Waste to Energy: A New Dimension in Generating Electricity in Bangladesh

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***Abstract*—The conventional fuels required for production of electricity is decreasing day by day and it is very important to find out alternative sources which can be used as the fuel for the production of electricity especially for developing countries like Bangladesh. With a population of 160 million Bangladesh produce enough amount of waste per day to ponder about this topic. So, we felt that it is worth working on this field and it is high time to inject the concept of Waste to Energy in Bangladesh. First, a base line survey was conducted for independent research to accumulate the data of total waste generation in Bangladesh. During this Endeavour it was found some local poultry farms are using poultry waste to generate electricity. These case studies encouraged to carry forward the Endeavour and to generate electricity from Municipal Solid Waste (MSW), cafeteria waste, and different composition of different wastes at the university campus to make the technology locally appropriate. A model for community based small and medium waste to energy power plant is being developed for proper waste management and possible solution of energy crisis in Bangladesh.**

***Index Terms*—Waste to energy, waste management, community business, economic analysis.**

I. Introduction

The natural resources in the form of fossil fuels are the raw materials from which electrical energy is generated and the day to day life of the people of today's world is solely dependent on the electrical energy [1]. Researchers in this field say that the reserved gas will be finished soon, and usage of gas is increasing day by day. In developing countries, especially in Bangladesh, there is not enough generation of electrical energy to keep up with the demand, and there is a scarcity of raw materials for producing the energy. Alternative sources are now explored to prepare for the future dearth of traditional energy sources. The waste materials can be a good source of energy as the amount of waste is increasing every day, and can help in meeting the electrical energy not only in Bangladesh but also in the world. Many countries are now switching to renewable energy sources, as they are clean and a suitable substitute for fossil fuels [2]. Some part of the world have already established a few waste to energy power plants but this is not enough and there is a huge scope of increasing the overall performance of the systems [3].

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II. Waste Resources In Bangladesh

For a developing country like Bangladesh, converting the waste materials into energy is economically advantageous. Let us first have a look at the waste generation and disposal of waste in Dhaka City as listed in Table I and the composition of that waste is listed in Table II [9].

Recycling industry wastes raises a total of 436 t/d [10] of material recovery as shown in the Table III. The amount recovered is the amount of waste to be managed by Dhaka City Corporation (DCC). Composting contributes very little to the waste reduction although the compostable waste has the largest portion among generated wastes.

The target level of waste disposal is set up on Table IV as shown below. As a result, 3,054 t/d is expected to be collected in 2015. The cumulative disposal volume is estimated at about 9 million tonnes by the end of 2015 [9].

The Study Team conducted waste generation source surveys in dry and wet seasons to obtain the unit waste generation rate of domestic waste and business waste. The results of the surveys are shown in Table V. The average waste generation rate from domestic sources proved to be 0.34 kg/c/day [9].

TABLE I: List of Generation and Disposal in Dhaka City

Item	Parameter
Estimated Generation	Domestic waste: 1,950 t/d Business waste: 1,050 t/d Street waste: 200 t/d
Generation Rate	Domestic waste: 0.34 kg/d/person (Domestic+Business+Street) waste: 0.56 kg/d/person
Calorific Value	All waste average: 550 to 850 kcal/kg
Bulk Density	All waste average: 0.24 t/m3
Share of disposal volume by dump site	Matuail: 65 % Berri Band: 30 % Uttara: 5 %
Total disposal volume at three dump sites	Wet season average: 1,400 t/d

TABLE II: Composition of solid waste in Dhaka City

Materials	Quantity (%)	
	Residential	Commercial
Food Waste (Organic)	84.37	79.49
Paper / Cardboard	5.68	7.22
Textiles	1.83	1.59
Plastics	1.74	1.48
Glass / Metals and construction debris	6.38	10.22

TABLE III: ESTIMATED VOLUME OF RECYCLED WASTES IN DHAKA CITY

Material	a)Estimated generatio-n of recyclable waste (t/d)	b)Estimated recycled waste (t/d)	c)Recycle rate	d) Contribution to waste reduction (b/3200)
Plastic	124	103	83%	3.2%
Paper	260	168	65%	5.3%
Glass	46	24	52%	0.8%
Metal	27	41	-	1.3%
Comp-ostable	2211	6	0%	0.2%
Others	99	94	95%	2.9%
Total	2767	436	-	13.6%

TABLE IV: TARGETS OF WASTE DISPOSAL

	Present 2004 (t/d)	Target for 2015 (t/d)	Year 2015/2004
Collection / Transport	1400	3054*	218% (almost twice)
Final disposal	1385	3032*	219% (almost twice)
Recycling	435	672	154%
Unidentified disposal	1380	920	One-third reduction

As of 2004, the total solid waste amount from domestic sources is estimated at 1,945 t/d generated by the population of 5.728 million with an average generation rate of 0.34 kg/person/d. As of 2004, the total solid waste amount from business sources is estimated at 1,035 t/d based on the survey conducted in this study[9]. The waste generated by non-resident people coming to Dhaka is considered as being contained in these categories of waste and street waste stated hereunder. In Dhaka City, DCC is cleaning the street by deploying approximately 5,000 cleaners. During the survey of unit waste generation of street waste, it was estimated that on average, one sweeper sweeps 110 m of road length. Average volume of street waste is assumed at 365 kg/km of road length as shown in Table 5. Hence, the road length, which is swept by 5,000 cleaners in a day, is estimated to be 550 km and the amount of waste is estimated at 200 t/d (0.365 t/km x 550 km = 201 t/d). As the total of above mentioned two wastes, namely domestic waste and business waste, approximately 2,980 ton of waste on average is generated in a day. By rounding up the figure to 3,000 t/d from fixed sources, the total generation amount in Dhaka City is estimated at 3,200 t/d with the amount from fixed sources is shared by domestic source and business source at 65% and 35%, respectively, as follows.

