Biogas Production From Municipal Waste: Prospect in Bangladesh

Md Mosleh Uddin, Md Sadman Sakib Mojumder; Mechanical and Chemical Engineering Department, Islamic University of Technology, Bangladesh

Abstract— **To meet the increasing demand of electricity alternative sources of electricity production are given more importance. The huge amount of waste in the urban areas of Bangladesh due the rapid growth of population can be a potential source of electricity production. The calculation shows that by adopting active biogas collection procedure in the major landfills of the main cities can produce 319989.36 KWh of electricity. Recommendations are given to develop this technology within minimized cost and ensuring environmental safety.**

***Index Terms*—Biogas, Bangladesh, Renewable energy, Solid waste**

I. INTRODUCTION

The continuous depletion of fossil fuel is sticking the concern into the search for new energy sources to be used. The potential energy sources have been emerged as renewable energy resources. For a long time multifarious sources of renewable energy are being investigated to meet the increasing energy consumption rate. To counteract with the growing demand researchers are exploring the new sources .The developing countries are going ahead to face the shortage of available energy. At present the main energy production in Bangladesh is based on natural gas(81.43%).As the demand is increasing and the reserve of the natural gas is decreasing,it is assumed that after 2011 the supply of the natural gas will start to decline. [1].Bangladesh as a country of low GDP is contemplating more on the renewable energy sources which are relatively cheap to extract. As an agricultural country Bangladesh has embedded with plenty of biomass which has been used for extracting energy by burning directly or making biogas. Animal manure being available in the rural areas are greatly used in producing biogas to be used for cooking and lighting.

Though the elements used in biogas production conventionally are plenty in rural areas, the energy consumption is very high in the urban areas. To meet the growing demand of power in the industries and transportation vehicle in the urban areas some sources are being investigated as a pilot project. In many developed countries the municipal waste are largely used to produce biogas .This not only meeting the remarkable portion of energy demand but also helping to maintain clean environment. In Bangladesh some potential sources of renewable energy are gaining attention such as production of biogas from human excreta, from kitchen waste, from animal manures.bio -diesel production from coconut pulp and jutropa.

II. BIOGAS

Biogas originates from bacteria in the process of bio-degradation of organic material under anaerobic (without air) conditions. The natural generation of biogas is an important part of the biogeochemical carbon cycle. Methanogens (methane producing bacteria) are the last link in a chain of micro-organisms which degrade organic material and return the decomposition products to the environment [2]. In this process biogas is generated, a source of renewable energy

The anaerobic digestion process undergoes three distinct process of micro organism.. activities.

1.The fermentative bacteria fermented and hydrolyzed the complex organic materials,carbohydrates,protein and lepid into fatty acid, alcholhol.carbon dioxide,hydrogen,amonia and sulfides.

2.The acetogenic bacteria consumes the primary products and produce hydogen,carbon dioxide and acetic acid.

3. In this stage two types of methanogenic bacteria work. The first reduces carbon dioxide to methane, and the second decarboxylates acetic acid to methane and carbon dioxide

Biogas is a mixture of gases that is composed of methane (CH_4): 40-70 vol.%, carbon dioxide (CO_2): 30-60 vol.%,other gases: 1-5 vol.%,hydrogen (H_2): 0-1 vol.% ,hydrogen sulfide (H_2S): 0-3 vol.%.[1] The calorific value of biogas is about 6 kWh/m^3 this corresponds to about half a litre of diesel oil. The net calorific value depends on the efficiency of the burners or appliances. Methane is the valuable component under the aspect of using biogas as a fuel.

The production of biogas is influenced by various factors such as temperature,pH condition of the input charges, nutrient concentration ,loading rate, toxic compound etc.

Temperature: The required temperature ranges from 3°C-70°C.Temperature between 35°C-38°C is considered optimal .Three temperature range is common. the psychophysics (below 20°C), the mesophilic (between 20°C and 40°C) and the thermophilic (above 40°C) ranges

pH value: To provide the better existence of methane producing bacteria the optimal range is 6 to 7.

To start the fermentation primarily some animal manure is to provided if the charge is composed of others organic materials.

