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Research Note

Economics of Electricity Generation Using Cattle Dung — A Case Study on Bio-methanation Power Plant in Ludhiana

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Abstract

The paper has examined utilization of cattle dung for electricity generation through a case study on bio-methanation plant in Ludhiana. There are 1550 dairies in the Haibowal dairy complex in Ludhiana and the cattle dung is drained into a nearby nullah. A plant for electricity generation using cattle dung has been established in the area under UNDP/ Global Environment Energy Programme. The paper has studied the economics of electricity generation at this plant and has found that it is profitable to utilize the cattle dung for electricity generation, the capital-output ratio being 2.2 and payback period being 4 years. Besides electricity generation the plant also provides bio-manure. It also checks water pollution and emission of green house gases. The study has suggested that such plants should be established in all the dairy complexes of the country to help in electricity generation. The large farmers should constitute NGOs and SHGs to establish such plants in their respective areas. The central and state governments should extend the necessary support for the establishment of such plants.

Key words: Bio-energy, cattle dung, bio-methanation, electricity generation, non-conventional sources of energy, Ludhiana

JEL Classification: Q20

Introduction

The economic growth of a country is directly related with energy, renewable as well as non-renewable. The non-renewable energy resources are limited, and excessive dependence on them not only causes environmental degradation but also escalates the cost of their production/extraction, leading to higher prices for the consumers. During the past few years, India has shown a significant growth in development of renewable energy sources, raising their share to12 per-cent in the total electricity generation in the country (Mishra and Singh, 2013). India's installed capacity for renewable energy has grown from 3.9 GW (Gigawatts) in 2002-03 to about 27.3 GW in 2012. Wind energy has been at the forefront on this account. It accounts for 68 per cent of the installed capacity, and is followed by small hydropower (3.55 GW), biomass power (3.56 GW) and solar power (1.4 GW) projects (MNRE, 2012-13).

The demand and supply gap in energy is pervasive, requiring serious efforts by the Government of India to augment energy supplies (CSO, 2013).However, the rising global challenges in energy generation, and environmental concerns have triggered research on alternative energy sources and technologies (Muchiri *et al*., 2012). Post oil crisis (1973) has shifted the focus towards energy conservation and non-conventional energy sources. Biomass is such one source of renewable energy. In rural India, it meets three-fourths of the rural energy demand (Ramachandra and Shruthi, 2007).

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Biogas is one of the renewable sources of energy. It is obtained as a by-product of the process called anaerobic digestion. It contains about 60 per cent methane (CH_4) and 40 per cent carbon-dioxide (CO_2). The green-house gas emissions from the livestock farms can be reduced following anaerobic digestion approach of converting cattle dung into bio-energy. Thus, this process can be widely applied for the production of the biogas on a large scale. Moreover, the resulting methane can be utilized for electricity generation, lighting, heating and cooking.

According to an estimate, on production of one kilowatt-hour of electricity from biogas, there is a net reduction of 414 g of CO_2 emission (Sefeedpari *et al.,* 2012). This type of cattle dung-use not only decreases foul odours in the living surroundings but also potentially increases farm income through electricity generation and by-products such as soil amendments (Poeschl *et al*., 2010). However, information on the economics of electricity generation from cattle dung is scanty. And, therefore, the present study has examined the economic feasibility and sustainability of animal dung utilization for production of methane and other marketable products like electricity, organic manure, and cow-dung cakes. The information will be helpful to the farmers, policymakers, financial institutions and NGOs in taking informed decisions on the use of cattle dung, the disposal of which is a serious problem, especially in the peri-urban areas.

The present study was conducted in an urban dairy cluster known as Haibowal dairy complex in Ludhiana city of Punjab with the objective of finding out alternative uses of cattle dung with a focus on the economic viability of bio-methanation as a source of energy from cattle dung. This waste-to-energy conversion is the first of its kind of demonstration project under the UNDP/Global Environment Facility (GEE) programme for energy recovery through bio-methanation process. This plant* has been designed for the scientific disposal of cattle dung, which otherwise is wasted and washed away into the nearby drains by the dairy owners causing environmental pollution and choking of the sewage system of the city. This plant has the capacity to use 235 tonnes of cattle dung per day and can generate 18,000 kW of electrical energy. The surplus energy after meeting the in-house power requirement is being fed into the State Electricity Grid for household supply. Besides electricity, this project also produces 47 tonnes of valuable nutrient-rich bio-manure, which is sold to the farmers (Singh, 2008).

