Electricity Genaration through Bio-waste and Solar: An Alternate Way to Mitigate the Electricity Demand for Individual Owner House in Remote Areas of Bangladesh

Sagor Biswas, M S A A F Shiblee, Shah Mohazzem Hossain, Md Rosaidul Mawla

Abstract— Electricity is the main reason behind the evaluation of human civilization. Modern social systems are goodly dependent on electricity. But for the population growth, electricity generation cost, and limited resource are the cause of 'power crisis', commonly known term in recent days. In view of Bangladesh, to meet this electricity demand of this vast population is not possible only for the government. As the electricity is generated through in it's conventional rule andits maintenance, transmission, distribution is costly, most of the rural areas are deprived of electricity. In this countrified areas own initiative power generation can be the possible way to meet their daily electricity demand. Consideration of use of electricity, environmental hazard and limited resources, renewable energy is the best alternative for the generation of electricity. In case of Bangladesh, for the geographical reason, the possibility of solar energy is very much suitable. Recent days, it seen that there is a dairy farm or poultry farm in every family for their economical support. Everyday this farm produces a huge number of waste. Moreover, there is an agricultural waste, food waste etc which can be a medium to produce the electricity. This bio-waste electricity generation is most effective and more conveniently use without any barrier. In this paper, introduce a combination of solar and bio-waste plant and its prospect, obstacle, advantage and disadvantage, which will able to fulfill the electricity demand of a individual house owner.

Index Terms— Bio-waste, Bio-gas plant, Poultry Waste, Agricultural waste, Solar energy, Slurry.

1 Introduction

According to human development report under UNDP (United Nations Development Programme) 2016 Bangladesh is 139th position (medium human development) in 188th country [1]. Bangladesh is experienced around 161 millions of people (29 million of household) which 15 millions of people are lived in rural areas [2]. Now total install power generation capacity is 16,402 MW and the number of consumer is 2 core 99 lac [3]. Govt. has tried to gain 100% efficiency in power capacity around 2021 year by target a predict generation capacity about 24000 MW [4]. But only government initiative is not possible to meet this huge amount of demand. There needs some public and private investment to meet this huge amount of electricity demand near future [5]. Basically, in Bangladesh natural gas is used to generate power and there are some coal mining plants in bangladesh are used as a second option for power generation.

Chart. 1. shown the percentage of different types of fuels is used to generate the electricity in perspective of bangladesh [6].

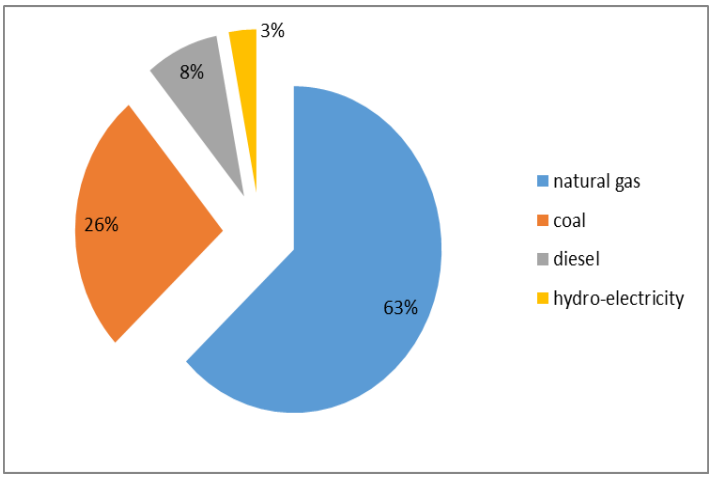

Chart. 1. Percentage of fuels to generated electricity.

