

## Assessment of Biogas Resources for Rural Electrification in Bangladesh

M. S. Islam\*, M. R. Islam, B. K. Das, Najmul Hoque

Department of Mechanical Engineering, Rajshahi University of Engineering & Technology,  
Bangladesh

E-mail: sohag09me@gmail.com

### Abstract

*Production of biogas from organic waste exposes massive interest in many parts of the world. Biogas production system offers various sorts of benefits over other forms of bio-energy as it provides different forms of energy and reduces huge amount of environmental impact. As Bangladesh is an agricultural country, it has blessed with plenty of biomass, which can be used as a source of biogas production. In rural areas of Bangladesh, where more than 65% of the population live, only 51% have access to electricity. There are about 102.6 million tons cow dung from 25.5 million cows and buffaloes and 12.9 million tons poultry litter from 291.5 million chickens and ducks until 2016 in Bangladesh. Such a large amount of these wastes has great fuel value which can be utilized to produce biogas for cooking, heating and electricity generation. Bangladesh has the potential to generate 5204 Mm<sup>3</sup> of biogas which could add around 7.30 GWh electricity to the national grid. The energy starved Bangladesh needs to promote biogas technology to reduce the dependence on conventional energy system as well to ensure energy security for the future.*

Keywords: Biomass waste, Biogas, Renewable energy, Electricity, Environment

### 1. Introduction

Increased energy demand, economic growth, depletion of fossil fuel and climate change due to excessive CO<sub>2</sub> emission in the environment are the main drivers for the transformation of the present energy system from fossil to renewable sources. Biomass can play an important role in this alteration to a low carbon economy [1-5]. Bangladesh is a developing country with a population of about 162 million living in an area of 147,570 sq. km and has been struggling to keep up with the energy demand of its large population. In rural areas, where more than 65% of the population lives, only 51% has access to electricity [6]. Only 3% of the total people have the access of natural gas coming to their households through national grid pipe lines and most of them live in the cities.

Meantime, most of the rural people depends on biomass, crop residues, leafs and twigs, dung cake and forest wood for cooking that imposes adverse effect in environment. Most of the energy needed for rural people comes from traditional biomass fuels comprising of agricultural residues (45%), wood and wood wastes (35%), and animal dung (20%) [7]. Generally, biomass are supplied over half (~62%) of the country's total energy consumption [8]. For this reason, huge amount of fuel woods is consumed annually, which consequently reduces the forest area. Presently Bangladesh has 1,429,000 hectares of forest cover which is about 11% of the total land area of the country [9] and forest cover of the country has been declining with the rate 2,600 hectares per year (FAO 2015). The technology practices in rural areas for burning agriculture, animal waste and fuel wood are inefficient (less than 10 %). Burning of these fuels is harmful to both environment and health due to emission of deadly CO<sub>2</sub> and rising of smoke cause air pollution.

So, it is necessary to promote alternative sources to generate energy in Bangladesh. Several research works are conducted to assess the biomass resources to generate electricity through gasification in Bangladesh [10-11]. Besides, biogas plant is one of the potential renewable energy sources since it can produce gas for cooking and lighting, electricity for power generation, and slurry for developing organic fertilizers. Bangladesh produces a huge amount of poultry waste, kitchen waste, animal manure, agriculture residues, food scrap, etc., which favors the generation of biogas in the country. The collection system of animal waste is easier compared to other resources and offers lots of social and ecological benefits including waste management, sanitation, reforestation and dependence on fossil fuel. After fulfilling the electricity demand of farms, the owners can earn extra money by selling electricity, biogas, and bio fertilizer to the others. This energy generation system is feasible for rural electrification since many rural households that cannot afford a solar system or a biogas plant rather they are purchasing electricity and biogas cheaper price than kerosene.

