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HOMER Based Feasibility Study of Off-Grid Biogas Power Generation Model Using Poultry Litter for Rural Bangladesh

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ABSTRACT: *Lack of access to electricity is one of the major impediments to the economic growth and development for any developing country. As well as limited reserve of conventional fuel and geo-location of Bangladesh arise the demand to find an effective alternative energy source for rural electrification. This document approaches a poultry-home based power generation model for rural Bangladesh and diagnosis its feasibility through HOMER, a micro power modelling and optimization software. The introduction on renewable energy and its importance is followed by present energy state in Bangladesh and prospect of biogas electrification technology, specially focused on poultry litter base system. Theoretical foundations on formation of biogas and electricity generation process are also presented. Main objective of the study is to diminish energy scarcity and connect rural people with the country's development through electrification*

Keywords - *Biogas , Electricity generation, Poultry litter, Feasibility,HOMER analysis.*

I. INTRODUCTION

Renewable energy comes from natural resources such as sunlight, wind, rain, tides, and geothermal heat, which are renewable (naturally replenished) [1].Mainstream forms of renewable energy: Wind power, Hydro power, Solar energy, Biomass, Biogas, Geothermal energy. Electric energy security is essential, yet the high cost and limited sources of fossil fuels, in addition to the need to reduce greenhouse gasses emission, have made renewable resources attractive in world energy-based economies [2].

Biogas technology, the generation of a combustible gas from anaerobic digestion, is a well-known technology [3]. But producing electricity from biogas is still relatively rare in most developing countries.

To meet the ever-increasing demand of energy, renewable energy can open up new possibilities in developing countries [4]-[5]. Renewable energy resource biogas can be used for off-grid electricity generation as well as it can be added with grid electricity. Due to the abundance of raw materials it is effective for rural electrification in Bangladesh. First part of the paper discusses about biogas related attributes. Afterwards biogas prospect for Bangladesh specially potential of poultry based biogas and bio-electrification technology are perused. This paper aims to propose an off-grid power plant for only home and farm uses in rural Bangladesh using poultry litter as biogas resource. Furthermore HOMER simulated results are disclosed to study economic feasibility of the proposed model.

II. BIOGAS

Biogas is a flammable gas that accrues from the fermentation of biomass in biogas plants. Biogas can be produced utilizing anaerobic digesters. These plants can be fed with energy crops such as maize silage or biodegradable wastes including sewage sludge and food waste [6].

2.1 Biogas Composition

Table -1: Biogas Composition [7]

Typical Composition of Biogas		
Compound	Chemical Properties	%
Methane	CH_4	50-75
Carbon dioxide	CO_2	25-50
Nitrogen	N_2	0-10
Hydrogen	H_2	0-1
Hydrogen sulphide	H_2S	0-3
Oxygen	O_2	0-0

2.2 Biological and Chemical Stages

The overall process can be described by the chemical reaction, where organic material such as glucose is biochemically digested into carbon dioxide (CO_2) and methane (CH_4) by the anaerobic microorganisms [8].

$C_6H_{12}O_6 \rightarrow 3CO_2 + 3CH_4$

There are four key biological and chemical stages of anaerobic digestion [9]:

- ❖ Hydrolysis
- ❖ Acidogenesis
- ❖ Acetogenesis
- ❖ Methanogenesis

Depending on temperature, there are two key processes [9]:

- ❖ Mesophilic digestion (between 20°C and 40°C).
- ❖ Thermophilic digestion(above 40°C)

Types of biogas plants [10]

- ❖ Floating cover digester
- ❖ Fixed cover digester
- ❖ The Balloon or Plastic Cover digester:
- ❖ Fiber glass biogas plant

III. PRESENT ENERGY STATE OF BANGLADESH

Natural Gas is used as main fuel for electricity generation in Bangladesh. Alarming issue is that, the country's gas reserves stand at 14.16 trillion cubic feet (tcf) as of June 2015 and 12.96 bcf (billion cubic feet) gases was extracted until May, 2015. If the current rate of extraction remains unchanged, the reserve would last until 2031[11].

Table -2: Installed capacity of BPDB power plants on December 2015[12]

Fuel Type	Capacity(Unit)	Total (%)
Coal	250.00 MW	2.14 %
Gas	7434.00 MW	62.59 %
HFO	2507.00 MW	21.11 %
HSD	956.00 MW	8.05 %
Hydro	230.00 MW	1.94 %
Imported	500.00 MW	4.21 %
Total	11877.00 MW	100 %

On the top of that, country provides electricity to only 74% of its population and maximum people in rural areas are living without electricity. Under this circumstance biogas based technology could be found effective for country's development [13].

Table -3: Bangladesh's power sector at a glance (June 2015) [14]

Generation Capacity	: 11,534 MW* (June, 2015)
Highest Generation	: 8,177 MW (13 August, 2015)
Total Consumers	: 17.5 Million (June, 2015)
Transmission Line	: 9,695 ckt. km
Distribution Line	: 3,26,000 km
Distribution Loss	: 11.36%
Per Capita Generation	: 371 KWh
Access to Electricity	: 74%

IV. Biogas Prospect In Bangladesh

Biogas mainly from animal and MSW (municipal solid waste) may be one of the promising renewable energy resources for Bangladesh. MSW contains an easily biodegradable organic fraction (OF) of up to 40%. It is a potential source to harness basic biogas technology for cooking, rural and urban electrification to provide electricity during periods of power shortfalls[15]-[17].

Table-4: Estimation of total biogas potential in Bangladesh [18]

Cattle Dung • Total cattle population of Bangladesh = 23 million • Dung available = 230 million Kg/day • Gas that may be obtained = 3106 million m3(Mm^3)/year • (1 kg of dung yields = 0.037 m^3 gas, each cow yields = 10 Kg dung/day)
Poultry Litter • Total poultry population (Chickens+ Ducks) of Bangladesh, (234+44) =278million • Total poultry litter that may be obtained = 27.8 million Kg/day • Gas that may be obtained = 750 Mm^3/year • (1 kg litter yields = 0.074 m^3 gas, each bird yields = 0.1 Kg litter/day)
Human Excreta • Total human population of Bangladesh = 140 million • Excreta available = 56 million Kg/day • Gas that may be obtained = 1512 Mm^3/year • (1 kg excreta yields = 0.074 m^3 gas, Excreta per person = 0.4 Kg per day)
Therefore total biogas potential in the country = 53Mm^3/year.

Effectively using this waste, per day approximately 20.5 MWh (mega watt hour) electricity could be generated, which may play a significant role in country's energy situation.

