation the gas produced should be very clean. The gas produced must fulfill the given below requirements:

- The methane content should be as high as possible as this is the main combustible part of the gas;
- The water vapor and CO_2 content should be as low as possible, mainly because they lead to a low calorific value of the gas;
- The sulphur content in particular, mainly in form of H_2S, must be low, as it is converted to corrosion-causing acids by condensation and combustion.(Electricity Generation from Biogas, 2013)

The gas production per day is 12.96m^3. if we take the methane content to be 60%(Bothi, 2007), then the methane in the biogas will be 5.18m^3. So in a year the methane production will be 1892 m^3. If we take the density of the methane as 0.717 kg/m^3(Khosrokhavar, 2011) , then 1356 kg of methane will be produced per year. This is equivalent to 28.49 tons of CO_2 (CH_4 is 21 times more potent than CO_2). So, if the biogas is produced from the unused cow dung it will reduce 28.49 tones of CO_2 per year.

4. Conclusion

From the data collected, it is found that a biogas plant of size 38m^3 can be constructed in the farm. This can produce energy of 125 kWhr and it can replace the use of 11.36m^3 natural gas, 12.07 liter kerosene, 13.88 liter petrol or 12.75 liter diesel per day.

The biogas can be either consumed in the farm or it can be distributed in the surrounding houses nearby by pipelines or either a generator can be connected and electricity can be produced which can be used for various purpose. The use of biogas in the farm will also help us to reduce 40.954tCO_2 per year. This will help in GHG emission reduction.

Here the biogas can be constructed as a single large unit or many smaller units. The decision can be made by comparing cost for construction, the area usage, ease of use, technical stability and skill needed for the construction.

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