Prospects and potential of biogas technology in Bangladesh

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***Abstract*—The issues of energy crisis, depletion of fossil fuel and global warming are growing concern in the world. To cope up with this situation, the role of renewable energy is becoming more and more significant to meet partially demand of global energy. Biogas is an auspicious renewable energy source that can solve the energy crisis problem at a great extent. As Bangladesh is an agricultural country, it has blessed with plenty of biomass which has been used for extracting energy by generating biogas. Animal manures being accessible in the rural areas are greatly used in producing biogas to be used for cooking and electricity. In Bangladesh around 59.6% of the total population is covered by electricity and 6% is covered under natural gas network. About 62.59% of total electricity develops from natural gas. The main concern of this paper is to quantify the solution of energy crisis through biogas and assess the economical, environmental and social impacts of biogas technology in Bangladesh.**

Keywords—Renewable energy, biogas, poultry waste, cattle manure, municipal waste, prospects of biogas.

I. INTRODUCTION

Fossil fuels are extensively used in transportation, power generation and machinery energy source due to its high heating power, availability and quality of combustion characteristics, but its reserve is draining day by day. Bangladesh, as a developing nation has been struggling to keep up with the energy demand for its large population. Bangladesh has installed power plants having the generating capacity of 11877 MW where maximum generation is 8177 MW and 93.9% power comes from fossil fuel [1]. Bangladesh government envisions that 5% & 10% of total energy production will have to be achieved from renewable energy sources by the year 2015 & 2020 respectively [1]. Biogas is one of the auspicious renewable energy sources which refer to a mixture of different gases generated by the decomposition of organic matter like agricultural waste, municipal waste and animal manure in the absence of oxygen. About 102.6 million tons Cattle dung from 25.5 million cows and buffaloes, 12.9 million tons poultry waste from 291.5 million chickens and ducks and 8.65 million tons municipal waste are produced in Bangladesh every year [2]. Such a large amount of these wastes have great economical value which can be utilized to produce biogas for cooking, heating and electricity generation. Besides, production of biogas from organic waste avoids emitting of methane and nitrous oxide in the environment. The intergovernmental panel reports on climate change that nitrous warms the atmosphere 310 times more than carbon dioxide and methane does so 21 times more [3].

II. BIOGAS AND ITS COMPOSITION

Biogas is a combustible mixture of gases. Methane (CH_4) and carbon dioxide (CO_2) are the main components of biogas which is formed by the anaerobic bacterial decomposition of organic compounds in absence of oxygen. The gases are produced from the waste products of the respiration of these decomposer microorganisms. The composition of the gases depends on the substances that are being decomposed [4]. It has burning properties like natural gas. It is about 20% lighter than air and calorific value is (5000-7000) kcal per cubic meter. It usually burns with 60% efficiency in a conventional biogas stove [5].

TABLE I. COMPOSITION OF BIOGS [6]

Components	***Percentage***
Methane (CH_4)	60-70
Carbon dioxide (CO_2)	30-40
Hydrogen (H_2)	2-2.5
Nitrogen (N_2)	1-1.5
Oxygen (O_2)	0.3-0.4
Hydrogen Sulfide (H_2S)	0.1-0.2

III. ANAEROBIC DIGESTION

It is an oxygen-free complex biological process, in which the feeding material is decomposed partially by the combined action of several types of microorganisms to generate biogas.

Biogas production by anaerobic digestion depends on various factors such as temperature, pH condition of feeding material, nutrient of charge, organic loading rate etc. The temperature range required for anaerobic digestion is 30°C-70°C but optimum range is between 35°C-38°C. Besides the

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optimum range of pH value is 6 to 7 [4]. The anaerobic digestion process and utilization of biogas are given below:

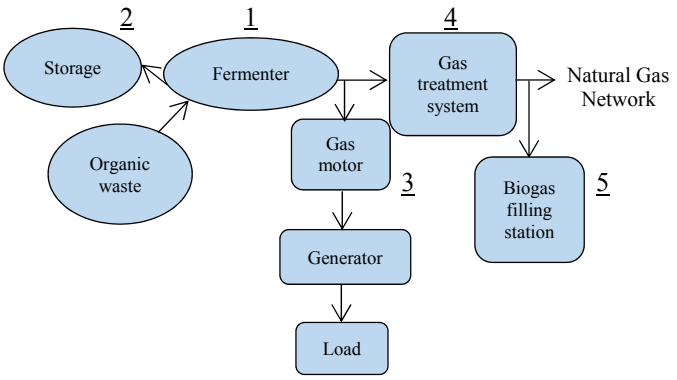

Fig. 1. *Energy production in a biogas plant.*

1. The digester contains biomass that anaerobically digest by the action of micro-organisms to produce the biogas and carbon dioxide.
2. Residual materials from the digester called slurry can be utilized as fertilizer, substantially reducing the use of fertilizer.
3. In a Combined Heat and Power (CHP) plant the biogas is combusted to produce both electricity and heat
4. The Gas upgrading plant increases the overall quality of the biogas by removing CO2, S and other impurities.
5. The upgraded biogas can be utilized in gas engine.