4.1 Prospect of Poultry Based Biogas

Poultry is an emerging and important sector that has been contributing progressively to our economy for the past decade [19]-[22]. It is one of the fastest growing and most promising industries with the brightest of futures for our country.

Along with this, the calorific value of poultry waste is higher than that of cow manure [23]. From "Poultry Business Directory 2015" we find the statistics about poultry farms and number of different types of poultry birds.

Table 5. Number of poultry farms in Bangladesh
(Poultry Business Directory 2015) [24]

No of poultry farms	
Grandparent farms	5
Parent stock farms	32
Commercial farms	50,000
Total (approx.)	50,037

Table 6. Number of Different Types of Poultry Birds& their wastes [24]

Total number of poultry birds	
Bird Type	Year 2014
Broiler	8094784
PS Layer	391580
PS Commercial Broiler	502852360
Commercial Layer	20157000
Cock real	20157000
Total (approx.)	550 million
Waste (approx.) -55million kg/day	

Per kg poultry waste may produce 22.5 cft gases as well as if the total poultry waste is used effectively, it may produce approximately 5500 Mwatt electricity which can be used to brighten rural life of Bangladesh with the light of progress.

Bangladesh has now around 75,000 biogas projects built under the Infrastructure Development Company Limited (IDCOL), the Bangladesh Centre for Science and Industrial Research (BCSIR) and the Department of Youth Development (DYD) [25].

V. PROPOSED MODEL

Proposed model is an off-grid power plant for only home and farm uses using poultry litter. Model has three distinct outputs-

- electricity,
- cooking gas and
- fertilizer for agriculture

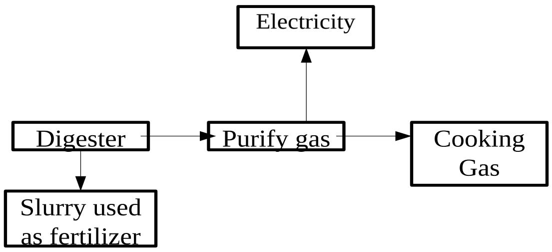


Figure 1: Outputs of Proposed model

Off-grid can be stand-alone power system or mini-grids that desire to provide a smaller community with electricity. Off-grid electrification is an approach to access electricity used in countries and areas with little access to electricity, due to scattered or distant population.

Proposed system is designed to function without the support of remote infrastructure, having 2 generators, each of them has distinct eight working hours. So the off-grid power plant will serve for 16 hours in a day. Generator1 serves only poultry farm demands for 8 a.m. to 4 p.m. whereas generator2 servers 5 families with 5 lights and 5fans according to user demands, as well as also meet up farm demands for 6 p.m. to 2 a.m.

This model proposes co-generation of electricity along with cooking gas for 5 families and slurry of the digester can be used as fertilizer for agriculture.

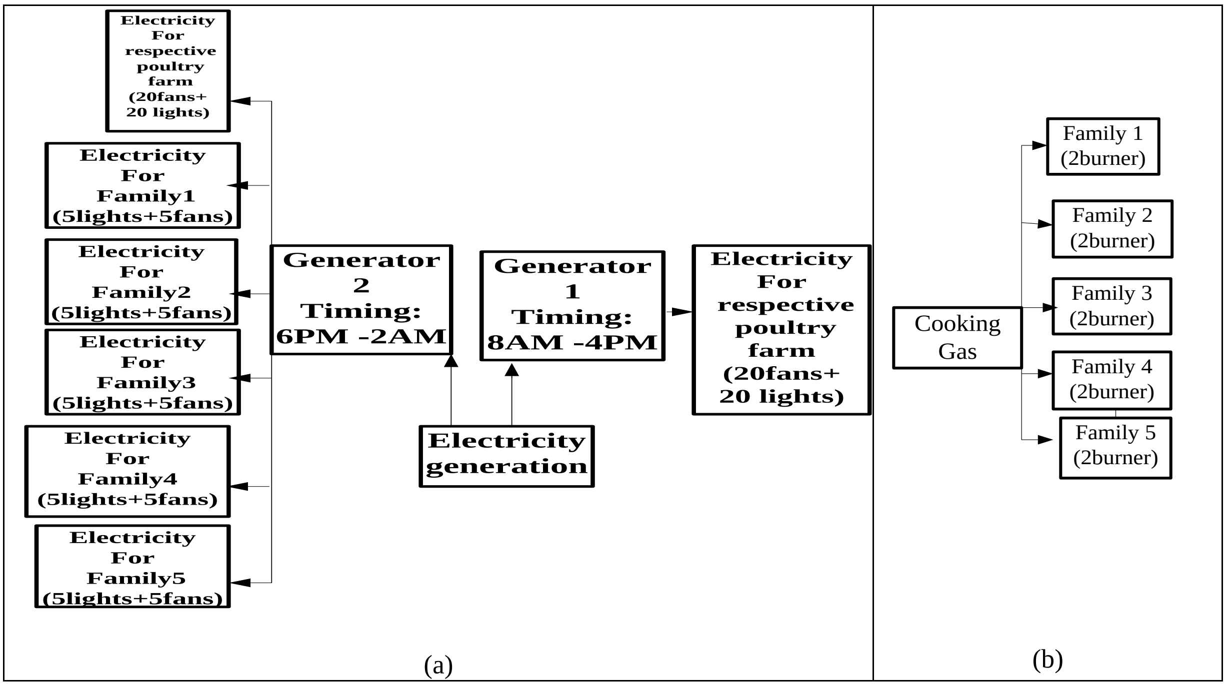


Figure 2: Proposed model (a) electricity distribution (b) gas distribution for cooking purpose

5.1 Methodology for Electricity Generation :

Poultry waste should used as the raw material of biogas digester. Output gas of the digester contains H_2S and moisture components and needs to be purified through H_2S and moisture removal unit. Output of the moisture removal unit should feed as fuel for combustion engines, which convert it to mechanical energy, powering an electric generator to produce electricity and supply it to desired load.

Generator produced heat can be utilized by using it for digester and moisture removal unit [26]-[28]. Also Slurry of the digester can be used as fertilizer, which has two benefits. Thus the overall system acts as an eco friendly system by keeping environment clean [29].