Later the used charges can be used instead of animal manure. The produces gas can be used directly from the digester.
Biogas has long been used in practice ,with production being carried out under both industrial and domestic conditions. Various technologies have been developed in such industrial countries as the United states, France, Germany, Finland. Israel, etc. Simpler technologies are use in India, China, Pakistan and other South Asian countries. [3]

Bangladesh has a wonderful climate for biogas production. The ideal temperature for biogas is around 35°. The temperature in Bangladesh usually varies from 6°C to 40°C .But the inside temperature of a biogas digester remains at 22°C-30°C, which is very near to the optimum requirement.
In Bangladesh animal dung, poultry waste, and agricultural residues have long been used to produce biogas in the plant. The highly production rate of animal dung has given it more attraction to be used as the chief biomass element. But in urban areas due to the unavailability of space animal farm is not available. So the concerned have turned into alternative sources of biogas. The municipal waste management could be a potential source of biogas production in the urban areas. Most of the developed countries are have adopted this municipal waste materials as their main bio gas production element. Bangladesh is yet to implement this municipal waste management system which could facilitate the major increase of biogas production to meet the demand of household cooking and transport fuel largely. The following table shows the increasing rate of municipal waste in the urban areas of Bangladesh.
Two basic process is being used to recover the energy from municipal solid waste. Such as
1.Thermochemical conversion: In this process the waste get de-composed to produce heat or fuel gas.
2.Bio-chemical conversion: In this process the waste become decomposed by the enzymatic action of some bacteria.
For the waste containing high percentage of non-biodegradable materials thermo chemical conversion is more suitable. The main technologies involved in this process are Incineration and gasification. For the waste having high percentage of Biodegradable organic materials and more moisture content thermo chemical conversion is preferable.

III. MUNICIPAL WASTE MANAGEMENT SYSTEM IN BANGLADESH

Municipal waste is the abandoned materials which have been thrown away after use in daily life in the urban area. Municipal waste generally compose of food scrap, packaging materials, used plastic materials, tire etc.Due to the increasing growth of urban population in Bangladesh this municipal waste is getting high concerns from the management perspective. Also the management of this huge amount of waste is a worth of large expense .The amount of municipal waste produced in different cities in Bangladesh is shown in the table 1 .[4] :

Table 1: Growth rate of urban population causing increased waste generation

Year	Urban Population	Total Urban Waste Generation (kg/Day)	Per Capita Waste Generation Rate in Urban Areas Kg/cap/day
1991	20.8 million	6,493000	0.31*
2005	32.76million	13,332000	0.41**
2025	78.44million	47,000000	0.60***

Source: * World Bank ,1998 ** Waste concern,2005, ***UMP,1999 [4]

The amount of produce municipal waste is about 7690 tons daily in six major cities in Bangladesh. The composition of the entire waste stream was about 74.4% organic matter, 9.1% paper, 3.5% plastic, 1.9% textile and wood, 0.8% leather and rubber, 1.5% metal, 0.8% glass and 8% other waste. This large portion of municipal waste being organic can contribute to the production biogas. The organic matters are mainly food waste and agricultural waste.[5]. Figure1 [3] shows the composition of typical municipal waste in Bangladesh.

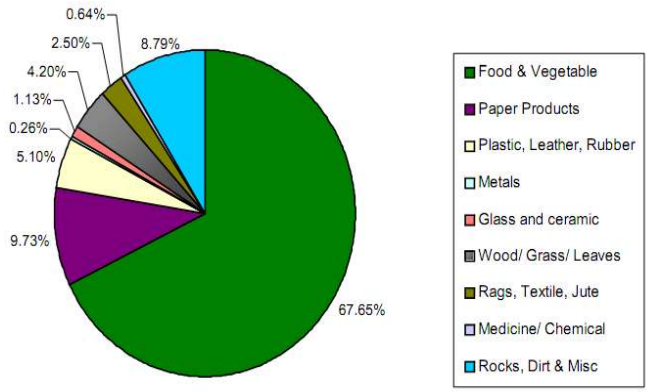

Fig 1. Average physical composition of urban solid waste.[3]

The prevalent waste collection system is mainly driven by community waste collecting bin system. The wastes are accumulated from the households to the local community bin. The municipality collects that by labor to the dumping zone usually known as landfill by open truck .This system allows the waste collection system to be inefficient .The unmanaged dumping zone takes a large land requirement and causes serious environmental hazards to the locality. The collection, transportation and disposal of the msw incurs a huge expense to the municipality.
A large amount of wastes is generated daily in the city of Dhaka. Power Cell, Ministry of Energy and Mineral Resources (MEMR), under the sponsorship of the World Bank, commissioned Bangladesh Centre for Advanced Studies (BCAS)[5] in 1998 for quantity assessment and Institute of Fuel Research and Development (IFRD) of BCSIR for

quality assessment of the city wastes. According to quantity assessment (BCAS, 1998), this city generated about 5000 tons of wastes daily in 2002 and the daily generation would increase to over 15,000 tons in 2025. This nuisance can be transformed into a resource if it can be processed to generate electricity.

Several technologies for the conversion of Municipal Solid Wastes to Electrical Energy (MSWEE) are now available worldwide. These include (a) Landfill, (b) Mass Burn Incinerator (MBI), (c) Fluidized Bed Incinerator (FBI), (d) Gasification, and (e) Plasma Converter .

