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ECONOMIC STUDY OF FAMILY SIZED SOLID STATE DEENBANDHU BIOGAS PLANTS FOR STATE OF RAJASTHAN

Nikita Wadhawan*

ABSTRACT

Biogas production has been quite dominant in rural areas of developing country at household and community levels especially addressing the aim of providing an affordable source of energy. Unfortunately, the biogas technology is not being adopted by the majority of the households from the rural area of India by default their inability to meet the condition as well as lake of knowledge regarding returns of their investment. For promoting such energy resource technologies, it is necessary to evaluate their economic viability in order to educate its potential of being a clean source of energy in our path to development. In this investigation, an attempt was made to determine the annual profit and payback period for family sized i.e. 1-6m^3 solid state Deenbandhu biogas plant. Installation cost and annual operational cost were calculated by accounting current market price for the state of Rajasthan. The hydraulic retention time was considered 75 days. It was observed that the as the size of biogas plant is increases, the payback period decreases.

INTRODUCTION

The over dependence on the fossile fuels poses risks such as depletion of fossile fuels resources and global climatic changes caused by the net increase in the atmospheric CO_2 levels. As the fossil fuels are limited and their demands are high, the gap can be met with energy generation from renewable resources. India had an installed base of about 125GW of electricity which included 66% thermal energy followed by hydro (26%), nuclear (3%) and renewable energy (5%). Of the current total renewable energy base, biomass constitutes 11.5%. Biomass comprises all the living matter presents on earth-derived from growing plants including algae, trees and crops or from animal manure [(1).] Traditionally, biomass had been utilized through direct combustion. Biomass refers to biodegradable material originating in land and aquatic environments. Cow dung cake is one of the most important and widely used biomass for the production of daily energy needs [(2)]. Burning of biomass or cow dung cakes through direct combustion is associated with a host of ills among the estimated 2.5 billion people around the world that do not have access to modern fuels. Indoor air pollution from traditional burning contributes to serious health problem, particularly cancer and respiratory infections that causes an estimated 1.6 million premature deaths annually [(3)].

Anaerobic digestion of biomass offers several advantages over direct combustion with several independence, complex sequential and parallel biological reactions, resulting in transformation of organic matter mainly into a mixture of methane and carbon dioxide which is usually refer to a Biogas[(4)]. More than 4 million family sized biogas plant i.e. 1-6m^3 capacities have so far been installed in the country since 1982-83 under National Biogas and Manure Management Programme being implemented by Ministry of New and Renewable Energy (MNRE), Govt. of India. For solid state deenbandhu biogas plant, the hydraulic retention time is 75 days as against 40 days given in IS9478:1989[(5)]. The deenbandhu model of biogas plant is designed on the basis of fixed dome biogas plant. The modification has been made to minimize the surface area of biogas plant to reduce their installation cost without sacrificing the efficiency.

In general, biogas obtained from Deenbandhu biogas plant from digestion of cattle dung mixed with equal quantity of water as feed slurry. Slurry is mixed

* Assistant Professor, Department of Renewable Energy Engineering, CTAE, MPUAT, Udaipur.

by thoroughly mixing fresh water (TSC normally 15-19%) with equal quantity of water to prepare slurry having TSC of 8-10% and fed into the plant. The digested slurry discharged from the plant is watery (content 94-96% moisture) containing 2.1% nitrogen, 0.8% phosphorus and 1.5% potassium is used as manure fro crop production. The slurry is spread on to the ground or collected into the pits or drying over the period of up to 45days to facilitate its transportation to the field for the use as manure. Large area is required close to the biogas plant for spreading and drying the slurry.

Due to requirement of water in bulk volume and area required for drying, the technology has not penetrated into water scare region of Rajasthan. Besides, a number of working plants become non functional every year mainly because feeding is discontinued during summer season due to scarcity of water. Such a major fraction of the available cattle dung is either converted to dung cakes for use as fuel or composted for use as organic manure. Experiments were carried out in fixed dome deenbandhu design family size biogas plant for anaerobic digestion of cattle dung solid state (TDS 16-18%). The water requirement for the regular use of the plant of fixed dome biogas plants for solid state digestion design is very low or almost nil. Therefore, the design is, in general, suitable for all regions (except hilly terrains) and more specifically for water scare regions where cattle rearing is in vogue.