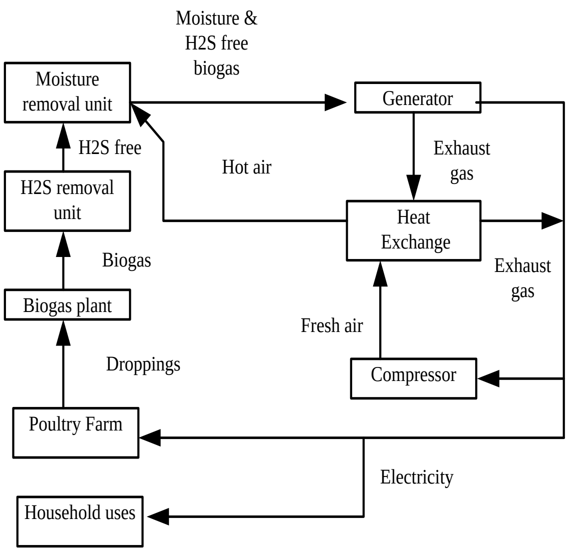


Figure 3: Electricity Generation process

5.2 Control Circuit:

The normal speed of an electric power generator is maintained by a control system that balances the demand on the generator and the steam supplied to the generator, in reference to the power system frequency. In the event when the load voltage fluctuated from the desired value, the control system is designed to simultaneously recover the load voltage to get the desired controlled output from the generator.

Digester produced gas is used as fuel of the DC gas generator. Generated emf of the generator can vary with different changing parameters of prime mover [30].

Generated emf, $Eg = \frac{P\varphi N}{60} . \frac{Z}{A}$

N = rotational speed of armature in revolutions per min. (rpm)

$$\frac{Eg_1}{Eg_2} = \frac{N_1}{N_2} . \frac{I_2}{I_1}$$

Along with changing generated emf, terminal voltage of the generator may also be changed, Fluctuation of gas and voltage are harmful for connected loads. Thus we need to keep the terminal voltage fixed at a desired level.

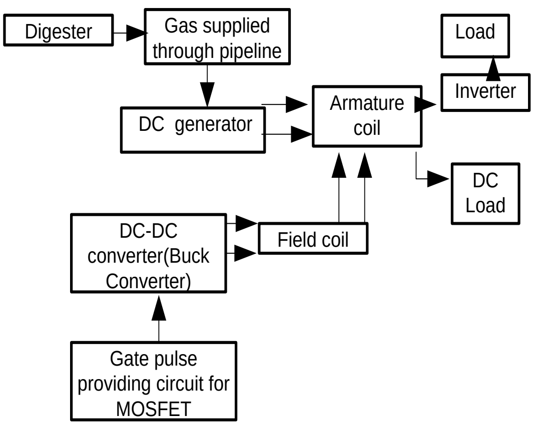


Figure 4: Overall Power generation process

DC-DC converter is a suitable solution to protect the loads from over voltage. Output of the converter can be dominated by controlling duty cycle of the gate pulse of switching device. Output of the converter should connect with the field coil and load should connect with the armature coil. For AC load armature coil output should pass through an inverter before connecting it with load.

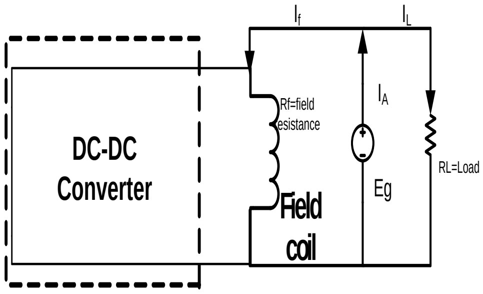


Figure 5: Electrical model of Power generation process

5.3 Estimation

Table-7: Estimation of the proposed Model

Total Birds 4000pcs	Breader 1000pcs	Feeder 3000pcs
Droppings	(1000 X 245g)≈245kg(per day)	(3000 X 98g)≈294kg(per day)
Total Biogas Resource: (245+294)kg =539kg ≈530 kg		
Produced Gas: 530kg x 2.5 cft =1347.5 cft ≈ 1300cft		
Cooking Gas= (5 x 80cft) =400cft		
Electricity = (1Kwh x900cft)/22.5 cft =40kwh ≈38kwh		

Estimation is done considering the farm has 4000 birds. Average amount of poultry droppings are used for calculating biogas. Amount of gas required per kWh electricity = 0.71 m 3 or 25cft (Considering 35% machine efficiency and30% carbon content) [23].

5.4 By products of the Model

- Cooking facility

After purification of the gas, it can also serve cooking purpose. As we all know Bangladesh is facing a gas shortage problem. So rest of the gas that contains methane can be used for household purpose.

- Fertilizer

Bio-slurry may be considered as a good quality organic fertilizer in Bangladesh agriculture. Analysis of representative cow dung and poultry litter slurry samples from biogas plants made at the Bangladesh Agricultural Research Institute (BARI) and Dhaka University (DU) has shown that slurry contains a considerable amount of both macro and micro nutrients besides appreciable quantities of organic matter. Toxic heavy metal concentration in them is minimal [31].

Bio-slurry organic fertilizer is environmental friendly, has no toxic or harmful effects and can easily reduce the use of chemical fertilizers up to 50%. Nutrients from organic sources are more efficient than those from chemical sources.

Table 8. Comparison of Biogas Fertilizer with Chemical Fertilizer

Name	Production with chemical fertilizer[ton/hector]	Production with biogas fertilizer [ton/hector]	percentage
Husk	8.28	9.02	8.93
Corn	7.00	9.5	35.7
Tula	3.13	3.97	26.8
vegetable	less	much	-

VI. HOMER ANALYSIS TO STUDY FEASIBILITY OF PROPOSED MODEL

Hybrid Optimization Model for Electric Renewable (HOMER) software is used to find out the final optimization and sensitive analysis [32]-[36] and to study the economical feasibility of the proposed model by comparing between diesel and biogas resources.