IV. TEMPERATURE CONTROL SYSTEM

The temperature control system enhances the rate of biogas production for large scale biogas plant. The temperature range required for anaerobic digestion is 30°C- 70°C. Temperature between 35°C-38°C is considered optimum. A temperature control system can be utilized to maintain the optimum temperature between 30°C-40°C in digester.

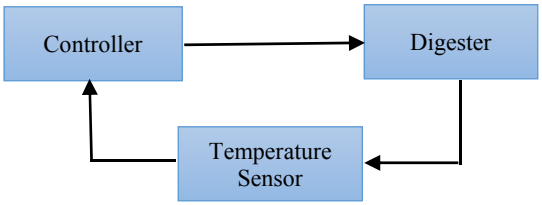

Fig. 2. *Temperature control system in digester.*

Temperature control system consists of control panel, an electric heater in digester and a temperature sensor. The temperature sensor is used to sample digester temperature. The electric heater is controlled through the controller. When the temperature of digester is below 30°C, the temperature sensor sends a signal to the controller to switch on the electric heater. Similarly when the temperature of digester is above 40°C, the temperature sensor sends a signal to the controller to switch off the electric heater.

V. STATISTICS AND ENERGY ANALYSIS OF ORGANIC WASTE IN BANGLADESH

A. *Poultry waste*

As Bangladesh is a promising place for poultry industry, the number of poultry farms have increased continually. The main objective of the poultry industry was to assist only food supply against a highly dense population. In 2013, the country had approximately 245 million chickens and 46 million ducks respectively that produced 12.9 million tons of waste [2]. This poultry waste can be extracted by anaerobic digestion (AD) process which has huge energy value.

TABLE II. ENERGY CALCULATION CHART [7]

Waste and droppings per chicken/duck per day	***Amount of biogas produced from 1 kg of poultry waste***	***Amount of biogas for 1 KW electricity generation***
0.1 kg	0.074 m^3	0.71 m^3

Total number of chickens and ducks= 291000000
So, Total amount of poultry waste= (0.1×291000000) kg
= 29100000 kg
Total amount of produced biogas= (29100000×0.074) m^3
= 2153400 m^3
Total electricity generation= (2153400÷0.71) KW
= 3032957 KW= 3033 MW

B. *Cattle dung*

Traditionally cattle dung is utilized as a fertilizer. Nowadays dung is collected and used to produce biogas. The international energy agency reports that bioenergy has the potential to meet more than a quarter of the world demand for transportation fuels by 2050. In 2013, the country had approximately 24 million cows and 1.5 million buffaloes respectively that produced 102.6 million tons of waste [2].

TABLE III. ENERGY CALCULATION CHART [6]

Dung from one cattle per day	***Amount of biogas produced from 1 kg of cattle dung***	***Amount of biogas for 1 KW electricity generation***
10 kg	0.034 m^3	0.71 m^3

Total number of cattle's= 25500000
So, Total amount of cattle waste= (10×25500000) kg
= 255000000 kg
Total amount of produced biogas= (255000000×0.034) m^3
= 8670000 m^3
Total electricity generation= (8670000÷0.71) KW
= 12211267 KW= 12211 MW

C. *Municipal waste*

Municipal waste disposal is one of the main problems being confronted by all nations across the world. The daily per capita per person solid waste produced in Bangladesh is about (300-400) gram and approximately 8.65 million tons municipal waste was generated in 2013. If we carefully analyze these waste, we will realize that most of these are biodegradable.

TABLE IV. ENERGY CALCULATION CHART

Amount of municipal waste per day	*Amount of biogas produced from 1 kg of municipal waste*	*Amount of biogas for 1 KW electricity generation*
21500000 kg	0.076 m^3	0.71 m^3

Total amount of municipal waste= 21500000 kg
Total amount of produced biogas= (21500000×0.076) m^3
= 1634000 m^3
Total electricity generation= (1634000÷0.71) KW
= 2301408 KW= 2301 MW

From the above calculations TABLE V has been drawn that shows the possibility of total amount of biogas production and electricity generation from organic waste in Bangladesh.