There are several procedure for collecting Biogas from the landfill in the form of landfill gas which contain 20-30% methane and using this gas for producing energy like heat, electricity. The main two types of landfill gas collection procedure is Active gas collection procedure and Passive gas collection procedure. It has been seen experimentally that passive gas collection system is not that much effective(EPA 1991) .So the most convenient way for Bangladesh should be Active gas collection procedure.

IV. Active Gas Collection Procedure:

It consists of several gas extractions well to collect landfill gas shown in fig 2. The collection wells are typically constructed of perforated or slotted plastic and are installed vertically throughout the landfill to depths ranging from 50% to 90% of the waste thickness. There may be horizontal well deep under the ground surface to allow the landfill gas movement within the landfill. The well are having valves to control the gas flow. There is the provision of vacuum or pump in the well to pull the gas out of the well through some piping system. The vacuum or pump depends on the size of waste and the amount of produced gas. The amount of vacuum or pump can be controlled according to the need.

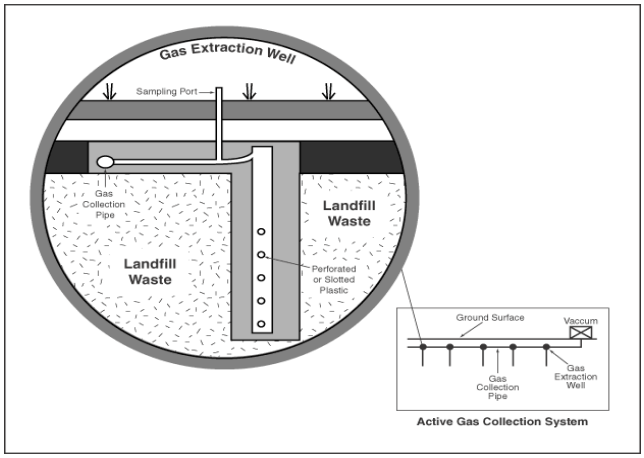

Fig 2. Active gas collection principal.

Then the collected gas through the piping from the well is sent to the well station. In well station the biogas is mixed up and transmitted to the primary horizontal network in the electric power station.[6].then the biogas is passed through some dehumidifier equipments to the combustion chamber of the generator for the electricity production. The schematic diagram has shown in Fig 3.

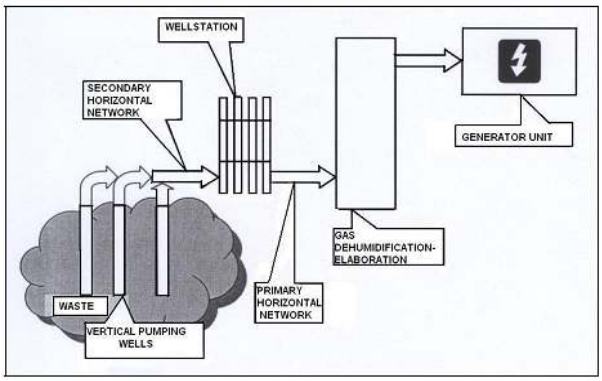

Fig 3. Generative procedure [6]

V. Calculation of Biogas production from Landfill

The rough approximation of biogas production from a landfill can be found out considering the calorific values and organic fraction. The following estimation is applicable for the waste containing both organic biodegradable or non-biodegradable matters.

Let,

Total waste quantity : W Kg

Net Calorific Value : NCV K-cal/kg.

Electrical energy recovery potential (KWh) = $NCV \times W \times 1/860 = 0.00116 \times W \times NCV$

Electric Power generation potential KW) = $0.00116 \times W/24 \times NCV = 4.8 \times 10^{-5} \times NCV \times W$

Conversion Efficiency = 25%

Net power generation potential (KW) = $1.2 \times 10^{-5} \times NCV \times W \quad (1)$

From the experimental data [7] in table 2 we have got the following data for Dhaka city:

Table 2. Calorific value of the waste.