6.1 Resouce inputs:

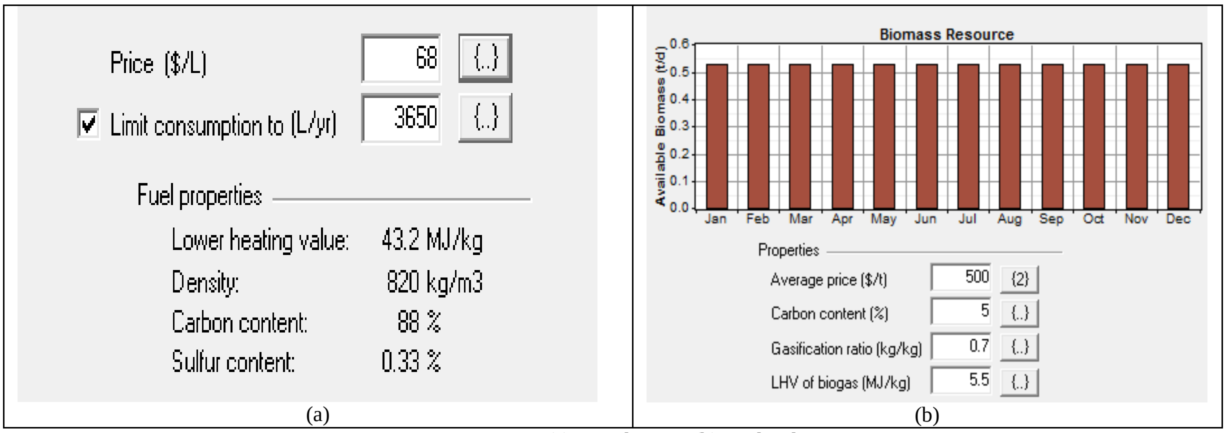


Figure 6: Resource inputs (a) Diesel inputs (b) Poultry litter inputs

6.2 Analysis for Generator1:

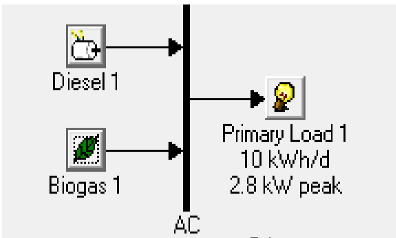


Figure 7: System with biogas generator ,diesel generator and load(for 8 a.m to 4 p.m)

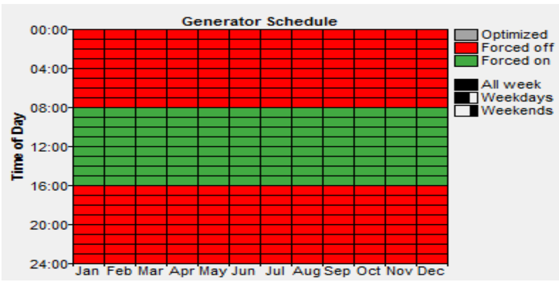


Figure 8: Schedule of generator1

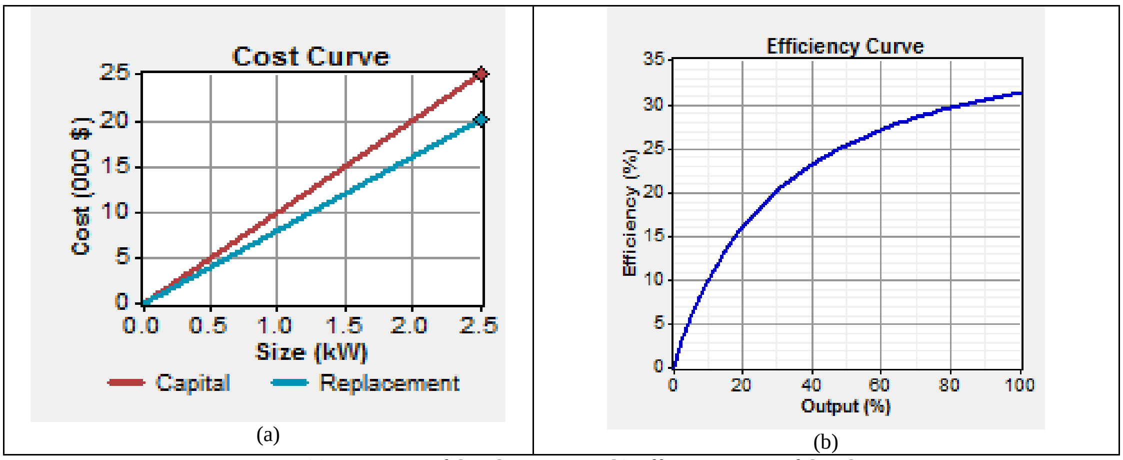


Figure 9: (a) Cost curve of diesel generator1 (b) Efficiency curve of diesel generator1

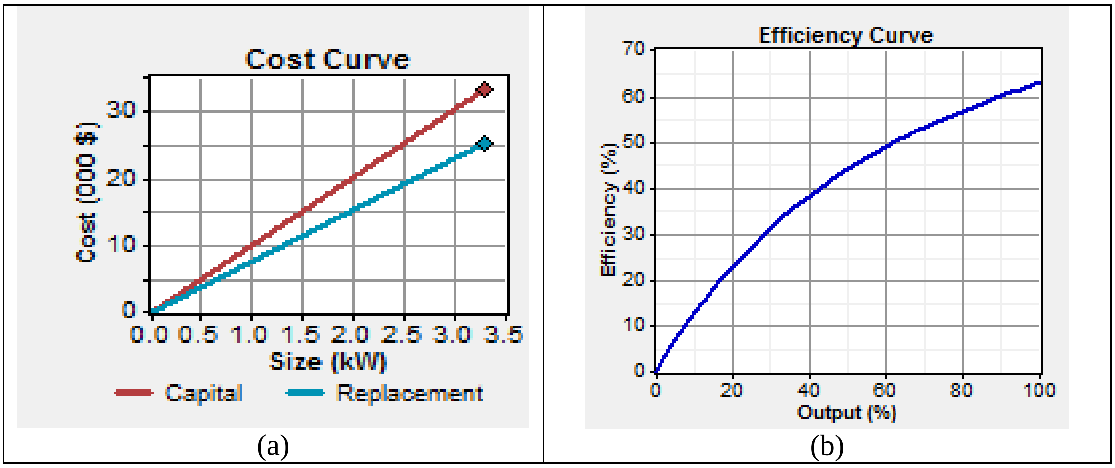


Figure 10: (a) Cost curve of biogas generator1 (b) Efficiency curve of biogas generator1

