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Techno-Economic Analysis of Thermal Application from Biogas Using Jatropha Oil Cake

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ABSTRACT Biogas, a clean and renewable form of energy could very well substitute (especially in the rural sector) for conventional sources of energy (fossil fuels, oil, etc.) which are causing ecological-environmental problems and at the same time depleting at a faster rate.*

Flexible balloon stirring digester (FBSD) was developed and techno economics of the developed biogas plant was done at GopalPura (Bhindar) about 55 km away from Udaipur during 2010. This project was done taking into consideration, biogas was used for thermal applications such as cooking meal, ghee and mava making, etc. by using biogas stove. It was observed that the flexible balloon biogas plant was economically viable when used for thermal applications. The capital cost of the plant was ' 75800 with benefit cost ratio, payback period and IRR of the plant was found to be 1.69, 1.76 years and 32 per cent respectively. The plant was found to economical for anaerobic digestion of JOC.

***Keywords:** techno economic, biogas plant, thermal application.*

Anaerobic digestion is widely used as a renewable energy source because the process produces a methane and carbon dioxide rich biogas suitable for energy production helping to replace fossil fuels. Also, the nutrient-rich digestate can be used as fertiliser. Anaerobic digestion is a versatile, effective and established method that is being used world-wide for the digestion of different organic wastes and the production of energy in the form of biogas. (Ahring *et al.*, 1992; Verstraete *et al.*, 2005).

A program devised to evaluate the life cycle economic performance of the digestion system. This was devised to accomplish the digester cost and energy production data as well as additional variables, were linked to cash flow, a program that provided the investment merit statistics NPV, IRR, SPP and Cumulative Cash Flow (CCF). (Anan, 1995).

The cash flow was a schedule of annual net profit (or loss) resulting from an investment and could take account such factors as amortization or the inflation rete for displaced fuels. The time value of money concept asserted that a current doller was more valuable than a future dollar. To assess true profitability, cash flows must be adjusted by the discount rate to put dollars into a consistent present value. Simple payback period (SPP) was often used as a criterion for determining investment acceptability. From cash flow, a SPP for the investment could be quickly calculated. He further stated that net present value (NPV) was an investment merit statistic that accounted for the time value of money by describing worth of an investment in dollars. (Lusk, 1998)

Renewable energy is one of the vital sources to meet partially the global energy demand of developed as well as developing countries. Biogas plant can be one of the major sources of renewable energy in Malaysia as huge amount of palm oil waste is available. Biogas plant can be of different types of which fixed dome and floating cover are in use in many countries for many years. The bag design is becoming popular in many countries. The fixed dome design is used in various palm oil mills. The generated gas can be used for cooking, lighting, power generation and the sludge can be used as fertilizer for land. Palm oil waste is easily available and inexpensive, the major share of costs are incurred at the initial stage. The operating and the maintenance costs are quite low. In the present work an attempt

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has been taken to study the technological parameters for commonly used fixed dome biogas plant for two different sizes. The costs related to the fabrication of plant are collected from various sources and the other items were estimated on the basis of available information. Net present worth, internal rate of return, benefit cost ratio and payback period were calculated. On the basis of calculated values it was found that the biogas plant is economically viable and viability increased with the increase of plant size. The technological suitability in the context of prevailing situation, economic viability and future scope of biogas plants has been evaluated. The findings of this study would give some directions and guidelines for future planning and implementation of biogas plants in Malaysia. (Begum. S. *et al.*, 2009).

Conventional energy usage has various environmental effects that cause global warming. Renewable energy sources are, thus, more favorable, because they have nearly zero emission. Biogas was merely seen as a sub-product obtained from anaerobic decomposition (without oxygen) of organic residue. One of the key concerns of biogas plants with energy generation is the disposal of comparatively large amounts of digestate in an economically and environmentally sustainable manner. In this article, the economic performance of the given biogas plant has been analyzed based on net present value (NPV) and energetic pay-back time (EPBT) concepts. The case study has produced an electricity yield of 2,223,951 kWh per year of feedstock digested. The hourly producible electricity energy has been 277.99 kWh. The producible heat energy has been 2,566,098 kWh per year and 320.76 kWh per day, respectively. The produced solid fertilizer and liquid fertilizer, respectively, have been 2047 t/a and 26,055 t/a. The plant with dairy cows and stall is a good economic situation under 3.4 years pay-back time, earning profits and showing a positive NPV of €27.74 million. The co-generation system has reduced emissions by 7506 t CO_2 per year. (Abdullah Akbulut, 2008).

In all, for a biogas plant to be economically and technically feasible, it may not be necessary that it recovers the cost that has been incurred to install it, within a desired time period. It is economically more viable if the cost of biproduct such as organic slurry coming out of it is also considered while calculating cost benefit ratio and pay back period.

The flexible balloon stirring digester having 6 m^3 capacity, was designed and fabricated for Jatropha Oil Cake waste. FBSD was installed at GopalPura, (Bhindar), about 55 km far from Udaipur and the techno-economical analysis of the flexible balloon stirring digester was evaluated in terms of net present worth, benefit-cost ratio, payback period and internal rate of return.

The techno economics of Flexible Balloon Biogas Plant was done taking into consideration, biogas was used for thermal applications such as cooking meal, ghee and mava making, etc. by using biogas stove. It was observed that the flexible balloon biogas plant was economically viable when used for thermal applications. For calculating techno-economic of the plant some parameters were considered such as cost of LPG per kg @ ‘30/-, a discount rate of 10 per cent, cost of one kg manure as ‘2/- and biogas production of 5804 lit/d.