This non-renewable resources are limited in amount. Because, this fossil fuel likes, coal, natural gas, oil have been used for many years. With time changes, this type of resources are alleviated. An alternative solution is needed to deal with the problems. Renewable resources are the best possible solution to mitigate this problem. Bangladesh has the possibility to generate electricity by using renewable resource like solar, biomass, wind and hydro-electricity. But, among all this

- ***Sagor Biswas*** *is currently pursuing BSc in Electrical, Electronic & Communication Engineering (EECE) Degree from Military Institute of Science & Technology (MIST), Dhaka, Bangladesh.*
  E-mail: sagork.neel@gmail.com
- ***M S A A F Shiblee*** *is working as a faculty member at EECE Dept in Military Institute of Science & Technology (MIST), Dhaka, Bangladesh.*
  E-mail: shib-lee_735@yahoo.com
- ***Shah Mohazzem Hossain*** *is working as a faculty member at EECE Dept in Military Institute of Science & Technology (MIST), Dhaka, Bangladesh.*
  E-mail: soneteee@gmail.com
- ***Md Rosaidul Mawla*** *is working as a faculty member at EECE Dept in Military Institute of Science & Technology (MIST), Dhaka, Bangladesh.*
  E-mail: mawla71@yahoo.com

opportunities solar and biomass has most promising and effective in Bangladesh [7].

1.1 Bio-waste And Solar Potentiality in Bangladesh

Approximately per year 3,85,000 exajoules (EJ) solar radiated on earth atmosphere, oceans and land masses. The heat asphyxia or insolation varies from 3.8kwh/m2/day to 6.4kwh/m2/day at an average value 5kwh/m2/day in Bangladesh [2]. Because of geographical location, it considered as an ideal place for utilization of solar energy. Annually over 1900kwh/m2 solar radiation is available here. Theoretically, approximate 69,751Twh/year solar energy is received in Bangladesh which is 300 times higher the electricity generated in the year of 2006. Chart-2 shows the annual monthly solar irradiation in six divisional districts in Bangladesh [7].

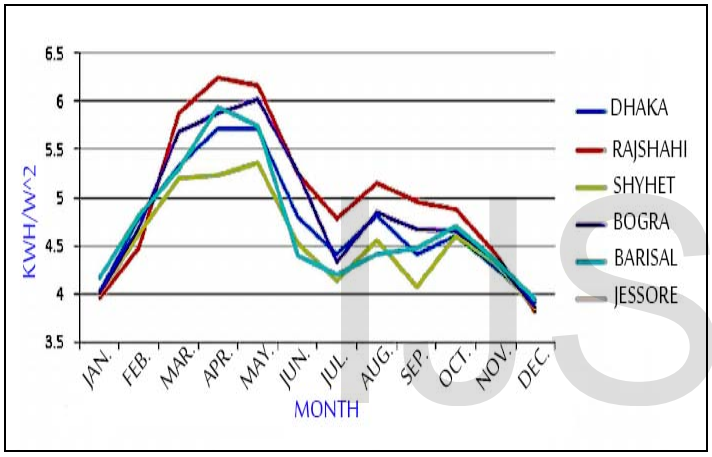

Chart.2. Monthly average solar irradiance in Bangladesh.

Presently, in Bangladesh about 50,000 poultry farms are available. A commercial layer can produce about 20kg waste per year. It is considered that, every year in bangladesh 15600 metric ton poultry manure is produced [8].

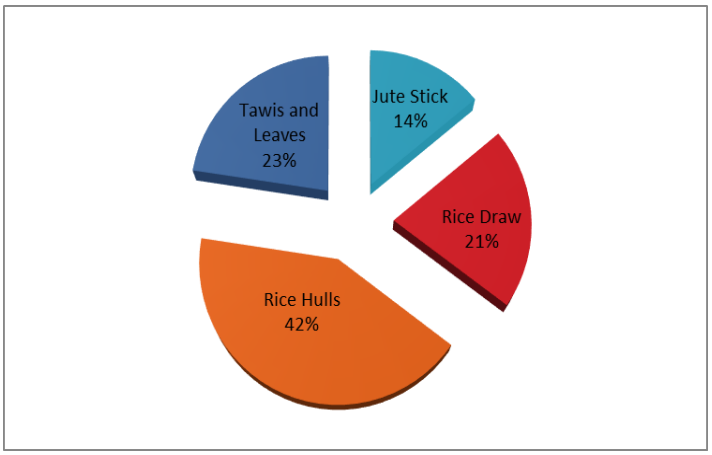

Chart. 3. Percentage of different traditional energy.