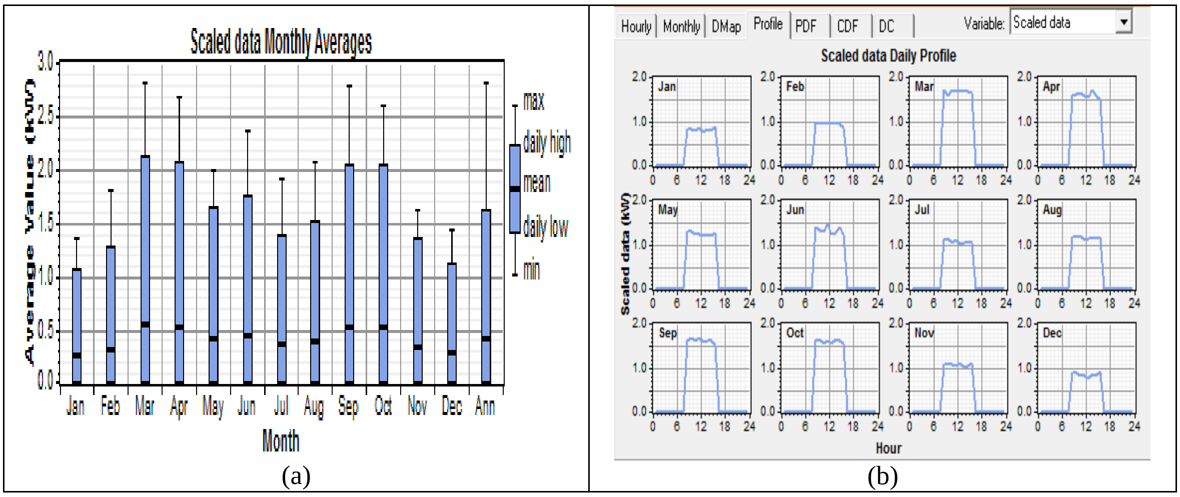
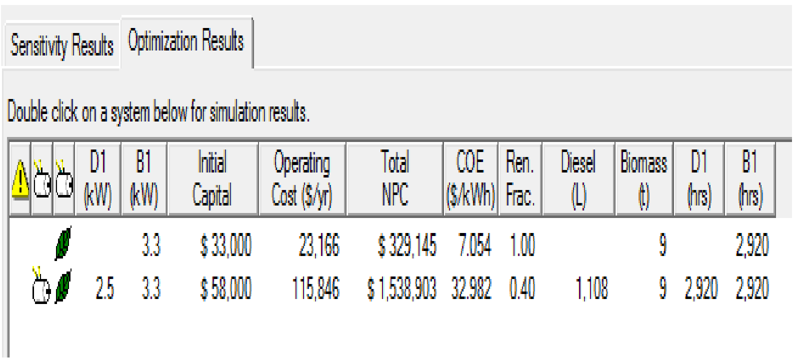
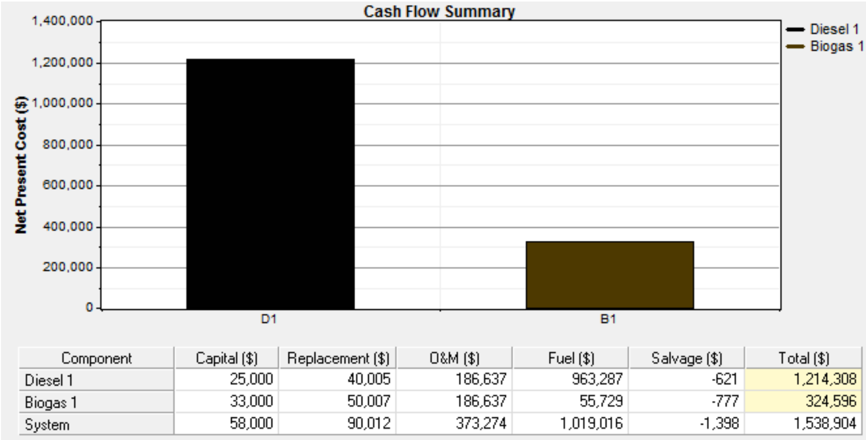


Figure 11: Load profile for generator 1 (a) Scaled data monthly average load profile (b) Scaled data daily load profile



D1 (kW)	B1 (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.	Diesel (L)	Biomass (t)	D1 (hrs)	B1 (hrs)
	3.3	$ 33,000	23,166	$ 329,145	7.054	1.00		9		2,920
2.5	3.3	$ 58,000	115,846	$ 1,538,903	32.982	0.40	1,108	9	2,920	2,920

Figure 12: Optimization results of biogas generator and diesel generator



Component	Capital ($)	Replacement ($)	O&M ($)	Fuel ($)	Salvage ($)	Total ($)
Diesel 1	25,000	40,005	186,637	963,287	-621	1,214,308
Biogas 1	33,000	50,007	186,637	55,729	-777	324,596
System	58,000	90,012	373,274	1,019,016	-1,398	1,538,904

Figure 13: Cost comparison between biogas generator and diesel generator

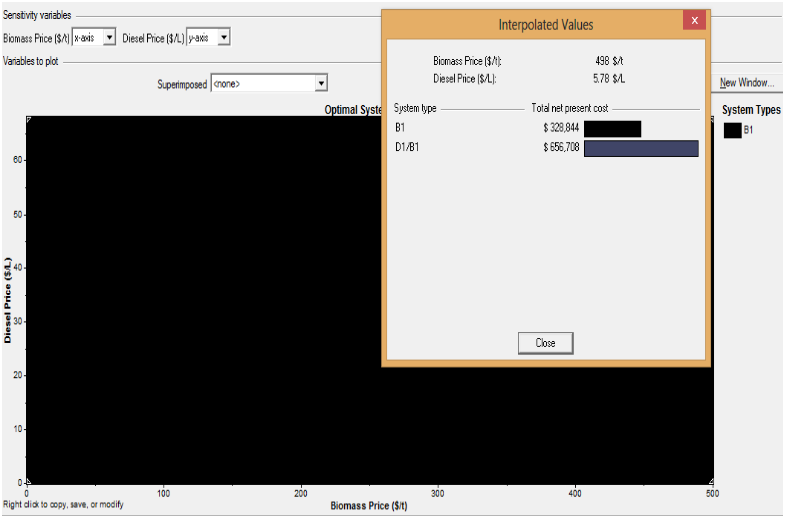


Figure 14: Sensitivity results of diesel generator1 Vs biogas generator1 (optimal system type)

6.3 Analysis for Generator 2:

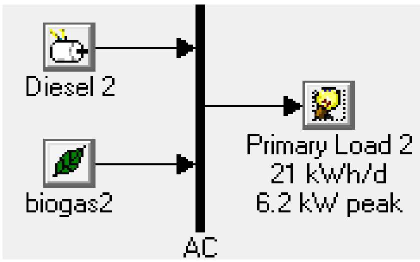


Figure 15: System with biogas generator ,diesel generator and load(for 6 p.m to 2 a.m)