TABLE V. ENERGY FROM ORGANIC WASTE (2013)

Source of organic waste	*Amount of produced biogas in cubic meter*	*Amount of generated electricity in MW*	*Percentage of generated electricity*
Poultry waste	2153400	3033	17.3
Cattle dung	8670000	12211	69.6
Municipal waste	1634000	2301	13.1
Total amount	12457400	17545	100

From TABLE V, we can draw a pie chart which shows the percentage of possibility of electricity generation from poultry waste, cattle dung and municipal waste in Bangladesh.

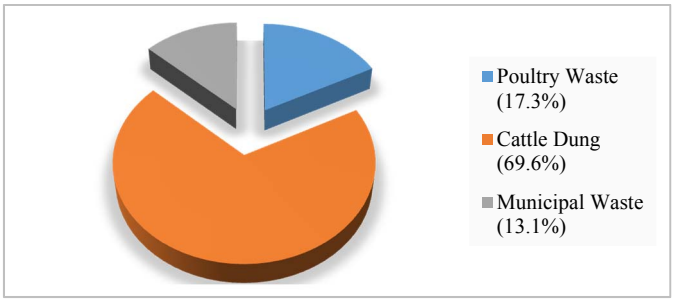

Fig. 3. *Possibility of electricity generation from organic waste (2013)*

VI. ECONOMICAL, ENVIRONMENTAL AND SOCIAL PROSPECTS

Biogas technologies have great significance for energy access, energy security, deplete dependency on fossil fuels, moderating climate change, sustainability and socio-economic benefits.

A. *Economical prospects*

Biogas has great potential to cover a variety of markets, including electricity, heat, transportation fuels and also to use the gas for direct combustion in household stoves and gas lamps. Bangladesh has installed power plants having electricity generating capacity of 11877 MW where maximum generation is 8177 MW and peak demand is 10283 MW until 2015 [1]. From TABLE V, total electricity generated from organic waste is 17420 MW. In 2013 if we could utilize at least 10% of total amount of organic waste, 1754 MW electricity would be produced which was able to fulfill 21% of peak demand out of 8339 MW in Bangladesh [1].

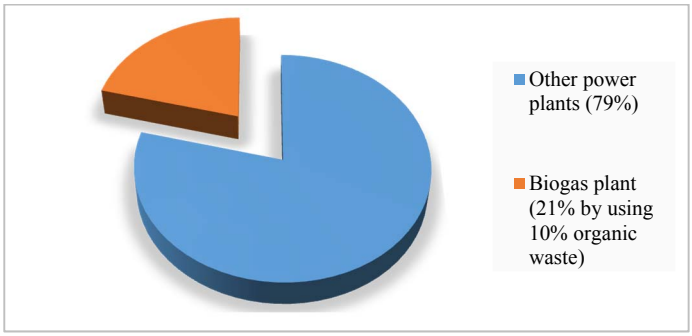

Fig. 4. *Possibility of electricity generation in Bangladesh (2013)*

Fig. 4 shows how biogas could play a vital role to fulfill 21% of peak demand if 10% of total amount of organic waste was utilized in 2013.

Biogas enables us to save the energy cost and earn money by selling biogas to the neighbors. Soil fertility in Bangladesh is gradually diminishing. One of the major factors is excessive utilization of chemical fertilizers. The by-product of a biogas plant is called bio-slurry. It is the best alternative supplement to chemical fertilizers for maintaining soil fertility. It is nontoxic. The nutrient quality of bio-slurry is higher than compost manure and chemical fertilizer.

B. *Environmental prospects*

There are increasing concerns about growing greenhouse gas (GHG) emissions and their impact on worldwide climate change. GHG reduction require strategies in different production sectors but the existing strategies are not yet effective.

Only in United States, over one billion tons of cattle manure is produced from livestock yearly [8]. Ammonia, VOCs, hydrogen sulfide and particulate matter are emitted from manure which can create health problems [9]. Ammonia can also contaminate ground water and lead to eutrophication of the soil [10]. Biogas plants have environmental benefits to the

reduction of greenhouse gas emissions and air pollutants in the atmosphere. This is possible through the controlled capture of CH_4 and the saving of fossil fuels by biogas replacement [11]. Unbalancing the eco-system is the main cause of natural disasters. Biogas technology can play a powerful role to keep the balance of eco-system as it will encourage farming and reduce deforestation.