As Bangladesh is an agricultural country, there is an availability in bio-mass sector. Agricultural waste like dried leaf, coconut shells, animal dung, jute stick, oilseeds, residues from wheat, potato etc. [2]. Aforementioned chart-3 depicted the percentage of different traditional energy. Generation of biogas is a chemical process where the organic matter is decomposed [9]. Table-1 shows the key gasious elements of the biogas plant.

TABLE 1
VARIOUS ELEMENTS OF BIO-GAS [10]

Name of the Gas	Percentages
Methane (CH4)	65-70%
Carbon-di-oxide (CO_2)	25-30%
Nitrogen, N_2	1-5%
Hydrogen, H2	0-3%
Hydrogen Sulfide, H_2S	0.1-0.5%
Carbon Monoxide, CO	0-0.3%

A mixture of equals amounts of biogas and water called slurry is prepared in mixing tank. This prepared slurry is passed through inlet pipe and store in digester. Gas outlet connected to the gas holder contains the flowed gases. The digester outlet preserves the fallow of the digester which can be use as a fertilizer in agricultural field [11].

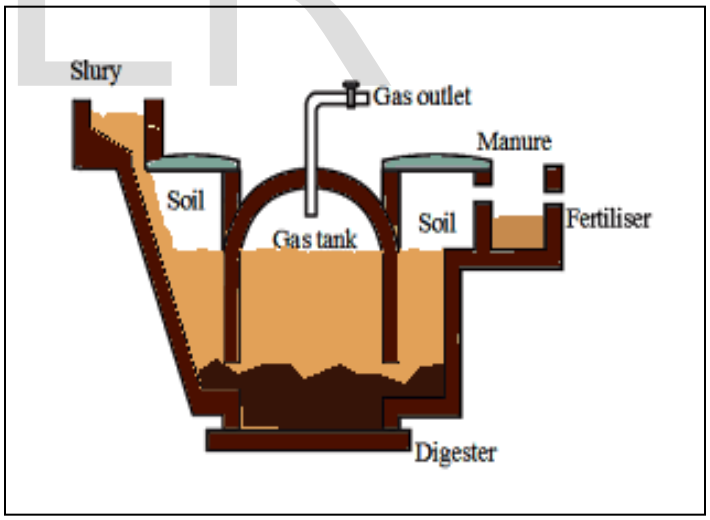

Fig. 1. Basic internal construction of a Bio-gas plant.

Aforementioned fig. 1. shown basic view of a bio-gas plant. Animal dung (cow dung) similar feedstock like, poultry waste, human excrete, leafy plant, agricultural waste, kitchen waste is re retained in the bio-gas plant for a period of time called HRT or Hydraulic Retention Time of the plant. This organic matters are digested with the absence of oxygen called anaerobically and produce a combusted mixture of gases e.g. 25 kg of cow dung digested an anaerobically 40 days' generation 1m3 of biogas with a 5125 kcal/m3 caloric value [9]

2 SCHAMATIC DIAGRAM OF PROCESS

Described system is consisted of a solar system and a bio-plant. Solar panel produce DC electricity in the presence of the sun. With the help of a charge controller, output power is stored through a battery for future use and converted as a AC electricity using a DC to AC converter. On other hand in digester, bio-plant produce the bio-gas which is act as a fuel of the power generator and used to produce the AC electricity. This two different sources produced electrical energy are connected through a control circuit. This combined plant produces electricity is further used to meet the load demand. This basic concept of combination of bio-pant and solar energy is shown in fig. 2.