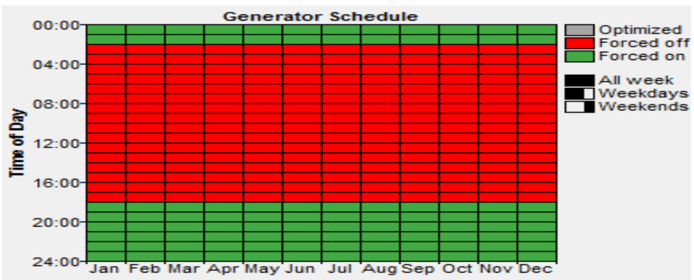


Figure 16: Schedule of generator2

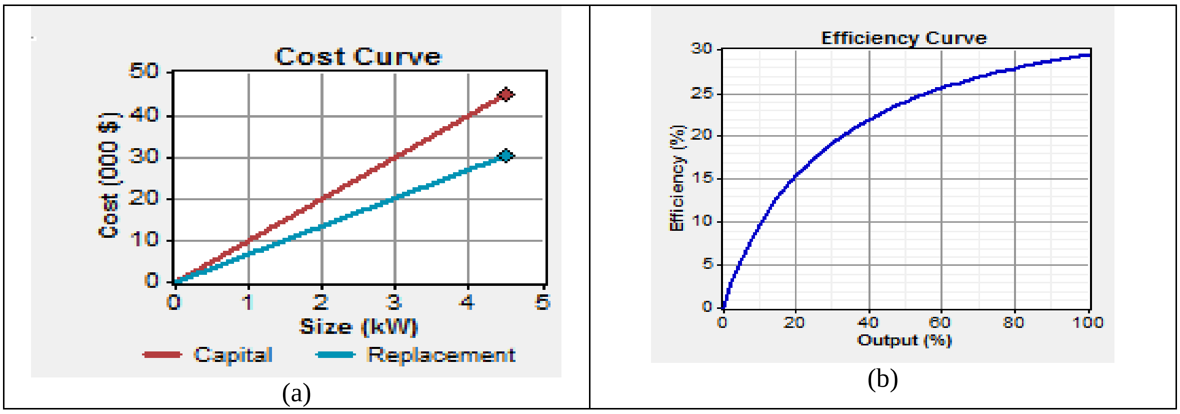


Figure 17: (a) Cost curve of diesel generator2 (b) Efficiency curve of diesel generator2

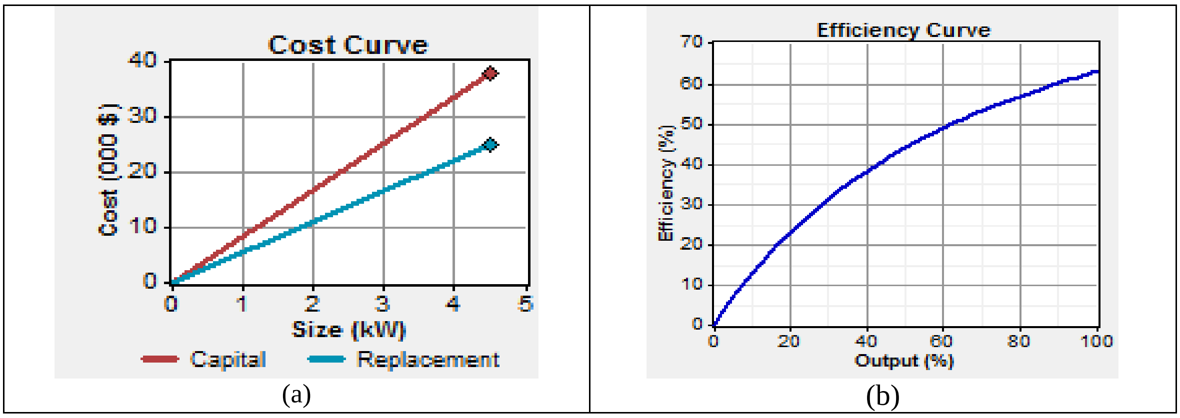


Figure 18: (a) Cost curve of biogas generator2 (b) Efficiency curve of biogas generator

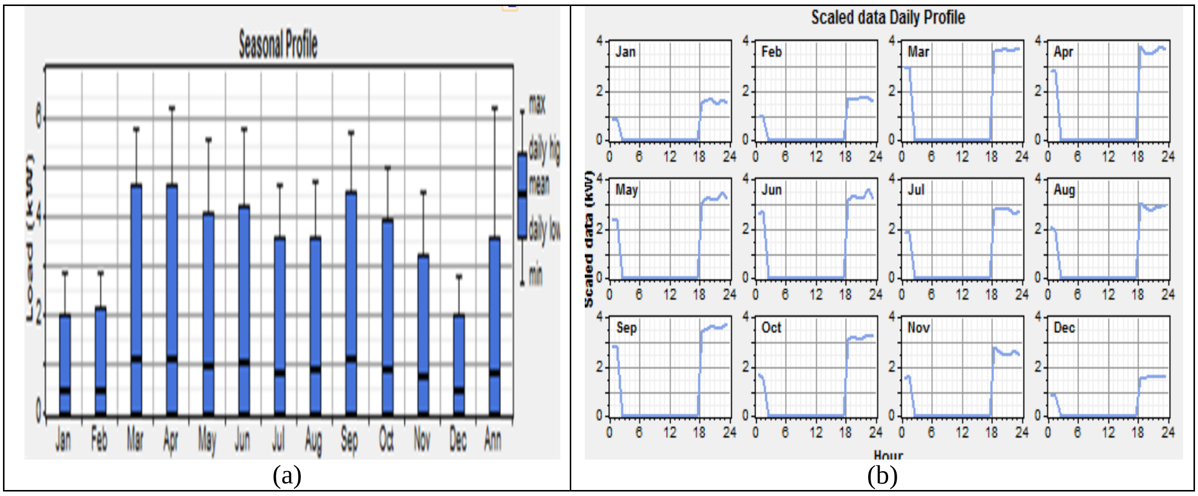
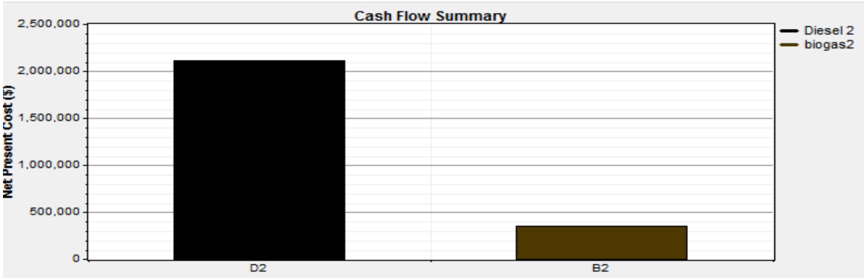


Figure 19: Load profile for generator2 (a) Scaled data daily load profile (b) Scaled data monthly average load profile

Double click on a system below for optimization results.