- Domestic waste: 1,950 t/d
- Business waste: 1,050 t/d
- Street waste: 200 t/d

III. CASE STUDY: FORTUNA GROUP, BANGLADESH

Fortuna is a privately held entrepreneurial and innovative company located in Dhaka, Bangladesh. One of the main businesses of this group is Agro Products. This company has a 40,000-sqft facility located in Fortuna Park, Kunia Gazipur. This facility has established a 24 KW waste to electricity power plant with technical from GTZ Bangladesh. A summary of the plant is given in Table. V.

TABLE V: SUMMARY OF FORTUNA BIO GAS PLANT

Capacity	24 KW
Dimension	26 m^3
Generator	Converted Gas Generator
Feed Type	Cow dung
Feed Volume	3000 KG/day
Construction Cost	BDT. 1,300,000
Operation Hour	2 h/day
Executing Agency	GTZ

The digester and the generator portions are showed in the following Fig. 1- 6. Everyday 40 celling fans and 70 light bulbs are operated for two hours.

Fig. 1. Feed well of the digester

Fig. 2. Gas dome

Fig. 3. Slurry bed

Fig. 4. Inside View of feed well digester

Fig. 5. Generator

Fig. 6. Prepared fertilizer from slurry

IV. Waste to Energy: A Social Business Model

According to the official statistics, the country's electricity shortage has gone up drastically. Authority said that last year (2009) electricity shortage was about 1400 MW to 1800 MW. As a result the common phenomenon is load shedding. In this proposal we have come up with a solution to generate and provide with the electricity in the load shedding hours to run the basic appliance e.g. light in an environment friendly and cost effective way.

- To help Dhaka city to properly dispose of municipal waste or domestic garbage;
- To generate electricity to provide to the consumers at the load shedding periods using municipal waste through anaerobic process;
- To find an environment friendly alternative way to generate electricity;
- To provide electricity to the limited income earners at a lower rate;
- To provide electricity to commercial shops after 8:00 P.M. in Dhaka city
- To popularize the waste to electricity theme so that more similar projects come up at large scale
- To sell the by product (composite fertilizer) commercially as an ecofriendly substitute to the chemical fertilizers.

V. The Potentials of the Industry

The target market for this project is the energy saving lights of the households as well as small shops in the underdeveloped area of the Dhaka city. A few examples may be Puran Dhaka, Badda etc. Currently there are a few electricity providers in many areas who own a large generator and supply electricity at the load shedding hours at the cost of Tk. 5-10 per bulb per day. We would like to cater to that particular market with an environment friendly and cost effectively generated electricity. We assume that the market will be a broad and sustainable one since we are providing with the service at a very low cost which most of the people will be able to bear.

VI. Financial Analysis

A. Setup Cost

For a 24 kW plant, P = BDT. 1300000 (From Case Study of Fortuna)
Plant life cycle is assumed to be, n = 20 years
Investment Rate of Return or IRR, i= 14% (Current Bank IRR is 12% in Bangladesh)
So, Annual cost will be,

$$A = p\left[\frac{i(1+i)^n}{(1+i)^n - 1}\right]$$

= 1,300,000 * .16
= BDT. 208,000

B. Operational Cost

Operational costs including salaries, maintenance and miscellaneous will be, BDT. 15,000
So yearly operational cost, OC = (15,000*12) = BDT. 180,000

C. Revenue

From Electricity:
Rated Capacity 24kW
Hours of operation per day, 2 Hrs
Energy generated in a day (24kW*2h) = 48kWh
Energy generated in a year (48kWh*365) = 17520 kWh
Rate of quick rental power in Bangladesh is BDT. 14 to BDT. 17 per kWh [13]

So, total revenue generated from electricity per year is, (17520*15) = BDT. 262800

From Compost Fertilizer:
Slurry generated per month, 10,000 kg
Slurry generated in a year, (10,000*12) = 120,000 kg
Rate of compost fertilizer per 40 kg is, BDT 60
Total revenue generated from Fertilizer per year is, (3000*60) = BDT. 180,000
Total Revenue earned a year is, (262800+180000) = BDT. 442,800

D. Cost Benefit Analysis (B/C Ratio)

The modified B/C ratio is calculated as follows [14]:

$$B/C = \frac{benefits - disbenefits - M\ \&\ O\,costs}{investment}$$

Here,
Benefits is total revenue earned, B = BDT. 442,800
M&O costs = BDT. 180,000
Annual equivalent of initial investment, A = BDT. 208,000
Disbenefits assumed to be zero

So, $$B/C = \frac{442800 - 180000}{208000}$$
$$= 1.26 > 1$$

Clearly B/C ratio is greater than 1. So the investment is justified.

VII. Conclusion

Bangladesh generates large quantities of solid waste, which can be used to our advantage to generate much needed electricity. The bulk of the solid waste is organic in nature. This is the part of the waste that undergoes the least amount of recycling, under the present municipal system. Recycling in Bangladesh may be seen to be expensive or cumbersome, but if the organic waste could be used to generate electricity, the process would become cost effective and popular.

The organic waste in Bangladesh would lend itself to the anaerobic production of methane. This is a very valuable fuel for electricity generation, while coming from an inexpensive source. If this resource is combined with the above mentioned social business model Bangladesh will be able to find a sustainable source of inexpensive renewable energy.

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