Methodology

To start with a list of dairy farmers in the Haibowal dairy complex was prepared to find out different methods of cattle dung disposal. Following the cumulative cube root frequency method (Singh and Mangat, 1996), the dairy farmers were categorized as small (< 62 animals), medium (63-162 animals), and large (>163 animals). Using the proportional allocation method, a random sample of 60 dairy farmers (40 small, 15 medium and 5 large) was selected for the survey. A questionnaire specifically designed for this survey was used to collect data from the selected farmers regarding their disposal pattern of cattle dung. Personal interviews were also conducted with the officials of bio-methanation plant. Data on capital investment, cost of fixed as well as variable inputs, supply of cattle dung to the power plant, production of electricity and dry manure were compiled from the reports and records of the plant.

Fixed costs included the depreciation of machinery and equipments, rental value of land, building and other structures, permanent labour and interests on fixed costs. Variable costs included cost of raw material, casual labour, electricity, water, and plant maintenance. Interests on variable costs were also included in variable costs. These cost components were used to work out break-even point, pay-back period and net returns. The data pertained to the year 2009-10.

Results and Discussion

The pattern of dung disposal being followed by small, medium and large farmers in Ludhiana city is presented in Table 1. In more than 38 per cent cattle dairies, the dung was disposed-off applying high-pressured water showers, that drained it through the sewage pipes into the *Buddha Nallah* nearby by the Dairy Complex. It is not only the wastage of water and cattle dung but also a cause of pollution. One-fourth

*The bio-methanation power plant won the award of Best Green Power Plant in Asia in 2007.

Table 1. Trends in disposal of cattle dung by small, medium and large dairy farmers in Ludhiana city, 2008-09

Category of farmers	Washing away	Making cow-dung cakes	Making farm yard manure	Supplying to power plant	Total
Small	14 (35.00)	9 (22.50)	7 (17.5)	10 (25.00)	40
Medium	7 (46.67)	2 (13.33)	1 (6.67)	5 (33.33)	15
Large	2 (40.00)	1 (20.00)	1 (20.00)	1 (20.00)	5
Total	23 (38.33)	12 (20.00)	9 (15.00)	16 (26.67)	60

Note: The figures within the parentheses indicate percentage of the row.

of the dairy farmers converted dung into cakes for utilizing as domestic fuel, and 15 per cent converted it into manure. Only 27 per-cent of the farmers sold the cattle dung to the bio-methanation power plant for electricity generation.

The details about dung supply, electricity generation and manure production are provided in Table 2 for each quarter of the year 2009-10. The supply of dung was highest during the quarter January-March, and lowest during the quarter April-June. Accordingly, electricity generation was at its peak during January to March. On the annual basis, about 5000 MW of electricity was generated during 2009-10.

The capital investment and item-wise cost of bio-methanation power plant are shown in Table 3. The capital investment included investments on machinery and equipments such as biologically induced mixing arrangement (BIMA), gas engine, macerator, screw presses, gas holder, start-up boilers, variable frequency drives, etc. It was found that the capital investment on machinery was ₹ 8 crore. The fixed costs constituted the major share (60.9 %) of the total costs. Depreciation on machinery and equipments were major components of the fixed costs and accounted for 46.0 per cent of the total costs. Land, building and other component structures were on lease from the Municipal Corporation of Ludhiana for a period of 25 years at almost negligible rates, so the lump-sum rental value of land was ₹ 434 only. The wages and interest on fixed costs as a percentage of the total costs were 8.30 per cent and 6.51 per cent, respectively. The variable costs accounted for 39.1 per cent of the total costs. The major component of variable costs was raw materials, viz. cattle dung and casual labour. Nearly 6 per cent of the total cost was on electricity and water used in the process of bio-methanation. The total cost was estimated as ₹ 1.73 crore.

Table 2. Quarterly supply of cattle dung, generation of electricity and production of dry manure in bio-methanation power plant in Ludhiana city, 2008-09

Quarter	Supply of cattle dung (tonnes)	Generation of electricity (MW)	Production of dry bio-manure (tonnes)
First	14144	1082	2399
Second	14545	1170	2572
Third	16529	1365	2892
Fourth	16961	1350	3178
Total	62179	4967	11041

Economic Evaluation of Bio-methanation Power Plant

Table 4 shows the gross and net returns from the sale of electricity and cattle dung manure. The annual gross returns from sale of electricity were estimated to be ₹ 1.81 crore. The gross returns the sale of organic manure were ₹ 1.96 crore — about 9 per cent more than that from the sale of electricity. On the whole, the plant realized the gross returns of ₹ 3.77 crore. The net returns from the sale of both electricity and organic manure were to the tune of ₹ 2.03 crore. The returns over the variable costs were estimated to be ₹ 3.09 crore.

