RESEARCH PAPER International Journal of Agricultural Engineering | Volume 6 | Issue 2 | October, 2013 | 427–430

Economic feasibility of biomass based downdraft gasifier power generation system

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Received : 10.07.2013; **Revised :** 05.10.2013; **Accepted :** 04.11.2013

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ABSTRACT : The economics of 10 kW downdraft gasifier based power generation system and thereby the feasibility of the system was computing by net present value (NPV), benefit cost ratio (BCR), payback period, cost of operation and cost of electricity generation. The economics of the system was evaluated for 12 h (Case I with government subsidy) and 16 h (Case II without government subsidy) of operation. The economic analysis was carried out for considering subsidy and without subsidy on initial investment to brings the past and future cost to present, discount cash flow method was determined with a 10 per cent discount rate. The NPV, BCR, payback period, cost of operation and cost of electricity generation comes in case I for operating duration of 12 h were 307950.95, 1.20, 1101 days, 32.33 and 3.38, respectively, whereas for 16 h it were 571696.39, 1.30, 787 days, 36.12 and 3.72, respectively. Similarly for case II the NPV, BCR, payback period, cost of operation and cost of electricity generation was worked out for operating duration of 12 h and were found to be 197950.95, 1.12, 1466 days, 40.97 and 4.27, respectively and for 16 h it worked out to be 785382.08, 1.47, 1293 days, 36.35 and 3.77, respectively. The payback period for biomass based gasifier power generation system were observed to be 2.15 - 3 years and 3.54 - 4 years in case I and II, respectively. The system was found more economically feasible according to cost of operation and cost of electricity generation at 12 h operating with government subsidy.

KEY WORDS : Downdraft gasifier, Biomass, Discounted cash flow, Benefit cost ratio, Net present value

HOW TO CITE THIS PAPER : Wasu, Gajanan (2013). Economic feasibility of biomass based downdraft gasifier power generation system. *Internat. J. Agric. Engg.*, **6**(2) : 427-430.

The present research work was mainly intended towards the assessment of cost of energy generation and the feasibility for power generation through biomass based gasifier power generation system. This information will help in deciding to retro fitting such system in rural area of the country to fulfill the energy demand. The gasifier based power generation system installed at Dr. Punjabrao Deshmukha Krushi Vidhyapeeth, Akola was studied as a case for the research project work with considering the various aspects of energy generation with the various cost measures.

One seventh of total energy consumption is from biomass which is the main energy resource for over 1.5 billion people in the world. Biomass energy is the only one which has both the property of fossil fuel and characteristics which mean that it can be stored, renewed and transferred. It is less restricted by natural conditions. Biomass energy can be transferred to use fuel thermal energy, electrical energy and the fuel as power by means of direct combustion, gasification and liquidation. High grade combustible gas like CO, H_2 and CH_4 can be formed by the gasification of biomass (Mengjie and Suzhen, 2002). Fossil fuel based technology has been primary source in India since last two decades to meet the thermal energy required in small as well as large industries. Number of small-scale industries that uses liquid fuels in the range of 100 litres per h to meet the heat requirements is quite large (Anonymous, 2001).

In the recent times, gaseous fuels are gaining prominence as cleaner fuels for power generation via internal combustion engine route; the power generation package including both reciprocating engines and gas turbine machinery. Among the clean sources of fuel for power generation, natural gas has been exploited largely due to significant availability in specific locations. Similarly, there is also an impetus on using gas generated from industrial and municipal wastes, namely diluted natural economical but also environmentally benign (Mukunda *et al.*, 1993).

Energy has as a major goal in the development of cost-competitive technologies for the production of power from renewable biomass crops. Paisley and Anson (1997) discussed the development and commercial demonstration of the Battelle high-through put gasification process power generating system. Hughes and Larson (1997) used a modeling approach to simulate the effect of varying moisture content in the gasifier feed biomass.

METHODOLOGY

The present study was carried out on biomass power generation system of 10 kW WBG (downdraft gasifier) installed capacity at College of Agricultural Engineering and Technology, Dr. Panjabrao Deshmukh Agricultural University (Dr. PDKV), Akola Maharashtra, India. The installation and the maintenance cost of the system for turnkey operation was collected. In present study, cost of energy generation has been evaluated. The cost of energy generation is evaluated by considering the optimum performance of the gasifier system. The life cycle cost of energy generation have determined by considering the present economic appraisal. The feasibility of the power generation of gasifier system was evaluated by discounted cash flow technique (DCF) (NWCC, 1997; Khambalkar *et al.*, 2009). The parameters like net present value, benefit-cost ratio, internal rate of return and payback period of the system was evaluated by considering the current nature of discount rate.