Unfortunately, the solid state deenbandhu biogas technology is not being adopted by the majority of the households from the rural area of India by default their inability to meet the condition as well as lake of knowledge regarding returns of their investment. Hence, this study has been conducted to evaluate the savings due to use of biogas plant.

RESEARCH METHODOLOGY

For studying the economics of different family size of Deenbandhu (1–6 m^3) biogas plant, the cost of construction and installation, annual operational cost and income from biogas thus produced are calculated by taking into account the current prices of the local market of Udaipur city, Rajasthan (India). The Government of India, for promoting the use of biogas, irrespective of the model and the capacity of biogas plant to be installed by any family, is providing a fixed amount of subsidy of Rs. 4000/- on one cubic meter biogas plant and Rs. 8000/- on two to six cubic meter biogas plant through its nodal agencies. Hence, for knowing the actual cost to be incurred for installation of a biogas plant, their respective subsidized amount is subtracted from the calculated cost of each capacity and each model.

RESULTS AND DISCUSSION

Cost of dung required

For calculating the annual operational cost of a biogas plant, besides other costs, we also need the cost of the dung required to run it. All other operational costs being the same for both cases, the input cost of dung may differ depending upon whether; previously, the dung was being used as manure or as fuel by making dung cakes. In the study in hand, an averaged value of both cases has been considered to calculate the cost of the annual dung requirement.

For the 1 m^3 capacity biogas plant, 25 kg of cow dung is required daily. For calculating the cost of dung in terms of manure, the direct cost of fresh dung, i.e. Rs.1 per kg, has been taken into account, but for calculating it in terms of fuel, firstly the LPG equivalent of the dung cakes that may be prepared from it has been calculated. For calculating the LPG equivalent of the dung cakes, it is considered that dry weight of the cake is 30% of the weight of dung used to prepare them. A thumb rule was also used as one cubic meter of biogas is equal to 0.43 kg of LPG and 12.3kg of dung cakes. Then, the prevailing price of LPG, i.e. Rs. 30 per kg, has been used to calculate the cost of dung in terms of fuel. The calculating method of annual dung requirement and LPG equivalent of dung is shown in eq. 1 & 2 [4].

Annual Dung requirement (kg) = Plant size×25×365 ...(1)

...(2) $\text{LPG equivalent of dung} = \frac{Dung\ Wt. \times 0.30 \times 0.43}{12.3}$

Annual operational cost

Annual operational cost of a biogas plant involves the annual depreciation on civil construction work and other installations, annual maintenance charges and cost of dung required to run it per annum. As per established standards, the life of the

Table 1: Civil Constuction

Material	Unit	Cost per unit	1 m3		2m3		3m3		4m3		6m3	
Brick	Nos.	Rs. 5/ Nos.	700	**3500**	1000	**5000**	1300	**6500**	1600	**8000**	2200	**11000**
Cement	Bag	Rs.260/Bag	9	**2340**	15	**3900**	17	**4420**	23	**5980**	29	**7540**
Concrete	M^3	Rs. 900/CM	1	**900**	1.25	**1125**	1.55	**1395**	1.98	**1782**	2.54	**2286**
Sand	Trolly	Rs. 2500/trolly	0.5	**1250**	1	**2500**	1.5	**3750**	1.75	**4375**	2	**5000**
GI pipe	Set	Rs. 200/set	1	**200**	1	**200**	1	**200**	1	**200**	1	**200**
AC pipe	Meter	Rs. 105/meter	10	**1050**	10	**1050**	10	**1050**	10	**1050**	10	**1050**
Paint	Kg.	Rs. 250/kg	1	**250**	1	**250**	1.5	**375**	2	**500**	3	**315**
				9490		**14025**		**17690**		**21887**		**27391**