VII. FUTURE PROSPECTIVE

Production of biogas from organic waste exposes massive interest around the world. Biogas technology offers vital environmental benefits in term of bioenergy. It provides different final products such as a renewable energy source, electricity production, heat generation, transportation fuel and a good fertilizer.

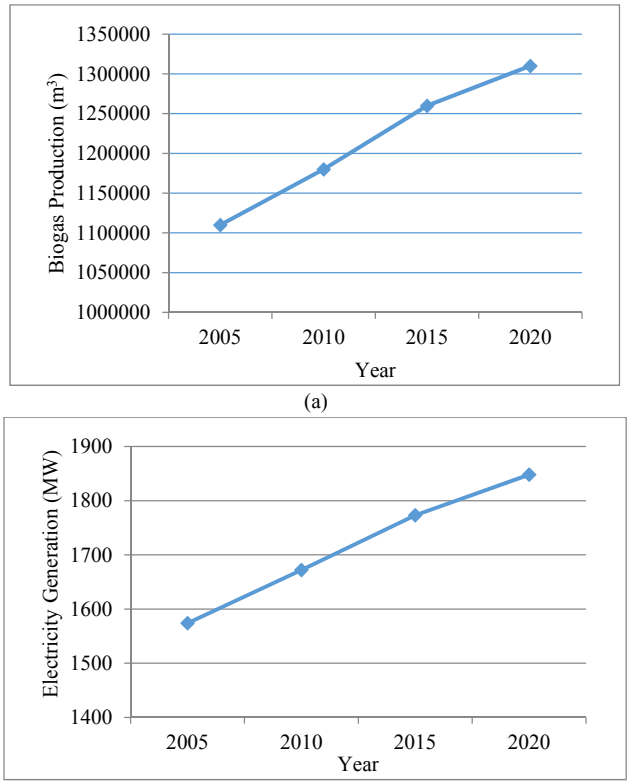

Fig. 5. *Graphical representation of possibility of (a) biogas production, (b) electricity generation; from 10% of total amount of organic waste in Bangladesh.*

Bangladesh has possibility to produce 13100000 cubic meter biogas by utilizing total amount (100%) of organic waste in 2020. If we ensure to utilize at least 10% of it, it will produce 1848 MW electricity which will cover 10.7% of peak electricity demand in 2020. To solve energy crisis in third world countries such as in Bangladesh and save the planet from the effects of climate change and greenhouse gases, we need investments in biogas technologies. In this regard, the developing countries have the opportunity to leapfrog conventional energy options in favor of cleaner energy alternatives such as biogas energy.

VIII. CONCLUSION

The outcome of this paper expresses that there is substantial scope for Bangladesh to fulfill its future power demand through biogas. Biogas energy sources conferred above can aid Bangladesh to generate more power in order to minimize load-shedding problem. It is high time to work with biogas technology to generate electricity rather than depending entirely on conventional method. Therefore, the government and non-government organizations should work together on biogas and biogas technology to solve energy crisis problem.

REFERENCES

[1] Bangladesh Power Development Board. http://www.bpdb.gov.bd/bpdb/index.php?option=com_content&view=article&id=126&Itemid=17

[2] FAOSTAT.-2013 http://faostat3.fao.org/browse/Q/QA/E

[3] Cow power: the energy and emissions benefits of converting manure to biogas by Amanda D Cuellar and Michael E Webber. IOP Publishing Ltd, Volume 3, Number 3. 2008

[4] Peter Jacob Jorgensen, "*Biogas- Green Energy.*" pp. 4

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

[6] Feasibility study on electricity generation from poultry litter based biogas in Bangladesh. DOI**:** 10.1109/ICDRET.2014.6861661

[7] Design and Benefit Analysis of Biogas Plant for Rural Development in Bangladesh. International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-3, Issue-3, 2014

[8] Kellogg R L, Lander C H, Moffitt D C and Gollehon N 2000 Manure Nutrients Relative to the Capacity of Cropland and Pastureland to Assimilate Nutrients: Spatial and Temporal Trends for the United States (March, 2007)

[9] National Research Council 2003 Ad hoc committee on air emissions from animal feeding, O Air Emissions from Animal Feeding Operations: Current Knowledge, Future Needs vol xxi (Washington, DC: National Academies Press) pp. 263

[10] Doorn M R J, Natschke D F and Meeuwissen P C 2002 Review of Emission Factors and Methodologies to Estimate Ammonia Emissions from Animal Waste Handling US Environmental Protection Agency.

[11] Environmental analysis of biogas production systems by Caterina Tricase & Mariarosaria Lombardi. Volume 3, issue 6. Pages 749-760, 2012. DOI:10.4155/bfs