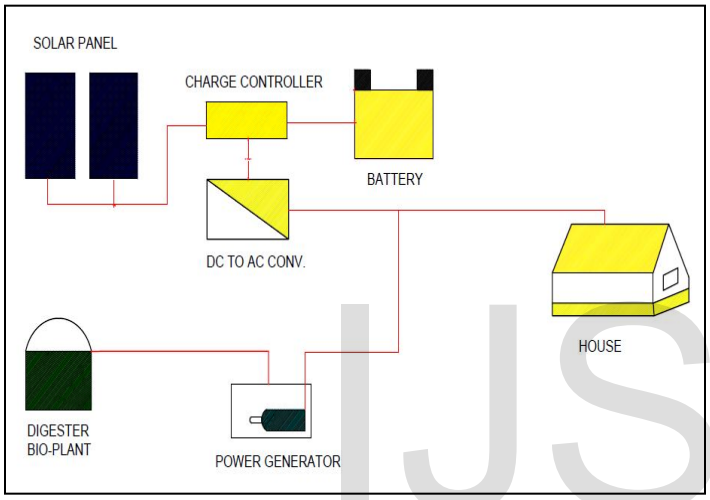

Fig. 2. Schematic diagram of the hybrid plant.

3 LOAD CALCULATION

3.1 Daily Load Demand

To understand the load demands we have to understand the behavior of load means, electrical appliance rating, its quantity and how many time it works. Table-2 shown the forecasted load demand in a single day consumed by the owner. This data is used to further load calculation.

TABLE 2
DAILY LOAD FORECASTING

Load name	Rating (W)	Quantity	Hours /day	Engery Consumed (Wh/day)
Ceiling Fan (48″)	70	2	6	840
Energy Bulb	20	5	6	600
Color TV (21″)	120	1	2	140
Mobile	5	-	0.3	1.5
Total	**365 W**			**1581.5**

3.2 Load Flow Analysis

Chart. 2. indicate how much percentage of power used by an individual load in a day of a total power. It helps to understand which appliance are very much need to control to save the electricity and also shown the amount of power it used.

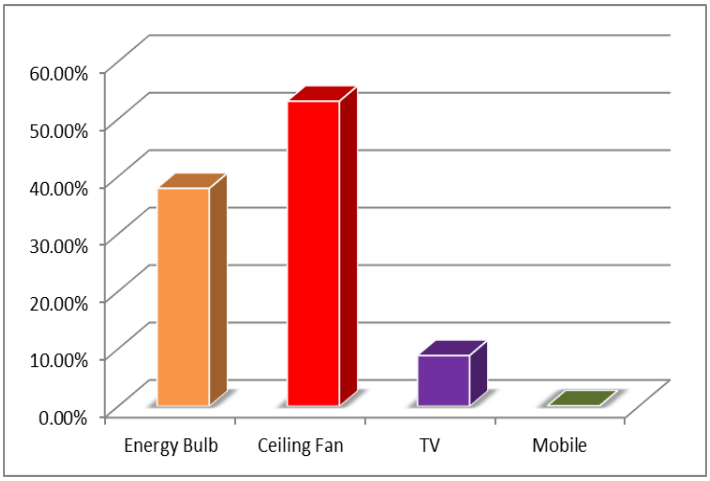

Chart. 2. Percentage of power consumed by individual load in a day.

4 SYSTEM DESIGN

4.1 Solar Based Design & Calculation

A. Size of PV panel:

The power required for solar system = 1581.5 * 1.3
= 2055.95 Wh/day

Total Wattpeak of PV panel capacity needed = 2055.95 / 4.32
= 475.91 Wp

Where,
Loss factor = 1.3
Panel generation factor = 4.32 [12]

No of PV panel needed = 475.91 / 250
= 1.90 modules or 2 modules

Consider,
Per solar panel = 250 Wp

B. Battery sizing:

Here,
Total consumed power in a day = 1581.5 Wh/day
Nominal battery voltage = 12 v
Days of autonomy = 1 days

Hence, Battery capacity (Ah) = (1581.5 Wh × 2)/ (0.87×0.6×12)

= 258.31 Ah

Where,
0.87 = loss factor
0.6 = depth of charge [12]
So, the battery should be rated 250 Ah and 12 V and 1 number of pieces.