Contents	Share by weight	Calorific values	Btu/lb	Kcal/kg
Water(moisture)	50%-70%	As received	1386-2600	770-1444
Carbon	6.02%-26.06%	Air dry (with moisture 5-8%)	2900-4300	1611-2389
Hydrogen	1.20%-3.53%		3200-6200	1833-3444

Taking this calorific value standard for all the cities in Bangladesh we can approximate the Net power generation in Bangladesh from the landfill waste.
So if we take the calorific values of the waste in air dried(with moisture 5-8%) form as the 2000 K cal/kg (median),we will get from "(1)" :
Net electric power generation potential (KW)=

$$1.2 \times 10^{-5} \times 2000 \times W = .024 \times W$$

From table 4 [8] we get that the total waste produced in Bangladesh per day is about 13332890 Kg
Net electrical power generation potential (kW)

$$= .024 \times 13332890 = 319989.36 \text{ KW}$$

VI. Conclusion

At present in Bangladesh the electricity production from municipal waste is done by incinerator process. From the study we can suggest that by adopting active gas collection procedure more electrical energy can be extracted from the municipal waste. To cope up with the increasing demand of energy there is no way but looking for alternative sources. As a country of large population and for the convenient environment Biogas might be the potential source of energy. Though recently government has initiated some pilot project with the help of some foreign NGOs, but the utilization of the full potential is yet to reach. The main problem is lying in lack of public awareness and social prejudices. Government should supply the needed equipments to the private organization with less expense to encourage the involvement in this sector. The unhygienic dumping zones in every cities could me turned into a potential source of electricity by adopting active gas collection technology instead of spending money to manage the waste in that areas and keeping a huge land area unused. To explore the untouched potential of biogas source of municipal waste following actions are recommended:

-To attract the investment in this sector government should demonstrate one pilot project with the help of foreign development partners.

-Private sectors should be given incentives to invest in electricity from municipal waste.
-The technologies used in the countries successfully adopted waste to electricity system should be imported with necessary subsidies.

-To facilitate the consciousness media should be used properly.

-Waste collection system should be improved to ensure effective output from active gas collection system.

References

[1] Bangladesh Power Development Board. Annual Report of 2006-2007. Dhaka, Bangladesh: BPDB, 2008.Availabe: www.**bpdb**.gov.bd/download/**Annual**%20**Report**-10.pdf
[2] Biogas Digest,Vol 1, Information and Advisory Service on Appropriate Technology (ISAT),GTZ
(PREGA), Bangladesh Country Report,2003.

[3] Obozov, A.D. and Asankulova, "Biogas in Kyrgyzstan", Applied Solar Energy, 2007, Vol. 43, No. 4, pp. 262–265

[4]Waste Concern Database, http://www.wasteconcern.org/database.html

[5] M. Alamgir and A. Ahsan," Municipal Solid Waste And Recovery Potential: Bangladesh Perspective" ,Iran. J. Environ. Health. Sci. Eng., 2007, Vol. 4, No. 2, pp. 67-76

[6] S. Karapidakis and Anna Tsave,"Electric Power Production By Biogas Generation at Volos Landfill In Greece" Applied Solar Energy,submitted for publication

[7] Dr.M.Eusuf, Technological Feasibility of CDM Project Dhaka City Solid Waste.NTE.Bangladesh

[8] JICA (2004) Solid Waste Management Project of Dhaka City Corporation, Final Report of JICA Expert, Bangladesh.Available: www.**dhakacity**.org/clean**dhaka**/.../Clean**Dhaka**MasterPlanMain.pdf

Table 3. Component weight of MSW generated in six major cities of Bangladesh

Waste category	MSW generation $\times 10^3$ Kg/day						All waste stream $\times 10^3$
	DCC	CCC	KCC	RCC	BCC	SCC	
Organic matter	3647	968	410	121	105	158	5409
Paper	571	130	49	15	9	18	792
Plastic	230	37	16	7	5	8	303
Textile & wood	118	28	7	3	2	5	163
Leather & rubber	75	13	3	2	1	1	95
Metal	107	29	6	2	2	2	148
Glass	37	13	3	2	1	2	58
Other	555	97	26	18	5	21	722
Total	5340	1315	520	170	130	215	7690
Population	11.00	3.65	1.50	0.45	0.40	0.50	-
Per capita (kg/day)	0.485	0.360	0.347	0.378	0.325	0.430	0.387*

Table 4.Total waste generation in urban areas of Bangladesh In 2005

City	*WGR (kg/cap/day)	No of city/town	Total population (2005)	Population ** (2005)	TWG (kg/day)		Average (kg/day)
					Dry season	Wet season	
Dhaka	0.56	1	6,116,731	6,728,404	3767910	5501140	4634520
Chittagong	0.48	1	2,383,725	2,622,098	1258610	1837570	1548.090
Rajshahi	0.3	1	425,798	468,378	140510	205150	172.830
Khulna	0.27	1	879,422	967,365	261190	381340	321.260
Barisal	0.25	1	397,281	437,009	109250	159510	134380
Sylhet	0.3	1	351,724	386,896	116070	169460	142.760
Pourashavas	0.25	298	13,831,187	15,214,306	3803580	5,553220	4678400
Other Urban Centers	0.15	218	8,379,647	9,217,612	1382640	2,018660	170065000
Total	-	522	32,765,516	36,042,067	10839750	15826040	13332890