Economic feasibility of biomass power system :

The project evaluation technique (discounted cash flow) was used to measure the economic feasibility of power generation system. This technique measures the productivity of the capital invested and for which the flows of costs and returns over life period. These costs can be brought to refer to the particular point of time *i.e.*, present period by discounting them.

For the success and commercialization of any new technology, it is essential to know whether the technology is economically viable or not. Therefore, an attempt was made to evaluate economics of 10 kW biomass based downdraft gasifier power generation system. Economic analysis of the system was carried out by employing following indicators as,

– Net present worth
– Benefit-cost ratio
– Payback period.

Following parameters were considered to carry out economic analysis of gasifier system:

– Life of the system was considered as 20 years.
– Repair and maintenance cost at 20 per cent of initial investment spread over 20 years.
– Discount rate of the system was assumed 10 per cent.
– The labour cost was taken @ Rs 100 per day.
– Biomass cost was Rs. 1.50 per day.
– The annual operating days of gasifier system was 300 days.
– Sale price of electricity was Rs. 6 per kWh.

Net present value :

In this method, generally the discounted rate, which reflects the price of the investment funds, is used to arrive at costs and returns to a common point of time. These costs are subtracted from the return to get the net present values of the systems. The positive net present values indicate that the investment is worthwhile and the size of the net present value (NPV) indicates how worthwhile the project is in utilizing the resources to maximize income. Following expression was used to work out the net present value.

$$\mathbf{NPV} = \sum_{t=1}^{N} \frac{\mathbf{R_t - C_t}}{\mathbf{(i+i)^t}}$$

where, R is the returns in the year t, C is the costs in year t, N is the project life, *i* is the discount rate in per cent.

The decision criteria are:

If	NPV > 0	Investment is worthwhile
	NPV < 0	Investment is not worthwhile
	NPV = 0	Neutral case.

Benefit cost ratio :

The benefit cost ratio measures the returns or benefit per unit of cost of investment.

$$\mathbf{BCR} = \frac{\sum_{t=1}^{N} \frac{\mathbf{Rt}}{\mathbf{(1+i)^t}}}{\sum_{t=1}^{N} \frac{\mathbf{C_t}}{\mathbf{(1+i)^t}}}$$

The decision criteria are:

If	BCR > 1	Investment is worthwhile
	BCR < 1	Investment is not worthwhile
	BCR = 1	Neutral case.

Payback period :

This is the simplest of the techniques for evaluating an investment proposal. It is defined as the time period within which the initial investment of the project is recovered in the form of benefits. In other words, this is the length of time between the starting time of the project and the time when the initial investment is recoupled in the form of yearly benefits. Expressing it in notation

$$\mathbf{P} = \frac{\mathbf{I}}{\mathbf{C}}$$

where, P is the payback period, I is the initial investment and C is the yearly net cash flow.

Theory of economic analysis :

The economics of gasifier base power generation system was calculated by evaluating various costs measured and by using the discounted cash flow techniques for system economic feasibility. The data regarding installation cost, cost of fuel and cost of labour for the case determined over operation.

The present analysis has been carried out for power generation of 12 h and 16 h with the scenario of without subsidy (Case I) and subsidy of 10 per cent discount rate (Case II) on total installation cost of gasifier based power generation system.

Cost of operation :

Cost of operation was calculated by using formula:

Cost of operation = Operation and mentinence cost / (No of operating days in year x No. of operating h in day)

Cost of operation = O & M cost / (Y x h) (1)

Cost of electricity generation :

Cost of electricity generation was calculated by using formula :

Electricity generation = (Operation and maintains cost + Depression cost) / (No of operating Days in year x No of operating h in day)

Cost of electricity generation = (O & M cost + D cost) / (Y x h) (2)

RESULTS AND DISCUSSION

The economics of 10 kW downdraft gasifier based power generation system and thereby the feasibility of the system was computing by net present value (NPV), benefit cost ratio (BCR), payback period, cost of operation and cost of electricity generation. The economics of the system was evaluated for 12 h (Case I with government subsidy) and 16 h (Case II without government subsidy) of operation. The economic analysis was carried out for considering subsidy and without subsidy on initial investment.

Economic feasibility of biomass power generation system :

Economics of 10 kW power generation systems was examined by computing net present value, benefit cost ratio and payback period. Capital statement of 10 kW power generation unit is given in Table 1.