4.2 Bio-waste Plant Design & Calculation

Dairy farm has 4 cows and 1 poultry farm consists of 100 layers' chicken. Average body weight of 220 Kg each a cow has minimum 10 kg of discharge [13].

A. Total Solid Consideration:

Let, System Temperature = 30°c
Hydraulic Retention Time (HRT) = 40 days [5].
Total discharge from livestock and others
= (10kg*4+3(avg.))
= 43 Kg/day

TS Value of fresh discharge = (43* 0.16) Kg/day
= 6.88 Kg/day
Where, TS = Total Solid.

8% concentration of TS considered,
Influent from 6.88 Kg solid = (100*6.88 / 8) = 86 Kg/day
So, Total amount of influent, Q = 86 Kg/day
So, the amount of water for the 8% concentration of TS
= (86 – 43) Kg/day
= 43 Kg/day

B. Produced Energy Estimation:

Maximum gas produce per kg of waste = 0.05 m3 [13]
Total produced gas by the system = 0.05 × Total bio-waste
= 0.05 * 43 kg/day
=2.15 m3
Now.
1m3 gas = 19 MJ (megajoules) energy
1 KWh =3.6 MJ
Energy production = (19 *2.15) / 3.6 KWh = 11.35 KWh

5 PLANT SETUP

Considering economic aspects, construction of a bio-plant is a cost-effective project than the solar plant. However, the installation cost of solar system is high but the life time of solar system is high, around 25 years which is higher than the bio-gas plant. Less maintenance is required in its whole life time for the digester [5]. Table-3 and Table-4 delineate the main apparatus needed to fulfill the bio-plant and solar plant and also shown the amount of equipment needed.

TABLE 3
BIO-PLANT REQUIRED EQUIPMENT [5]

Plant Item
Intraco Gas Generator, 560 Watt
Hydraulic and Gas Collecting Chamber (11 CFT)
Digester (210 CFT)
Purification Unit
Mixing tank or waste collector

TABLE 4
SOLAR SYSTEM REQUIRED EQUIPMENT

Amount	Item
2	Solar PV module, (monocrystalline,250 Wp)
1	12V 250Ah Lead Acid Deep Cycle Solar Battery
1	Solar inverter
1	Charge controller
-	Electrical wire

6 FURTHER FACTS

Heat, fuels and electrical power are the three form of bio-energy [14]. Bio-gas can be used as a cooking gas alternative of LPG. Food waste, kitchen waste, animal dung and the digested slurry can be used as organic manure as fertilizer in agricultural field. Urban waste and domestic waste which is decomposable can be used as a raw material of large bio-waste plant which can keep our environment self and clean. Impurities of waste materials can reduce the production. There are some refining process before going to digesting digester. Construction bio-gas plant is slightly costly but applying a scientific way it can be cost effective. Bio-gas is made with the absence of oxygen gases, hence in nature or air it become flammable with presence of oxygen [15]. As bio-gas is aerobically chemically reaction process, a fixed temperature maintains for proper output which nearly 35°-38°C. In winter session, which is difficult to maintain [6]. Floodwater into digester can reduce the generation capacity of bio-gas, so it constructs in such a way that is prevent the overflow of water [5]. Dust fallen above the solar panel can reduce the power producing capacity. For large scale power generation battery bank was used for storage of PV energy which installation cost is high [6].

7 CONCLUSION

In this age of technology essentiality of electricity can't be described. Without electricity the daily work is impossible. But for the various reason rural areas are deprive of electricity. To mitigate the daily electricity demand renewable energy based electricity production by individual initiative is the only possible solution for this crises. Govt. and private support is very much need for this kind of investment and to introduce this

type of project. Proper utilization of bio-gas plant can be the best way to reduce the disposal problems. Moreover, solar energy is the best suitable resources and the new door of possibility of electricity production in case of our country. Effective use of this describe system can easily handle almost the shortage of daily need of a private house. For the prospect of future green, save and clean energy it might be the promising path and the solution of electricity scarcity.