Labour

	1m3	2m3	3m3	4m3	6m3
Working Days	4	4	6	8	10
Rate of mason	500	500	500	500	500
Cost of mason	**2000**	**2000**	**3000**	**4000**	**5000**
Rate of mason II	500	500	500	500	500
Cost of mason II	**2000**	**2000**	**3000**	**4000**	**5000**
Labours@Rs. 300	2	2	2	2	2
Cost of Labour	**2400**	**2400**	**3600**	**4800**	**6000**
Total	6400	6400	9600	12800	16000

	$1m^3$	$2m^3$	$3m^3$	$4m^3$	$6m^3$
Civil Construction (A)	9490	14025	17690	21887	27391
Labour (B)	6400	6400	9600	12800	16000
Total Cost {C= A+B}	**15890**	**20425**	**27290**	**34687**	**43391**
Subsidy (D)	4000	8000	8000	8000	8000
Net Cost of Installation (C-D)	11890	12425	19290	26687	35391

civil work, gas supply line is considered to be 25 and 20 years, respectively, rendering the corresponding annual depreciation to be 4% and 5%. Further, the maintenance charges are taken to be 2% of the net installation cost [4]. However, the annual operational cost of the Deenbandhu model of biogas plant for capacities varying from 1 to 6 m^3 is calculated.

Income from biogas plant

If cow dung is used to run a biogas plant, it proves to be a source of double income. Firstly, the biogas produced is a fuel of appreciable calorific value. Secondly, the residual slurry is a good manure of appreciable nutritional value. It is worth mentioning here that the quantity of residual slurry is the same as that of the cow dung fed in a biogas plant. While calculating the income from a biogas plant, it has been presumed that only 80% of the gas produced is available for cooking and 20% is wasted due to one or the other unavoidable reasons. Here also, the LPG equivalent of the biogas produced is calculated for finding the income from biogas. The prevailing price of dried slurry, which is by weight about 30% of the total residual, is taken to be Rs. 1.5 per kg.

Net economics

The economics of a biogas plant involves the calculation of annual profit and payback period for the different models, where

Annual profit [4] =Annual income - Annual operational cost ...(3)

And

Payback period[4] = Cost of installation/Annual profit ...(4)

Accordingly, the economics of the Deenbandhu model for capacities varying from 1 to 6 m^3 are calculated.

The cost of installation, cost of dung, annual operational cost and annual income of the solid state deenbandhu model is calculated and shown in Table.1-5 respectively and plotted in Fig.1.

Table 2: Calculation of annual dung requirement in terms of manure as well as fuel

S.N.	Capacity of biogas plant	Dung requirement	Cost of dung as manure	LPG equivalent dung	Cost of LPG i.e. cost of dung in terms of fuel
	m^3	kg	Rs.	kg	Rs.
1	1	9125	9125	95.7	2871
2	2	18250	18250	191.4	5742
3	3	27375	27375	287.1	8613
4	4	36500	36500	382.8	11484
5	6	54750	54750	574.2	17226

Table 3: Calculation of annual operational cost of Deenbandhu Model

Name of component with life	Annual Depreciation rate	Annual Depreciation /input cost (Rs.) for the biogas plant of capacity				
	%	1 m^3	2m^3	3m^3	4m^3	6m^3
Civil Construction	4	380	561	708	875	1096
Maintenance charges	2	317	408	546	694	868
Cost of LPG i.e. cost of dung in terms of fuel	-	2871	5742	8613	11484	17226
Total (Rs.)	-	**3568**	**6711**	**9867**	**13053**	**19190**