Table 1 : Capital Statement for 10 kW downdraft gasifier

Sr. No.	Particulars	Parameter
1.	Power, kW	10
2.	Installation cost, Rs	6,50,000
3.	Subsidy, Rs	1,10,000
4.	Net Installation cost, Rs	5,50,000
5.	Project lifetime, years	20
6.	Sale price of electricity, Rs/kW-h	06
7.	Annual interest rate, %	10

The economics of the system was evaluated for 12 h and 16 h of operation. The economic analysis was carried out for considering subsidy and without subsidy on initial investment. To bring the past and future cost to present, discounted cash flow was determined with a 10 per cent discount rate.

Net present worth:

Net present worth for 10 kW power generation systems is presented in Table 2. When the system was operated for 12 and 16 hs per day, net present worth calculated by considering subsidy on initial investment was found to be Rs. 307950.95 and Rs. 571696.39, respectively. When the system was operated for 12 and 16 hs per day, net present worth determined by without subsidy was found to be Rs. 197950.95 and Rs. 785382.08, respectively. Thus, the project was feasible for operating on 12 and 16 hs operations with the Government subsidy. Also, it was found feasible without the Government subsidy for both 12 and 16 h of operation per day.

Benefit-cost ratio :

The B:C ratio of the system was found out by taking ratio of present worth of benefit and present worth of cost. Table 2 revealed benefit cost ratio of the system operated for 12 and 16 h per day. It was found that benefit cost ratio for the system operated for 12 and 16 h per day operation with considering the subsidy and without subsidy were 1.20, 1.30 and 1.12, 1.47, respectively. Thus, it is concluded from Table 2 that the investment is justified and the project is economically feasible considering government subsidy and without government subsidy.

Table 2 : Economic indicators for 10 KW producer gas based power generation systems

Particulars	12 h		16 h	
	With subsidy	Without subsidy	With subsidy	Without subsidy
NPW(Rs)	307950.95	197950.95	571696.39	785382.08
B-C ratio	1.20	1.12	1.30	1.47
Payback period	1101 days	1466 days	787 days	1293 days
cost of operation (Rs/h)	32.33	40.97	36.12	36.35
Cost of electricity Gen. (Rs/kW)	3.38	4.27	3.72	3.77

Payback period :

Payback period discriminates whether the project is feasible or not for the threshold lifetime. The net cash flow was calculated by deducting yearly operating costs from the gross annual income of the gasifier system. The cumulative net cash flow was then calculated for different years. For the system operating 12 h per day and 16 h per day with government subsidy, the payback period was worked out to be 1101 days for 12 h per day and 787 days for it 16 h per day, operation. Similarly for the system operated 12 h per day and 16 h per day without Government subsidy, the payback period was worked out to be 1466 days for 12 h per day and 1293 days for 16 h per day, operation.

Cost of operation :

Cost of operation of system was calculated by using equation (I) Table 2 revealed cost of operation of system operated for 12 and 16 h per day, considering with Government subsidy and without Government subsidy. It was found that cost of operation with Government subsidy and without Government subsidy were Rs. 32.33, 36.12 and 40.97, 36.35, respectively.

Cost of electricity generation :

Cost of electricity generation of system was calculated by using equation (II). Table 2 revealed cost of electricity generation of system operated for 12 and 16 h per day, considering with government subsidy and without government subsidy. It was found that cost of electricity generation with government subsidy and without government subsidy were Rs. 3.38, 3.72 and 4.27, 3.77, respectively.

Conclusion :

The economic feasibility of the biomass power generation system was determined over the life of the system. The results obtained from this method indicate that the implementation of the system is feasible for both the cases with an acceptable NPV.

Economic indicators in terms of net present worth, benefit cost ratio and payback period for 10 kW power generation systems was determined. The system was found economically feasible for 12 and 16 h of operation considering government subsidy and without government subsidy. Net present worth for 12 and 16 h was Rs 307950.95 and Rs 571696.39, respectively with subsidy. Similarly without government subsidy net present worth for 12 and 16 h was Rs 197950.95 and Rs785382.08, respectively. The benefit cost ratio for with subsidy for both operated hour was 1.20 and 1.30, respectively. Similarly without government subsidy for both operated hour was 1.12 and 1.47, respectively. It is concluded from economic analysis that system is economical feasible for both cases. The cost of operation of the system was found minimum at 12 hour with government subsidy *i.e.* 32.33 Rs/h and cost of electricity generation was found minimum at 12 hour with government subsidy *i.e.* 3.38 Rs/kW. The system was found more economically feasible according to cost of operation and cost of electricity generation at 12 hour operating with government subsidy. The costs of energy generation have varied with the burden of capital taking in to consideration for analysis.

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