Biomass Price ($/t)	Diesel ($/L)				D2 (kW)	B2 (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.	Diesel (L)	Biomass (t)	D2 (hrs)	B2 (hrs)
500.000	68....				4.5	4.5	$ 83,000	186,555	$ 2,467,801	25.428	0.48	2,096	13	2,920	2,920
500.000	0.000				4.5	4.5	$ 83,000	43,557	$ 639,808	6.592	0.33	2,408	12	2,920	2,920
0.000	68....				4.5	4.5	$ 83,000	180,173	$ 2,386,214	24.587	0.48	2,096	13	2,920	2,920
0.000	0.000				4.5	4.5	$ 83,000	37,672	$ 564,580	5.817	0.33	2,408	12	2,920	2,920

Figure 20: Optimization results of biogas generator and diesel generator



Component	Capital ($)	Replacement ($)	O&M ($)	Fuel ($)	Salvage ($)	Total ($)
Diesel 2	45,000	60,008	186,637	1,821,635	-932	2,112,348
biogas2	38,000	50,007	186,637	81,587	-777	355,454
System	83,000	110,015	373,274	1,903,222	-1,709	2,467,802

Figure 21: Cost comparison between biogas generator and diesel generator

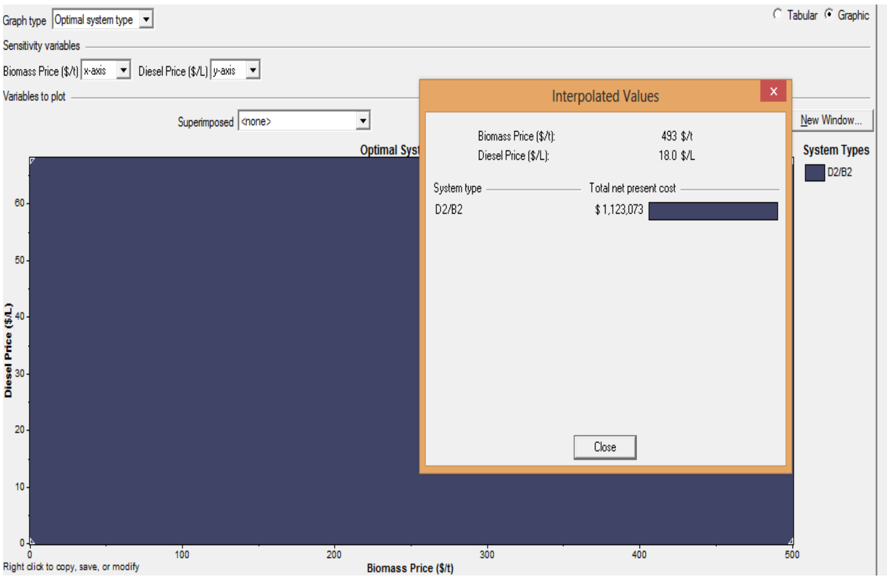


Figure 22: Sensitivity results of diesel generator Vs biogas generator (optimal system type)

6.4 Observation

Assessment is carried out in the HOMER environment to observe the feasibility of proposed model for an off-grid home-farm system for rural Bangladesh.

Fig-6 shows resource input parameters those are used for simulation. Analysis is done for two generators separately. For generator1, Fig- 9 & Fig-10 display cost curve and efficiency curve for diesel and gas generator respectively. Fig-17 and Fig-18 exhibit same parameters for generator 2. It is clearly observe in both cases that biogas generator provide much better efficiency than diesel generator.

System overview, generator on-off schedule and load profiles for generator1 are shown in Fig-7, Fig-8 and Fig-11 accordingly. For generator 2, mentioned parameters are exposed in Fig-15, Fig-16 and Fig-19 subsequently.

Fig-13 and Fig-21 illustrates cost effective feature of biogas for both cases separately showing a huge difference between biogas and conventional fuel cost.

The levelized COE (cost of energy) is the average cost per kWh of useful electrical energy produced by the system. HOMER uses the total net present cost (NPC) to represent the life-cycle cost of a system. Costs may include capital costs, replacement costs, operating and maintenance costs, fuel costs, the cost of buying electricity from the grid, and miscellaneous costs such as penalties resulting from pollutant emissions. Optimization results of generator 1 and generator 2 are presented in Fig-12 and Fig-20 respectively. Both figures demonstrate that NPC and COE are much less for biogas based system compared to diesel based system.

Optimization and sensitivity results of the proposed model clearly portrait the feasibility of poultry litter based bio-electrification technology.

VII. CONCLUDING REMARKS

Along with rest of the world, Bangladesh is also facing an accelerating crisis of the globally established fossil fuels, therefore immediate different breakthroughs for renewable energy is necessity to reach our electricity goal. Off-grid renewable energy systems are not only urgently needed to connect a vast number of people with a source of electricity, but are also most appropriate due to geographical constraints and costs for grid extension. In developed countries, minigrids are increasingly considered an option to improve energy security, power quality and reliability. In this document, an off-grid, poultry litter based power generation model is proposed and HOMER based assessment demonstrate the feasibility of the model for rural Bangladesh. Declining cost and increased performance of off-grid biogas based renewable energy systems are gradually rendering them more cost-competitive compared to alternatives.

REFERENCES

[1] El Bassam, Nasir, Preben Maegaard, and Marcia Lawton Schlichting.*Distributed Renewable Energies for Off-grid Communities: Planning, Technologies, and Applications*. Newnes, 2013.

[2] Ellabban, Omar, Haitham Abu-Rub, and Frede Blaabjerg. "Renewable energy resources: Current status, future prospects and their enabling technology."*Renewable and Sustainable Energy Reviews* 39 (2014)-Elsevier: 748-764.

[3] Weiland, Peter. "Biogas production: current state and perspectives." *Applied microbiology and biotechnology* 85.4 (2010): 849-860.

[4] S. R. Bull, “Renewable energy today and tomorrow,” *Proceedings of the IEEE*, vol. 89, no. 8, pp. 1216-1226, Aug. 2001

[5] J. M. Guerrero, F. Blaabjerg, T. Zhelev, K. Hemmes, E. Monmasson, S.Jemei, M. P. Comech, R. Granadino, and J .I. Frau, “Distributed generation: toward a new energy paradigm,” *IEEE Industrial Electronics Magazine*, vol. 4, no. 1, pp. 52-64, Mar. 2010.

[6] “Biology project on Biogas plant,An unique approach to alternative energy source in rural india”. Internet: http://www.slideshare.net/TulikaGhosh1/biogas-plant-project-47375752, April24,2015.