REFERENCES

[1] S. Jahan, "Human Development Report 2016, Human development composite indices," pp. 204.

[2] Md. R. Ahmed, S. R. Hazra, Md. M. Rahman and R. J. Bhuiyan, "Solar-biomass Hybrid System; Proposal for Rural Electrification in Bangladesh," Electrical and Electronics Engineering: An International Journal (ELELIJ) Vol 4, No 1, February 2015.

[3] Present Installed Power Generation Capacity Retrieved from Online, "http://www.bpdb.gov.bd/bpdb_new/index.php/site/page/13e9-2cc0-ce41-9c09-088d-94d5-f546-04a6-b4fa-1d18," on data 31 July, 2018.

[4] Prediction of Generation Capacity is Retrieved from Online, "http://www.bangladesh.gov.bd/," on data of 01 Aug 2018.

[5] S. M. Hossain, M. N. Uddin, "'Single-Owner' Plant as an Alternate Solution for Electricity in Rural Areas,", International Journal of Engineering and Technology (IJET), Vol 9, No 5, Oct-Nov 2017, pp. 3922-3930.

[6] J. D'Rozario, S. Shams, S. Rahman, A. Sharif, E. Basher, "Cost Effective Solar-Biogas Hybrid Power Generation System," 978-1-4799-7800-7/15/, 2015 IEEE, pp. 2756-2760.

[7] Md. T. Islam, S.A. Shahir, T.M. Iftakhar Uddin, A.Z.A Saifullah, "Current Energy Scenario and Future Prospect of Renewable Energy in Bangladesh", Elsevier, Jul. 2014, pp. 1074–1088.

[8] B.C. Sarker, M. A. Alam, M. M. rahman, F. M. Tariqul islam and M.G.F. Chowdhury, "Waste Management of Commercial Poultry Farms in Bangladesh" Journal of Innovation and Development Strategy, Vol 3, Issue 1, Jan. 2009, pp. 34-37.

[9] M.A.O. Mydin, N.F. Nik abllah, N. Ghazali, "Development of Environmental Friendly Mini Biogas to Generate Electricity by means of Food Waste," Journal of Materials and Environmental Science, Vol 5, Issue 4, Mar 2014, pp. 1218-1223.

[10] A. Joshi, J. Jose, N. Bansiwal, N. Soni, "Study on Electricity Generation through Biogas on Small Scale," International Journal of Innovative Research in Science, Engineering and Technology Vol. 6, Issue 4, April 2017, pp. 6662-6669.

[11] Y. Tiwari, P. Priyadarshni, Dr. S. Kr Chaudhary" A Study of Solar and Biogas Hybrid Power Generation System with Max Power Tracking by Solar Panel," International journal of Electrical and Electronics Engineers, vol. no. 07, issue 02, july-december 2015, pp. 257-266.

[12] Solar Based calculation is Retrieved from online, "http://www.firstgreen.co/2014/08/solar-pv-system-sizing-step-by-step-approach-to-design-a-roof-top-system-and-software-analysis/," on data of 01 Aug 2018.

[13] S. M. Hossain, M. M. Hasan, "Energy Management through Bio-gas Based Electricity Generation System during Load Shedding in Rural Areas," TELKOMNIKA, Vol.16, No.2, April 2018, pp. 525-532.

[14] G.R.K.D. Satya Prasad, Dr. K. V. Kumar Reddy, Dr. Ch. Saibabu, "Hybrid Solar & Kitchen waste based Plant for Green Buildings: An Approach to meet the standards of Zero Energy Buildings," International Research Journal of Engineering and Technology (IRJET), Volume: 02, Issue: 08, Nov-2015, pp. 1335- 1338.

[15] S. Bhardwaj, P. das, "A Review: Advantages and Disadvantages of Biogas," International ResearchJournal of Engineering and Technology (IRJET), Volume: 04, Issue: 10, Oct -2017, pp. 890-893.