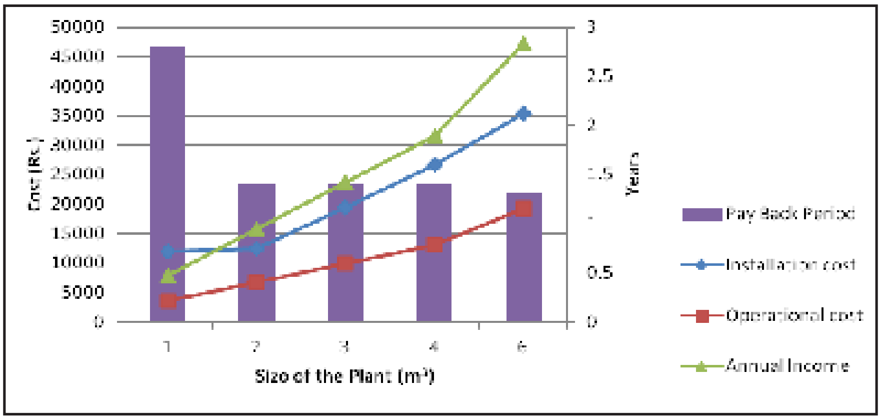
Table 4: Calculation of annual income form a biogas plant

Capacity of biogas plant	Annual biogas production	Usable Gas	LPG equivalent of usable gas	Income from Gas	Dried slurry available	Income from slurry	Total income
M^3	M^3	M^3	kg	Rs.	kg	Rs.	Rs.
1	365	292	125.6	3766.8	2738	4106	7873
2	730	584	251.1	7533.6	5475	8213	15746
3	1095	876	376.7	11300.4	8212.5	12319	23619
4	1460	1168	502.2	15067.2	10950	16425	31492
6	2190	1752	753.4	22600.8	16425	24638	47238

Table 5: Calculation of economics of Deenbandhu model biogas plant

Name of the component	Unit	Size of the biogas plant				
		1m³	**2m³**	**3m³**	**4m³**	**6m³**
Installation cost	Rs.	11890	12425	19290	26687	35391
Annual Operational Cost	Rs.	3568	6711	9867	13053	19190
Annual income	Rs.	7873	15746	23619	31492	47238
Annual profit	Rs.	4305	9035	13752	18439	28048
Payback period	Years	**2.8**	**1.4**	**1.4**	**1.4**	**1.3**

Fig.1: Cost wise comparison of different models of Deenbandhu biogas plant.



As indicated by Fig.1, for all the capacities varying form 1-6m³, the operational and annual income is gradually increases. While calculating the operational cost through the cost of dung as input for corresponding capacities is the same for all sizes of plant. All other components, like depreciation, maintenance charges etc., are fixed percentage of the respective costs of installation. This is the basic reason for the trends of the cost of installation and annual operational cost being uniformly increases for the capacities varying form 1-6m³. The installation cost for 1 & 2 m³ sized plant comes similar. The reason for this trend is the cost of labour for both the plant is same where as the subsidy amount is different. Thus the payback period is differs. After 2m³ sized plants, as the plant size increases, the payback period remains same, confirming to the standard trends of the economics of installation and operational cost of any technical project.

CONCLUSION

For deenbandhu model, as the capacity of the biogas plant is increases, the cost of installation, annual operational cost and annual income is increases proportionally where as the payback period remains same for more than two cubic meter sized plant. Payback period of 1m³ sized plant is double than the 2m³ plants because of differ in subsidy amount. As per the economic standards, the economics of the solid state deenbandhu biogas plants sounds good.

REFERENCES

Venkateswara, P.R. and Baral, S.S. 'Biogas in India'. Akshay Urja. Volume 6, Issue 5&6. June 2013. 48-51.

Indian Standard- Family Size biogas Plant. Code of Practice. Bureau of Indian Standards. Second Revision. New Delhi, 1998.

Shrimali, G., Slaski, X., Thurber, M.C. and Zerriffi, H. (2011) 'Improved stoves in India: A study of sustainable business models. Energy Policy, doi: 10.1016/j.ive enpol.2011.07.031

Singh, K.J. and Sooch, S.S. (2004) 'Comparative study of economics of different models of family size biogas plants for state of Panjab, India'. Energy Conservation and Management 45, 1329-1341.

Kurchania, A.K., Sharma, D. And Sharma, A. Technical bulletin on family size solid state deenbandhu fixed dome design biogas plant. Publisher BDTC, Udaipur.

Solanki, C.S. 'Renewable Energy Technologies'. PHI learning private limited. New Delhi. 2012.

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