[7] “Basic Information on Biogas” , www.kolumbus.fi. Retrieved 2.11.07

[8] Agrawal, Karan M., B. R. Barve, and Shareena S. Khan. "Biogas From Press mud." *IOSR journal of mechanical and civil engineering (IOSR-JMCE) ISSN* (2010): 2278-1684.

[9] Ziemiński, Krzysztof, and Magdalena Frąc. "Methane fermentation process as anaerobic digestion of biomass: Transformations, stages and microorganisms." *African Journal of Biotechnology* 11.18 (2014): 4127-4139.

[10] Bond, Tom, and Michael R. Templeton. "History and future of domestic biogas plants in the developing world." *Energy for Sustainable development*15.4 (2011): 347-354.

[11] The Daily Star. “Bangladesh’s gas reserve to last until 2031”. Internet: http://www.thedailystar.net/backpage/gas-reserve-last-until-2031-104479, June 29, 2015

[12] Bangladesh Power Development Board. Internet: http://www.bpdb.gov.bd/bpdb/index.php?option=com_content&view=article&id=150&Itemid=16

[13] A.Jamil. “Biogas and Cattle Organs- An Alternative Significant Source of Energy for Sustainable Development in Rural Bangladesh.” M.Sc. Thesis, Södertorns Högskola, Stockholm, Sweden, 2006-07

[14] Power Cell. Internet: http://www.powercell.gov.bd/index.php?page_id=267

[15] Biswas, Wahidul K., Paul Bryce, and Mark Diesendorf. "Model for empowering rural poor through renewable energy technologies in Bangladesh." *Environmental Science & Policy* 4.6 (2001): 333-344.

[16] Biswas, Wahidul K., and N. J. D. Lucas. "Economic viability of biogas technology in a Bangladesh village." *Energy* 22.8 (1997): 763-770.

[17] Hossain, A. K., and O. Badr. "Prospects of renewable energy utilisation for electricity generation in Bangladesh." *Renewable and Sustainable Energy Reviews* 11.8 (2007): 1617-1649.

[18] Salma A. Iqbal, Shahinur Rahaman, Abu Yousuf, “Present Scenario of Biogas Technology in Bangladesh-Prospects, Potentials and Barriers,”Proceedings of the 15th Annual paper Meet, “APM 2013”, At Dhaka,Bangladesh,Pages: 1-9

[19] Islam, Mohammad Shariful, Asif Islam, and Md Islam. "Variation of biogas production with different factors in poultry farms of Bangladesh."*Developments in Renewable Energy Technology (ICDRET), 2014 3rd International Conference on the*. IEEE, 2014.

[20] Islam, M. Rofiqul, M. Rabiul Islam, and M. Rafiqul Alam Beg. "Renewable energy resources and technologies practice in Bangladesh." *Renewable and Sustainable Energy Reviews* 12.2 (2008): 299-343.

[21] Shamsuddoha, Mohammad. "A sustainable supply chain process model for Bangladeshi poultry industry." *Curtin Business School, Doctoral Students' Colloquium*. 2010.

[22] Huda, A. S. N., S. Mekhilef, and A. Ahsan. "Biomass energy in Bangladesh: Current status and prospects." *Renewable and Sustainable Energy Reviews*30 (2014): 504-517.

[23] A.S.M.Hasan,M.F.Khan, R.Mostafa;A.Kaium "Feasibility study on electricity generation from poultry litter based biogas in Bangladesh." *Developments in Renewable Energy Technology (ICDRET), 2014 3rd International Conference on the*. IEEE, 2014.

[24] Poultry business directory 2015 - Poultry Khamar Bichitra. Internet: http://www.poultrykhamarbichitra.com/mg/Directory-2015-Part-A.pdf

[25] BSS News Dhaka. “Plan to install ‘Bio-Socket’ in 35,000 biogas plants forelectricity”.Internet: http://www.bssnews.net/newsDetails.php?cat=0&id=388242&date=2014-02-09, Feb 9, 2014

[26] Kelleher, B. P., et al. "Advances in poultry litter disposal technology–a review." *Bioresource technology* 83.1 (2002): 27-36.

[27] Rao, P. Venkateswara, et al. "Biogas generation potential by anaerobic digestion for sustainable energy development in India." *Renewable and Sustainable Energy Reviews* 14.7 (2010): 2086-2094.

[28] Watkins, Pete, and Peter McKendry. "Assessment of waste derived gases as a renewable energy source–Part 1." *Sustainable Energy Technologies and Assessments* 10 (2015): 102-113.

[29] X. Fan, Z. Li, T. Wang; F. Yin; X. Jin, "Introduction to a Large-Scale Biogas Plant in a Dairy Farm," *Digital Manufacturing and Automation (ICDMA), 2010 International Conference* onYear: 2010, Volume:1Pages: 863 - 866, DOI: 10.1109/ICDMA.2010.271

[30] Sharmin Sobhan, Tanvir Ahmad, "Modeling and Analysis of Control Circuit for Biogas Electrification Technology," *International Journal of Research in Engineering and Technology*, vol. 4, issue 10, pp. 06–11, Oct 2015

[31] Islam, M. S. "Use of bioslurry as organic fertilizer in Bangladesh agriculture."*Prepared for the presentation at the International Workshop on the Use of Bioslurry Domestic Biogas Programme. Bangkok, Thailand*. 2006.

[32] Sen, Rohit, and Subhes C. Bhattacharyya. "Off-grid electricity generation with renewable energy technologies in India: an application of HOMER."*Renewable Energy* 62 (2014): 388-398.

[33] Mondal, Md Alam Hossain, and Manfred Denich. "Assessment of renewable energy resources potential for electricity generation in Bangladesh."*Renewable and Sustainable Energy Reviews* 14.8 (2010): 2401-2413.

[34] Dalton, G. J., D. A. Lockington, and T. E. Baldock. "Case study feasibility analysis of renewable energy supply options for small to medium-sized tourist accommodations." *Renewable Energy* 34.4 (2009): 1134-1144.

[35] Sureshkumar, U., P. S. Manoharan, and A. P. S. Ramalakshmi. "Economic cost analysis of hybrid renewable energy system using HOMER." *Advances in Engineering, Science and Management (ICAESM), 2012 International Conference on*. IEEE, 2012.

[36] Zoulias, E. I., and N. Lymberopoulos. "Techno-economic analysis of the integration of hydrogen energy technologies in renewable energy-based stand-alone power systems." *Renewable Energy* 32.4 (2007): 680-696.