The results obtained were enlisted in the Table 1 and 2 for economical analysis of the system. It was observed that the investment of the system was achieved in 1.76 years only which is viable and feasible also. (Lusk, 1998)

Table 1
Benefit cost ratio for the developed biogas plant

Sr. No.	*Present worth of cost (‘)*	*Present worth of Benefit (‘)*	*Benefit Cost Ratio*
1	155672	263811.1	1.69

Table 2
Computation of payback period for developed biogas plant

Sr. No.	*Total capital investment(‘)*	*Net annual saving(‘)*	*Payback period (Years)*
1	75800.00	42938.00	1.76

The total investment and possible achievable profit is given in the Table 3. Cost required for the material for construction, installation is shown in Table 4. The benefit cost ratio was found to be 1.69

Table 3
Study of Details of the Income and Expenditure for construction and utilizing biogas plant

Sr. No.	*Particulars*	*Income/Expenditures*
(i) Expenditures		
1.	Capital cost	‘ 75800/-
2.	Labour cost for running plant and mixing the charge	‘ 12000/- per year
3.	Maintenance cost of the plant	‘ 1000/- per year
(ii) Income		
4.	Amount of LPG replaced annually (kg)	871.62 / year
5.	Value for this LPG replaced	‘ 26148.0/- per year
6.	Value addition due to organic manure production	‘ 36500/- per year

Table 4
Cost of Material for construction of biogas plant

Sr. No.	*Item Description*	*Qty*	*Unit Price (‘)*
1	Balloon Type Biogas Plant suitable for Jatrophade-oiled cake with Biogas Flow Meter Plant capacity: 6 m^3 Balloon volume : 9.4 m^3 Material rubber fabric coated with rubberized nylon fabric	1	40800/-
2	Biogas Storage balloon (Capacity 6 m^3)	1	25000
3	Foot Pump for Biogas Agitation, (Capacity 2.00 litre)	1	2600
4	Pipe and Valves for Biogas Foot Pump,	1	1500
5	Industrial Biogas Double Stove	1	1000
6	Stand for Biogas Storage balloon	1	2400
7	Inlet and outlet for Balloon type Biogas Plant	1	1500
8	Presoaking Tank with valve for Jatropha waste, (7 m × 5 m)	1	1000
	Total		**75800/-**

with a payback periods of 1.76 years (Table 1 and 2). It can be inferred that the developed JOC based flexible balloon biogas plant was technically as well as economically feasible.

The net present worth for the system was calculated on the basis of present investment and the interest rate considered for the system and the profit achieved in each year. The life of plant was considered 10 year thus the NPW for JOC based flexible balloon biogas plant was ‘ 108139.00/-. The net present worth were calculated for next 10 years and presented in the (Table 5). The internal rate of return for the developed plant was calculated and found to be 32% for 10 years. The

Table 5
Study of Cash outflow for biogas plant construction and utilization

Year	*Cash Outflow (‘)*	*PW of Cash Outflow (‘)*	*Cash Inflow (‘)*	*PW of Cash Inflow (‘)*	*NPW (‘)*
1	2	3	4	5	(5) - (3)
0	75800.00	75800.00	00.00	00.00	–75800.00
1	13000.00	11817	42938.00	39030.64	27213.64
2	13000.00	10738	42938.00	35466.79	24728.79
3	13000.00	9763	42938.00	32246.44	22483.44
4	13000.00	8879	42938.00	29326.65	20447.65
5	13000.00	8073	42938.00	26664.5	18591.5
6	13000.00	7332	42938.00	24217.03	16885.03
7	13000.00	6669	42938.00	22027.19	15358.19
8	13000.00	6071	42938.00	20052.05	13981.05
9	13000.00	5512	42938.00	18205.71	12693.71
10	13000.00	5018	42938.00	16574.07	11556.07
Total		**155672**		**263811.1**	**108139.1**

Table 6
Internal rate of return for developed biogas plant for JOC

		30% Discount Factor		*34% Discount Factor*	
Year	*Cash Flow*	*Discount Factor*	*Present Value*	*Discount Factor*	*Present Value*
0	–75800	1	-75800	1	-75800
1	42938.00	0.7692	33027.91	0.7463	32044.63
2	42938.00	0.5917	25406.41	0.5569	23912.17
3	42938.00	0.4551	19541.08	0.4156	17845.03
4	42938.00	0.3501	15032.59	0.3102	13319.37
5	42938.00	0.2693	11563.2	0.2315	9940.147
6	42938.00	0.2071	8892.46	0.1727	7415.393
7	42938.00	0.1594	6844.317	0.1289	5534.708
8	42938.00	0.1256	5393.013	0.0962	4130.636
9	42938.00	0.0943	4049.053	0.07179	3082.519
10	42938.00	0.0725	3113.005	0.05357	2300.189
		NPW	132863.1	NPW	25437.82
			IRR, %	**32**	

higher percentage of the internal rate of return indicated the good economical return of the investment. (Sotirios Karellas, *et al*., 2009). Table 6 shows the calculations of IRR for developed biogas plant.

Hence, The capital cost of the plant was ‘ 75800 and the benefit cost ratio, payback period and IRR of the plant were found to be 1.69, 1.76 years and 32 per cent, respectively. The plant was found to be economically feasible for thermal application of biogas.

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