Biogas plants shared by multiple households would be a successful initiative for rural electrification. It will not only bring low-income groups under a biogas program by linking them with micro-credit but also encourages the intermediaries for collecting cow dung or poultry wastes from farmers and selling these to biogas plant owners, who do not have enough cows or poultry. Moreover, this system can be successfully promoted to local entrepreneurs, including poultry and livestock farmers. Rural electrification through biomass waste has also been connected with agriculture through the promotion of slurry, which is the source of high quality organic fertilizer. Agriculture cost will decrease and yield will increase from these initiatives. This present study mainly focused on the potentiality of biogas based electricity production and promotion of biogas plants to electrify rural areas in Bangladesh.

## 2. Biogas and biogas technology in Bangladesh

### 2.1 Biogas

Biogas is a combustible mixture of different gases produced by the breakdown of organic matter in the absence of oxygen. It consists mainly of methane (CH<sub>4</sub>) and carbon dioxide (CO<sub>2</sub>) and is formed from the anaerobic bacterial decomposition of organic compounds in absence of oxygen. It combined with methane (50-75%), carbon dioxide (25-50%), nitrogen (< 1 - 2%), hydrogen (0-1%), hydrogen sulfide (0-2%) and Oxygen content (<1%) [12]. The gases are produced from the waste products of the respiration of these decomposer microorganisms at temperatures between 30°C-40°C or 50°C-60°C [13]. The composition of the gases depends on the substances that are being decomposed. The constituents of biogas are shown in Table 1.

**Table 1:** Percentage of constituent for biogas

Sl No.	Constituent	Chemical formula	Percentage (%)
1	Methane	CH <sub>4</sub>	55-70
2	Carbon dioxide	CO <sub>2</sub>	30-45
3	Hydrogen Sulfide	H <sub>2</sub> S	
4	Nitrogen	N <sub>2</sub>	1-2
5	Hydrogen	H <sub>2</sub>	
6	Carbon monoxide	CO	

### 2.2 Biogas potential in Bangladesh

Biogas based power generation is very much favorable in a country like Bangladesh since it is a source of green energy, minimizes land use, lower maintenance and operating costs, reduces greenhouse gases and also providing a way to increase family income by selling excess biogas. Bangladesh is an agricultural country and about 16% of total GDP comes from agriculture. As a result, it has a huge livestock potential. Cattle, goats, poultry, buffalos, sheep and goats are the general sources of livestock in the country. The manure from these livestock is conventionally used as cooking fuel and fertilizer in rural areas of Bangladesh. These animal manures have the potential to solve power demand situation and ability to electrify rural community in the country. Biogas generated from animal manure can be one of the promising renewable energy resources for Bangladesh. The ideal temperature for biogas generation is around 35°C. 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 [14]. It also provides a convenient way to eco-friendly disposal of animal waste by reducing bad odor annoyance gas emissions. Biogas can also reduce the amount of deforestation by supplying cooking fuel to the rural people as well as improving their life standard by generating electricity on a small scale. The quantity of manure produced from the animals depends on weather condition, age, breed and feeding habits.

**Table 2:** Number of livestock's and poultry in Bangladesh [6]

Livestock/poultry	Number (in millions)				
Fiscal Year	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Cattle	23.12	23.19	23.34	23.98	23.63
Buffalo	1.394	1.44	1.45	1.45	1.46
Goat	24.14	25.11	25.27	25.43	25.6
Sheep	3.002	3.082	3.14	3.2	3.27
Total livestock	51.66	52.83	53.21	53.59	53.97
Chicken	234.68	242.86	249.01	255.31	261.77
Duck	44.12	45.7	47.25	48.86	50.22
Total poultry	278.8	288.56	296.26	304.17	312.29