The break-even quantity and payback period were estimated to evaluate the economic viability of investment. The break-even quantity of electricity generation was 620177 kW, and for dry manure, it was

Table 3. Capital investment and costs of bio-methanation power plant in Ludhiana city

S. No.	Particulars	Amount (in lakh ₹)	Per cent
A	**Capital investment**		
	Machinery and equipments	800	100.00
B	**Fixed costs**		
	Rent on land & building on lease	0.0043	0.002
	Depreciation on machinery @ 10% p.a.	80.00	46.03
	Casual labour	14.41	8.31
	Interest on fixed costs @ 12% p.a.	11.40	6.52
	Sub-total (B)	105.8	60.86
C	**Variable costs**		
	Raw material	28.31	16.29
	Permanent Labour	14.90	8.57
	Electricity	9.93	5.71
	Maintenance Cost	7.94	4.57
	Interest on Variable Costs @ 12% p.a.	6.95	4.00
	Sub-total (C)	68.04	39.16
D	**Grand total (B+C)**	173.84	100.00

Table 4. Net margins and economic evaluation for bio-methanation power plant in Ludhiana city

Particulars	Amount
Number of electricity units produced	4967 MW
Total costs incurred in electricity production	₹ 17384500
Cost of per unit electricity	₹ 3.50
Returns from sale of electricity @ ₹ 3.66/unit	₹ 181.8 lakh
Returns from sale of dry manure @ ₹ 1500/tonne	₹ 195.6 lakh
Gross returns	₹ 377.4 lakh
Returns over variable costs	₹ 309.3 lakh
Net returns	₹ 203.6 lakh
Break-even quantity (No. of units)	46.20 lakh
Break-even quantity as % of total output	93
Break-even quantity (tonnes)	10815.88
Break-even quantity as % of total output	82.93
Pay-back period (years)	3.93

Table 5. Input-output relationship for bio-methanation power plant in Ludhiana city

Capital output ratio	2.17
Share of fixed costs in capital output ratio	1.32
Share of variable costs in capital output ratio	0.85
Benefit-cost ratio (at variable costs)	1.17
Benefit-cost ratio (at total costs)	1.77

10816 tonnes. The payback period was about 4 years for the investment on this plant.

The study has found that the rate of income in relation to investment may vary. Therefore, an attempt was made to present different ratios of output/benefit (Table 5). A perusal of Table 5 reveals that investment of one rupee (fixed and variable resources) provided a return of ₹ 2.17. It means earnings of ₹1.77 which came out to be 81.6 per cent of the total earnings and the remaining 18.4 per cent was the total cost on bio-methanation power plant. A further split of gross returns as the ratio to the total cost revealed the share of fixed cost in capital/output ratio to be 60.8 per cent, the

remaining 39.20 per cent being the share of variable costs in the capital/output ratio.

Problems of Power Plant

The plant faces the problems of inadequate and erratic supply of raw material. Only the dairies located near the plant, supply dung to the power plant. Another problem being faced by the plant is scarcity of labour, which becomes acute during sowing and harvesting seasons of crops. The BIMA digester and the other machines and equipments have been imported from Austria, and therefore in case of any fault, the spare parts are also to be imported from Austria, which is a costly and time-consuming process.

Conclusions and Policy Implications

The bio-methanation power plant is a novel innovation for producing electricity from cattle dung which otherwise is drained into the *nallahs*. The power plant in Ludhiana is probably first of its kind and produces electricity at the cost of ₹ 3.50 per kilowatt-hour. The plant is designed for 1 Mega Watt capacity but it is not being fully utilized. Although the plant is running on profit, it has potential to provide more returns. There are more than 1550 dairies in the Haibowal dairy complex and the cattle dung is drained into the Buddha Nullah that flows across these dairies. These dairies produce approximately 5170 thousand tonnes of cattle dung per annum, of which 2533 thousand tonnes is drained away and only 1447 thousand tonnes is sold to the bio-methanation power plant. It is suggested that dairy farmers should sell their cattle dung to the bio-methanation power plant @ ₹ 5/ quintal instead of draining it. Cattle dung is a good source of biogas and employing biogas technology, the biological waste can be converted into energy which will help improve the quality of life and health.

Biogas is produced by either anaerobic digestion or fermentation of biodegradable materials. It comprises mainly methane (CH_4) and carbon dioxide (CO_2), with a small amount of hydrogen sulphide and moisture. The biogas mitigates a wide range of environmental undesirables to provide high quality organic fertilizer, provides gas for cooking or electricity generation thereby reducing demand for fuel wood and charcoal for cooking. It improves water quality and mitigates greenhouse gas emissions (Ogwo *et al.*, 2012). If large and rich farmers form cooperatives and adopt the technology of converting cattle dung into electricity, then most of the dairy complexes can become self-sufficient in electricity need and can also supply electricity to the neighbouring localities.

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