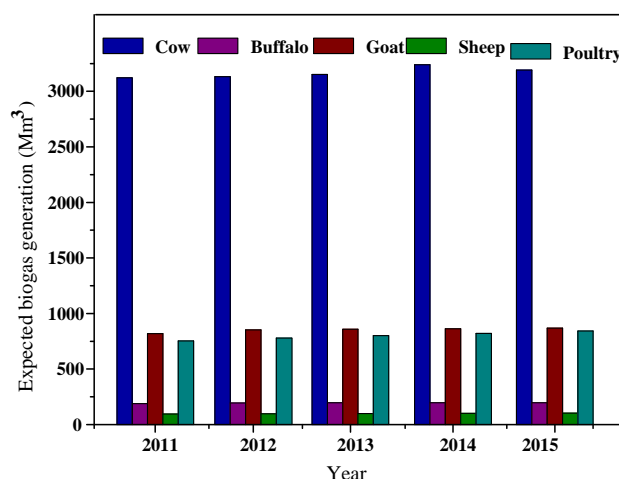
Table 2 presents the number of livestock and poultry in Bangladesh from FY 2010–2011 to FY 2014–2015. From Table 2, it is observed that the amount of livestock and poultry are increasing day by day, which in turns

increase the extent of manure. According to the statistics, in FY2008–09 there were about 23.12 million cattle, 1.39 million buffaloes, 24.14 million goats, 3 million sheep, 234.64 million chickens and 44.12 million ducks.

**Table 3:** Potential for biogas generation from animal waste in 2014-2015

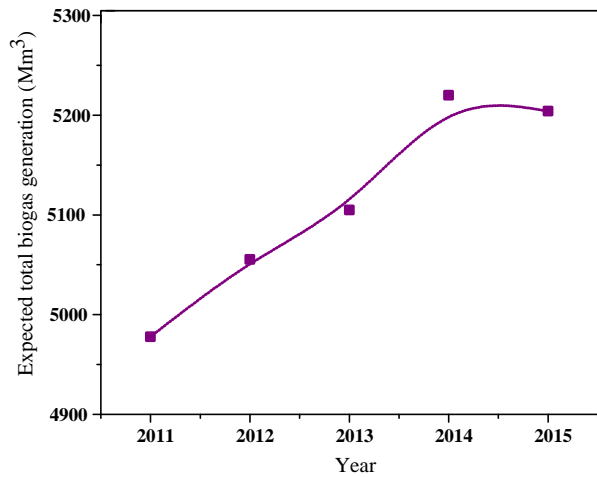
Sl No.	Sources	Total amount (in millions)	Manure generation (kg/day)	Biogas obtained (m <sup>3</sup> /kg of manure)	Total biogas production (Mm <sup>3</sup> /year)	Amount of electricity generation (kWh/m <sup>3</sup> of biogas)	Total electricity potential (GWh)
1	Cattle	23.63	10 [ 7]	0.037 [7]	3191.232	1.4 [13]	7.30
2	Buffalo	1.46	10 [7]	0.037 [7]	197.173		
3	Goat	25.6	1.55 [15]	0.06 [17]	868.992		
4	Sheep	3.27	1.44 [16]	0.06 [16]	103.1227		
5	Poultry	312.29	0.1 [17]	0.074 [7]	843.49		
6	Total				5204.01		

Table 3 shows the projected biogas generation and electricity potential of animal and poultry waste in Bangladesh in FY 2014-2015. It is possible to generate 2023 MW electricity by using these animal manure, which can solve energy demand situation and load-shedding problem of Bangladesh. The amount of waste produced per day by livestock and poultry is estimated using the generation ratio of neighboring countries. It was taken as 10 kg manure/animal/day for cattle and buffalo, 1.55 kg manure/animal/day for goat, 1.44 kg manure/animal/day for sheep and 0.1 kg manure/poultry/day.

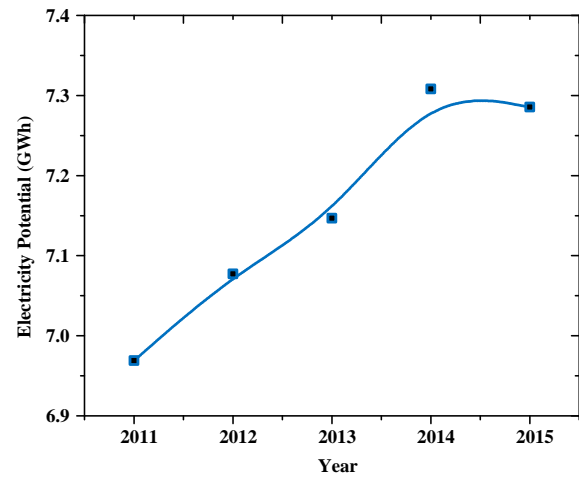


**Fig. 1.** Source wise expected biogas generation in Bangladesh

The total biogas produced in a year is calculated by multiplication of the biogas production per year and the number of livestock /poultry. Using these ratios, it is approximated that the amount of total biogas generation is 5204 million cubic meters in FY2014-15. Figure 1 show the source wise biogas generation in the different fiscal years of Bangladesh. It is observed that cow dung has the highest potential of generating biogas. Since the economy of the country depends on agriculture and most of the rural household owned cow not only for milk but also for earning their livelihood. As a result, most of the biogas plants in the country run on cow dung. Meantime, poultry based biogas plant has significant impact on total biogas generation since poultry sector supplies the most of the countries protein demand. The functionality of poultry based biogas plant is feasible due to its high efficiency as well as for convenient waste collection system.



**Fig. 2.** Total expected biogas generation in different years of Bangladesh



**Fig. 3.** Electricity potential through biogas in different years of Bangladesh

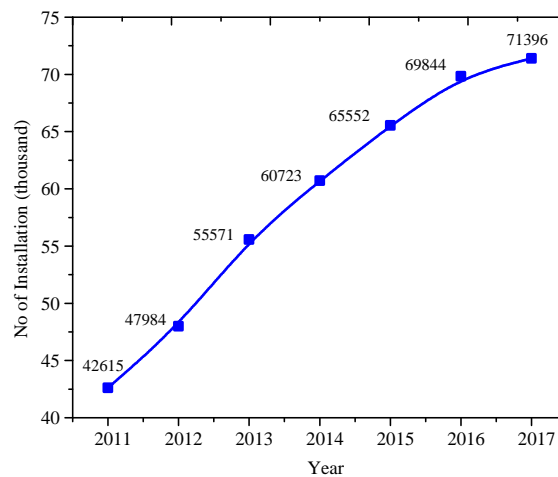
Figure 2 and Figure 3 shows the total amount of biogas generation and corresponding electricity potential of Bangladesh in different fiscal years. The generation of biogas depends on various factors such temperature, pH value, quality of waste. In the year 2015, Bangladesh has the total potential to generate 5200 Mm<sup>3</sup> of biogas. If the available resources could be recovered, it is possible to generate 7.30 GWh of electricity to electrify rural population.

### 2.3 GoB Policy:

The GoB introduces National Domestic Biogas and Manure Program (NDBMP) under a state-owned financial support institute, IDCOL with the goal to establish a sustainable and commercial biogas sector in Bangladesh. This institution gets all kind of financial assistance from the World Bank to support all kinds of infrastructure development, with focus on energy related infrastructure. IDCOL has been executing NDBMP program in Bangladesh since 2006 with funding from SNV Netherlands and KfW. Till April 2017, IDCOL has financed construction of over 46,200 biogas plants all over the country through its 45 partner organizations. They planned to install 60,000 biogas plants in Bangladesh by 2018 [18]. Grameen Shakti one of the partner organizations of IDCOL has established over 31943 biogas plants up to 2015. Bangladesh Government has taken the future plan to produce 7 MW electricity from biogas by the year 2021 [19].

### 2.4 Practices of Biogas Technology in Bangladesh:

Biogas mainly from animal and MSW may be one of the promising renewable energy resources in Bangladesh. The first biogas plant (floating dome type) in Bangladesh was installed in 1972. To adopt this technology among the beneficiaries, various government and non-government organizations constructed numerous bio-digesters in different location since 1974.



**Fig. 4** Year wise cumulative installation of biogas plants in Bangladesh

Since the energy production from biogas technology is higher compared to other biomass conversion technologies, common people show less interest to this technology. So, there is a need for subsidy or promotional policy to promote this technology in rural areas. Figure 4 illustrates the cumulative installation biogas plant throughout the country. The promotional activities along with soft loan provided by IDCOL attract the consumer to install biogas plant. Around 71,396 numbers of biogas plants are currently running in Bangladesh.

### **3. Socio Economic Benefit:**

Besides some direct benefits such as cooking gas and organic fertilizer obtained from biogas plant, it has lots of physical, social, economic and environmental impacts on society. Biomass burning causes indoor air pollution that is very much responsible for acute respiratory infections on human health which results in death of young children in developing countries. Women's are the worst victims of smokes in the kitchen. Biogas provides a cleaner way to use biomass fuel and helps in reducing air pollution. The scarcity of energy and load shedding in rural area causes for the low literacy rate in developing countries since children or younger people involved in education do not get enough light in evening and night. Also, biogas technology installation saved time that could be used for children to provide quality education as well as high literacy rate. Since biogas is an emerging technologies and it plays a vital role in the energy sector, there is a huge opportunity for employment generation by the adaptation of biogas plant in households. Forest wood is the major source of domestic cooking and heating fuel which consequently reduces the forest area and imbalances the local ecology. Dissemination of biogas plant will save forest resources and reduce biomass consumptions. The fertility of the soil has been declining gradually by prolonged use of chemical fertilizers. A biogas plant yields bio-slurry having high content of nitrogen, potassium and phosphorus that will help to produce organic matters in the soil and improves its fertility. The time needed for fuel wood collection and cooking will be reduced by using biogas plant. Women can utilize the saved time for income generating activities like handcrafts, small business, livestock rearing, or provides quality education to their children's. Global warming and mitigation of CO<sub>2</sub> are major concerns in the current world. The practices of renewable energy could be a key for maintaining an ecological environment. Using of biogas instead of direct burning of biomass will reduce CO<sub>2</sub> emissions as well as global warming.

### **4. Challenges and barriers:**

Though Bangladesh practices biogas technology since 1972, it failed to gain much popularity due to some barriers which in turn hindered its widespread use. High plant cost, monsoon flooding, heavy rainfall during rainy season, and declining number of cattle per household are considered as the limiting factors for the development of biogas based power generation in Bangladesh. Since the conversion cost of biogas is high compared to the low price of electricity and natural gas, general users show less interest. Lack of proper fund and high rate of interest on loan are the main financial barriers to promote biogas technology in Bangladesh. Besides, the high custom duties, taxes on technical equipment, and absent of attractive tariff for biogas discourage the local investors. Also, there is no grid connectivity with biogas plant. There are no such training facilities to develop skilled manpower and expert in this sector and lack of awareness and motivational activity about the use of biogas are the institutional barriers. Due to the absence of quality assurance and standard for biogas plants along with the poor technical knowledge of user, biogas technology loses its popularity. There are a few institutions who are working at present (IFRD, BCSIR) and GoB should increase research and development activities in biogas sector. Absence of biogas based energy policy at national level and action plan for biogas related project; it lags behind compared to other RE technologies. Though biogas sector faces severe problems in recent time, production of electricity by using biogas is still to be flourished in Bangladesh.

### **5. Conclusion:**

Bangladesh is an agricultural country and more than 70 % of its total population depends directly or indirectly on agriculture. Energy generation from these available agricultural wastes through biogas production can be a strong alternative option to mitigate rural energy demand. Besides, it will reduce higher level of deforestation, greenhouse gas emissions and dependence on fossil fuels. Biogas is a clean, efficient, and sustainable source of energy to protect the environment from various adverse effects. Bangladesh has the potential to generate 5204 Mm<sup>3</sup> of biogas in the year 2015 which could enhance around 7.30 GWh electricity to the national grid. But there are some limiting factors such as high plant cost, monsoon flooding, and heavy rainfall during rainy season, and declining number of cattle per household retards the development of biogas based power generation in Bangladesh. Research and dissemination of biogas throughout the country should be given priority in solving present energy crisis. An organized effort of the corresponding authorities and stakeholders and effective management of biogas policy will improve the adaptation approach to mitigate the challenges of energy crisis in Bangladesh.

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